ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

M. TECH. BIOTECHNOLOGY

REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES(PSOs):

PSO	Programme Specific Outcomes
PSO1	Apply engineering principles and modern computational tools to design, analyze, and optimize biotechnological processes for healthcare, agriculture, and environmental applications.
PSO2	Demonstrate the ability to work effectively in multidisciplinary teams, adhering to ethical standards and managerial practices, to develop innovative biotechnological solutions for societal benefit.

ANNA UNIVERSITY, CHENNAI

POST GRADUATE CURRICULUM (NON.AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.Tech. Biotechnology **Regulations:** 2025

Abbreviations:

BS – Basic Science (Mathematics)
ES – Engineering Science (General (G), Programme Core (PC), Programme Elective (PE))
SD – Skill Development
SL – Self Learning
L – Laboratory Course
T – Theory
LIT– Laboratory Integrated Theory
PW– Project Work
TCP– Total Contact Period(s)

SEMESTER I

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	BY25101	Applied Biostatistics	T	3	1	0	4	4	BS
2.	BY25102	Genetic Engineering and Genome Editing	LIT	3	0	4	7	5	ES (PC)
3.	BY25103	Advanced Bioprocess Technology	T	3	0	0	3	3	ES (PC)
4.	BY25104	Immunotechnology	LIT	3	0	4	7	5	ES (PC)
5.	BY25105	Plant and Animal Biotechnology	T	3	0	0	3	3	ES (PC)
6.	BY25106	Technical Seminar	-	0	0	2	2	1	SD
Total Credits							**26**	**21**	

SEMESTER II

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	BY25201	Separation Processes in Biotechnology	LIT	3	0	4	7	5	ES (PC)
2.	BY25202	Computational Biology	LIT	3	0	4	7	5	ES (PC)
3.	BY25203	Metabolic Engineering	T	3	0	0	3	3	ES (PC)
4.	---	Programme Elective I	T	3	0	0	3	3	ES (PE)
5.	---	Programme Elective II	T	3	0	0	3	3	ES (PE)
6.	---	Industry Oriented Course I	-	1	0	0	1	1	SD
7.	BY25204	Industrial Training[#]	---	---	---	---	---	---	SD
8.	----	Self Learning Course	---	-	-	-	-	1	-
Total Credits							**24**	**21**	

[#] Evaluation will be done in third semester for the Industrial Training.

SEMESTER III

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	---	Industry Oriented Course II	-	1	0	0	1	1	SD
2.	---	Programme Elective III	T	3	0	0	3	3	ES (PE)
3.	---	Programme Elective IV	T	3	0	0	3	3	ES (PE)
4.	---	Programme Elective V	T	3	0	0	3	3	ES (PE)
5.	BY25301	Bioprocess and Product Development Laboratory	L	0	0	6	6	3	ES (PC)
6.	BY25204	Industrial Training[#]	-	-	-	-	-	2	SD
7.	BY25303	Project Work I	---	0	0	12	12	6	SD
Total Credits							**28**	**21**	

SEMESTER IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	BY25401	Project Work II	---	0	0	24	24	12	SD
Total Credits							**24**	**12**	

Total Credits for the Programme = 78

PROGRAMME ELECTIVE COURSES (PE)

S. No.	Course Code	Course Title	Periods			Total Contact Periods	Credits
			L	T	P		
1.	BY25001	Plant Design and Process Economics	3	0	0	3	3
2.	BY25002	Food Processing Technology	3	0	0	3	3
3.	BY25003	Cancer Biology and Therapeutics	3	0	0	3	3
4.	BY25004	Enzyme Technology and Biocatalysis	3	0	0	3	3
5.	BY25005	Industrial Fermentation Technology	3	0	0	3	3
6.	BY25006	Biochemical Engineering	3	0	0	3	3
7.	BY25007	Bioreactor Design and Control	3	0	0	3	3
8.	BY25008	Applied Genomics and Proteomics	3	0	0	3	3
9.	BY25009	Bioprocess Modeling and Optimization	3	0	0	3	3
10.	BY25010	Renewable Energy and Green Technology	3	0	0	3	3
11.	BY25011	Synthetic Biology	3	0	0	3	3
12.	BY25012	Advances in Environmental Biotechnology	3	0	0	3	3
13.	BY25013	Biopharmaceuticals and Biosimilars	3	0	0	3	3
14.	BY25014	Cell Culture Technologies	3	0	0	3	3
15.	BY25015	Nanobiotechnology	3	0	0	3	
16.	BY25016	Biosensors and Diagnostic Applications	3	0	0	3	3
17.	BY25017	Human Molecular Genetics	3	0	0	3	3
18.	BY25018	GMP and Validation in Bioprocess Industries	3	0	0	3	3
19.	BY25019	Translational Biotechnology and Entrepreneurship	3	0	0	3	3
20.	BY25020	Regulatory Affairs in Biotechnology	3	0	0	3	3

S. No.	Course Code	Course Title	Periods			Total Contact Periods	Credits
			L	T	P		
21.	BY25021	Artificial Intelligence and Machine Learning in Healthcare	3	0	0	3	3
22.	BY25022	IoT in Biotechnology	3	0	0	3	3
23.	BY25023	Regenerative Medicine	3	0	0	3	3
24.	BY25024	Programming for Biotechnologists	3	0	0	3	3

BY25101	Applied Biostatistics	L	T	P	C
		3	1	0	4

Course Objectives:

This course provides a strong foundation in probability and statistical methods with applications in biotechnology and life sciences. Students will model uncertainty using random variables and standard distributions. It covers correlation, regression, sampling, and hypothesis testing techniques. Emphasis is also placed on experimental design and variance analysis for effective interpretation of biological experiments.

Probability Concepts And Random Variables : Sample space and events, Classical and axiomatic probability- Conditional probability, Total probability and Bayes' theorem, Random variables: discrete and continuous -Distribution functions, Expectation and moments.

Activity: Calculate probabilities and expectations for given biological data sets using Bayes' theorem.

Standard Distributions and Their Applications: Discrete distributions: Binomial, Poisson, Geometric - Continuous distributions: Normal, Exponential, Gamma - Bivariate distributions - Joint, marginal, conditional probabilities.

Activity: Case Study on Real-world data examples from biotechnology.

Correlation, Regression and Model Fitting: Correlation coefficient, Pearson's and Spearman's methods - Simple linear regression - Curve fitting using least squares, Linear, quadratic, exponential, power models.

Activity: Case Study on application to biological problems.

Sampling and Hypothesis Testing : Sampling techniques, Random, stratified, systematic sampling - Sampling distributions, Central limit theorem, Tests for single mean and difference of means (Large and small samples), F, Test for equality of variances, Chi square test for goodness of fit – Independence of attributes.

Activity: Conduct hypothesis tests (t-test, chi-square) on sample biological datasets.

Design of Experiments and Analysis of Variance: Principles of experimental design, Replication, randomization, local control- ANOVA: One-way and two-way classifications, Design techniques: Randomized Block Design (RBD), Latin Square Design (LSD).

Activity: Demonstration of Design of experiment software tool.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%) and Internal Examinations (50%)

References:

1. Johnson, R. A., Miller, I., & Freund, J. (2016). *Miller and Freund's probability and statistics for engineers* (9th ed.). Pearson Education Asia.
2. Forthofer, R. N. (2007). *Introduction to biostatistics: A guide to design, analysis, and discovery*. Elsevier Academic Press.
3. Gupta, S. C., & Kapoor, V. K. (2020). *Fundamentals of mathematical statistics* . Sultan Chand and Sons.
4. Ross, S. M. (2020). *Introduction to probability and statistics for engineers and scientists* (6th ed.). Elsevier.
5. Spiegel, M. R., Schiller, J., & Srinivasan, R. A. (2012). *Probability and statistics* Schaum's outline series). Tata McGraw Hill.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc19_bt19/preview
2. https://onlinecourses.nptel.ac.in/noc23_bt13/preview

	Description of CO	PO	PSO1	PSO2
CO1:	Apply probability and random variable concepts to analyze biological data.	PO1(3), PO2(2)	3	2
CO2:	Use statistical distributions and regression methods for solving biotechnology problems.	PO3(1), PO2(2)	2	3
CO3:	Conduct hypothesis testing and sampling to draw valid conclusions in experiments.	PO1(1), PO3(2)	2	1
CO4:	Design experiments and perform ANOVA for process optimization in biotechnology.	PO3(3)	2	2

BY25102	Genetic Engineering and Genome Editing	L	T	P	C
		3	0	4	5

Course Objective:

- To provide students with in-depth knowledge on genetic manipulation techniques enabling them to design and apply molecular tools for precise genome modification.

Specialized Cloning and Expression Vectors: Bacterial Artificial Chromosomes (BACs) and Yeast Artificial Chromosomes (YACs), Expression Vectors, Shuttle Vectors, Reporter Vectors, Gateway Vectors, scaffold/matrix attachment regions (S/MAR) vectors, viral vectors (e.g., lentiviral, adenoviral, and AAV systems) integrating and non-integrating vectors, inducible expression systems (tetracycline), RNA expression vectors, dual promoter vectors

Activity: Prepare a comparative chart of different expression vectors, highlighting their features, advantages, and applications.

Modern Approaches in Molecular Cloning: Next-generation cloning techniques - Gibson assembly, golden gate cloning, seamless in-fusion cloning; synthetic biology approaches - DNA synthesis and gene synthesis technologies, design and construction of synthetic genetic circuits, modular cloning systems; Cloning for Metabolic Pathway Engineering, *in vivo* DNA assembly in Yeast or mammalian cells, cell-free systems for cloning and expression

Activity: Group discussion on the pros and cons of synthetic biology tools like modular cloning and in vivo DNA assembly.

Epigenetics and Gene Regulation: Epigenetics: Key Principles and Processes; differences between genetic and epigenetic changes; types of Epigenetic Modifications - DNA methylation: mechanisms, enzymes (DNMTs), and functions Histone modifications: acetylation, methylation, phosphorylation, ubiquitination, non-coding RNAs and their role in epigenetic regulation; Mechanisms of Epigenetic Regulation - Chromatin structure and remodelling, Role of histone code in gene expression, Epigenetic control of transcription

Activity: Design a simple experiment to detect histone modifications using available literature and propose a hypothetical result.

RNA-Mediated Gene Silencing: Introduction to RNA-Mediated Gene Silencing; RNA Interference (RNAi) Pathway - Mechanism of RNAi: initiation, amplification, and effector steps, Role of Dicer, Argonaute (AGO) proteins, and RISC complex, Differences between siRNA and miRNA pathways,Endogenous and exogenous sources of dsRNA; Transcriptional and post-transcriptional gene silencing

Activity: Case study analysis of RNAi-based therapies, summarizing mechanisms and therapeutic applications.

Targeted Genome Engineering: Overview of genome editing; Molecular Mechanisms Underlying Genome Editing, DNA repair pathways: Non-Homologous End Joining (NHEJ) and Homology Directed Repair (HDR), double-strand breaks (DSBs) and their role in genome editing; Zinc Finger Nucleases (ZFNs): design, mechanism, and applications, Transcription Activator-Like Effector Nucleases (TALENs), CRISPR-Cas9 system mechanism of action

Activity: Workshop to design ZFNs, TALENs, or CRISPR guide RNAs for a given gene sequence and predict possible off-target effects.

Laboratory Experiments:

1. Cloning a reporter gene (GFP) into expression vector
2. Synthesis of Complementary DNA (cDNA) from RNA Template
3. Release of insert using restriction digestion
4. Primer designing for PCR
5. DNA amplification by using conventional PCR
6. Purification of DNA from Agarose Gels
7. Reverse transcription PCR
8. Detection of DNA Methylation using Restriction Enzymes (HpaII and MspI)
9. miRNA Target Binding Using Synthetic Oligos
10. CRISPR cascade mediated gene silencing.

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Assignments (20%), Flipped Class (5%), Practical (30%), Internal Examinations (40%)

References:

1. Brown, T. A. (2016). *Gene cloning and DNA analysis: An introduction* (7th ed.). Wiley-Blackwell.
2. Ascher, D. (2023). *Foundations of molecular cloning*. American Academic Publisher.
3. Carlberg, C. (2024). *Gene regulation and epigenetics*. Springer Cham.
4. Hannon, G. J. (2003). *RNAi: A guide to gene silencing*. Cold Spring Harbor Laboratory Press.
5. Appasani, K. (2018). *Genome editing and engineering*. Cambridge University Press.

E-Resources:

1. NPTEL : Genetic Engineering & Applications
   https://archive.nptel.ac.in/courses/102/103/102103013/
2. NPTEL: Genome Editing and Engineering
   https://onlinecourses.nptel.ac.in/noc22_bt35/preview

	Description of CO	PO	PSO1	PSO2
CO1:	Identify and utilize different cloning vectors and expression systems for effective gene cloning and expression.	PO1(3), PO2(2)	3	2
CO2:	Demonstrate proficiency in next-generation cloning techniques and synthetic biology tools for constructing genetic circuits.	PO3(1), PO2(2)	2	3
CO3:	Evaluate epigenetic modifications and RNA interference mechanisms that regulate gene expression in biological systems.	PO1(1), PO3(2)	2	1
CO4:	Implement genome editing technologies to modify genes precisely and understand their applications in research and therapeutics.	PO3(3)	2	2

BY25103	Advanced Bioprocess Technology	L	T	P	C
		3	0	0	3

Course Objective:
To equip students with advanced theoretical and practical skills in bioprocess design, modeling, control, and innovation for sustainable industrial applications

Stoichiometric Analysis and Bioprocess Balances: Concept and significance of stoichiometric modeling in bioprocesses; Yield coefficients and biomass-substrate-product relationships; Advanced black-box stoichiometry for microbial systems, Elemental balancing: CHON analysis, Degrees of reduction and redox balance; Heat balance in aerobic and anaerobic systems; Identification and correction of gross measurement errors using reconciliation techniques, Case-based interpretation of stoichiometric constraints in recombinant and mixed cultures.

Activity: Calculate substrate-to-product conversion efficiencies using given fermentation data and balance elemental composition for a mixed culture.

Kinetic Modeling and Advanced Fermentation Strategies: Advanced kinetics of substrate consumption, biomass growth, and product synthesis; Substrate, product, and biomass inhibition models (Monod, Haldane, Levenspiel); Design and performance analysis of continuous cultures (chemostat, turbidostat, chemostat in series); Fed-batch strategies: exponential feeding, DO-stat, pH-stat methods; Cell recycling and total cell retention systems: benefits and engineering challenges; Optimization of cultivation modes based on kinetic parameters and productivity.

Activity: Using experimental growth data, fit Monod and inhibition kinetic models and predict biomass concentration under different substrate concentrations.

Modeling of Fermentation and Cellular Processes: Fundamentals of bioprocess model formulation: assumptions, scope, and limitations; Unstructured models at population level: Monod-type, logistic models; Structured models: compartmental models based on cell physiology and metabolism; Morphologically structured models (e.g., pellet vs. filamentous growth), Genetically structured models: plasmid stability, recombinant protein expression dynamics, Cybernetic models: regulation of substrate utilization and pathway prioritization.

Activity: Create and simulate a compartmental model representing different cell physiological states and analyze their impact on product formation.

Bioreactor Engineering and Process Control: Design principles of stirred tank bioreactors (CSTR): vessel geometry, material selection; Agitator and motor design: torque, shear considerations, and scale-up aspects; Power consumption in aerated systems: estimation and optimization; Sparger types and design parameters; Mixing time estimation and its impact on process performance; Oxygen mass transfer: k_La measurement and enhancement strategies; Heat removal mechanisms and reactor cooling strategies; Instrumentation and control: monitoring pH, DO, temperature, foam, and pressure.

Activity: Design a control strategy for maintaining dissolved oxygen levels in a stirred tank bioreactor and perform scale-up calculations.

Emerging Bioprocesses, Innovation & Regulatory Compliance: Recent advances in microbial and enzymatic bioprocesses: algal biorefineries, green chemicals, biosimilars, and cell-based products. Integration of bioprocess engineering with digital tools. GMP: Concepts, regulatory requirements, facility design, documentation, quality control. GLSP: Best practices in lab safety, aseptic handling, biosafety levels, waste disposal. Case studies on process development and innovation in industrial biotechnology.

Activity: Develop a checklist for GMP compliance and perform a mock audit of a bioprocess lab setup based on GLP guidelines.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%) and Internal Examinations (50%)

References:

1. Bailey, J. E., & Ollis, D. F. (2021). *Biochemical engineering fundamentals*. McGraw-Hill Education.
2. Shuler, M. L., & Kargi, F. (2017). *Bioprocess engineering: Basic concepts*. Pearson Education.
3. Nielsen, J., & Villadsen, J. (2011). *Bioreaction engineering principles*. Springer.
4. Stanbury, P. F., Hall, S. J., & Whitaker, A. (2016). *Principles of fermentation technology*. Elsevier.
5. Flickinger, M. C. (Ed.). (2010). *Encyclopedia of industrial biotechnology: Bioprocess, bioseparation, and cell technology*. Wiley.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc25_bt65/preview
2. https://onlinecourses.nptel.ac.in/noc24_bt17/preview

	Description of CO	PO	PSO1	PSO2
CO1:	Apply stoichiometric principles to analyze and balance bioprocess systems.	PO1(3), PO2(2)	2	3
CO2:	Develop and interpret kinetic models for microbial growth and product formation.	PO3(1), PO2(2)	2	2
CO3:	Design and evaluate bioreactor systems with appropriate process control strategies.	PO1(1), PO3(2)	3	2
CO4:	Understand regulatory requirements and implement best practices for bioprocess safety and compliance.	PO3(3)	1	2

BY25104	Immunotechnology	L	T	P	C
		3	0	4	5

Course Objective:
To familiarize the students to gain an insight into the immune system and to provide students with a comprehensive understanding of the technological applications of immunological principles in research, diagnostics, and therapeutics.

Overview of Immune System: Introduction to the Immune system, Various components of the immune system, Innate and adaptive immune responses, Cellular and Molecular aspects of immune system, Recognition of pathogens and activation of Toll-like receptors, Complement system.

Activity: Create a flowchart showing innate vs. adaptive immunity and key components like Toll-like receptors and complement system.

Antigen-Antibody Interactions: Antibodies: their structure, classes and function, Principles of antigen-antibody interactions: Affinity, avidity, cross-reactivity, Complete and incomplete antigen and antibody, Precipitation, immunodiffusion and agglutination reactions, agglutination inhibition, co-agglutination, Immunoelectrophoresis, Complement fixation test, Labelled antigen antibody interactions: Immunohistochemistry and Immunocytochemistry work flow, staining techniques for live cell imaging and fixed cells – common detection methods and applications.

Activity: Perform a simple agglutination test (e.g., blood typing or latex bead agglutination) and record results.

Antibody Generation and Engineering: Monoclonal and polyclonal antibodies, Hybridoma technology, Phage display technology, Antibody engineering: chimeric, humanized, and recombinant antibodies, Antibody purification and characterization, Applications of monoclonal antibodies in diagnostics and therapeutics, Bispecific antibodies, catalytic antibodies, ADCs, CDC, ADCC and Immunotoxins.

Activity: Prepare a diagram explaining hybridoma technology and steps to produce monoclonal antibodies.

Immunological Techniques : PBMC separation from the blood; Isolation of monocytes/macrophages, macrophage culture, Principle and applications of immunoassays: RIA, ELISA, ELISpot, chromium release assay, plaque-forming cell (PFC) assay, CFSE proliferation assay, Western blot, Immunofluorescence, Confocal microscopy and Flow cytometry.
Activity: Isolate PBMCs from blood using density gradient centrifugation (demonstration or virtual lab).

Development of Immunotherapeutics: Prophylactic and therapeutic Vaccines: Types of vaccine; mRNA, DNA, Cancer, Dendritic cell and recombinant vaccine, Adjuvants and their role in vaccines, Immunosuppressive drugs, Cytokine based therapies, CAR-T cell therapy, Nanotechnology in immunotherapy, Artificial Intelligence in immunotherapy.

Activity: Research and present a brief report on a recent vaccine technology (e.g., mRNA vaccine for COVID-19).

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Assignments (20%), Flipped Class (5%), Practical (30%), Internal Examinations (40%)

Laboratory Experiments:

*****1.Preparation of antigens for immunisation and Routes of immunisation in Mice (Subcutaneous, Intraperitoneal, Intravenous and Intramuscular)

*2) Methods of bleeding in Mice (Tail Vein Bleeding, Saphenous Vein Sampling, Retro-orbital Sinus Puncture and Submandibular (Facial) Vein Sampling)

3) Separation of mononuclear cells by Ficoll-Hypaque.

4) Detection of specific antigen by Western blot analysis

5) Immunoprecipitation

6) Quantitative Precipitin assay

7) Antigen & Antibody capture ELISA

8) Evaluation of Antigen by Sandwich ELISA

9) IgG Purification

10) Detection of antigen in a tissue section by Immunohistochemical staining

* Approval of IAEC is mandatory for experiments involving Live animals

References:

1. Stranford, S., Owen, J., Jones, P., & Punt, J. (2023). *Kuby's immunology.* Macmillan Learning.
2. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2021). *Cellular and molecular immunology* . Elsevier Science Health Science.
3. Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2016). *Roitt's essential immunology*. Wiley-Blackwell.
4. Williams, C. (2012). *Methods in immunology and immunochemistry.* Academic Press.
5. Hay, F. C., & Westwood, O. M. R. (2008). *Practical immunology.* Wiley-Blackwell.

E-Resources:

1. NPTEL**:** https://onlinecourses.nptel.ac.in/noc25_bt21/preview https://archive.nptel.ac.in/courses/102/105/102105083/
2. Taylor & Francis Groups: Instant Notes Immunology By P.M. Lydyard https://repository.stikesbcm.ac.id/id/eprint/168/1/books_5453_0.pdf
3. Kuby-Immunology sixth edition https://muhammad1988adeel.wordpress.com/wp-content/uploads/2011/04/kuby-immunology-6th-edition.pdf
4. Garland Science: Bios Instant Notes Immunology by Peter Lydyard https://students.aiu.edu/submissions/profiles/resources/onlineBook/e2G3G4_(BIOS%20instant%20notes)%20Peter%20M%20Lydyard_%20A%20Whelan_%20Michael%20W%20Fanger-Immunology-Garland%20Science,%20Taylor%20&%20Francis%20(2011).pdf

5. Elsevier: Immunology & Serology by Mary Louise Turgeon https://samicrobiology.wordpress.com/wp-content/uploads/2018/08/immunology-serology-in-laboratory-medicine-5e.pdf

	Description of CO	PO	PSO1	PSO2
CO1:	Describe the structure and function of the immune system and its components.	PO1(3), PO2(2)	2	3
CO2:	Explain antigen-antibody interactions and immunological assay techniques.	PO3(1), PO2(2)	2	2
CO3:	Illustrate antibody production methods and antibody engineering technologies.	PO1(1), PO3(2)	3	2
CO4:	Analyze the development and applications of immunotherapeutics and vaccines.	PO3(3)	1	2

BY25105	Plant and Animal Biotechnology	L	T	P	C
		3	0	0	3

Course Objective:

- To impart students with a comprehensive understanding of the principles, techniques, and applications of biotechnology in both plant and animal systems

Plant Tissue Culture: History of plant tissue culture; media preparation, nutrients and plant hormones; sterilization techniques; establishment of cultures, totipotency, callus culture, cell suspension culture, applications of tissue culture-micro propagation; Somatic embryogenesis; synthetic seed production; protoplast culture and somatic hybridization – applications; Cryopreservation; Plant secondary metabolites- concept and their importance.

Activity: Induce callus from a leaf explant on nutrient medium.

Genetic Modification in Plants: Gene Transfer Techniques, Agrobacterium-mediated transformation -Ti plasmid, T-DNA integration, vir genes; Direct gene transfer methods,Particle bombardment (biolistics), Electroporation, PEG-mediated uptake, Microinjection; Chloroplast transformation -advantages and process; Molecular markers - RAPD, RFLP and DNA fingerprinting-principles and applications.

Activity: Build a simple diagram/model of the Ti plasmid showing T-DNA transfer.

Animal Cell Culture: Basics of animal cell culture, media, supplements, conditions; types of animal cell lines, primary, continuous, immortalized; culture systems- monolayer, suspension, 3D culture; cryopreservation and cell line authentication; cell viability and cytotoxicity assay(MTH), applications - recombinant protein production, vaccine development**,** hybridoma technology for monoclonal antibody production.

Activity: Perform an MTT assay to check cell viability after treatment.

Genetic Engineering in Animals

Gene Transfer Methods, Physical methods, **Microinjection into pronucleus, electroporation, biolistics (gene gun);** chemical methods - **lipofection (liposome-mediated transfer), Calcium phosphate precipitation;** Biological methods**-** retroviral and lentiviral vectors, adenoviral and AAV vectors, transposon-based systems (Sleeping Beauty, PiggyBac); k**nock-in and knock-out models; s**omatic cell nuclear transfer, embryo splitting and embryo transfer.

Activity: Watch a microinjection video and draw a basic process flowchart.

Biosafety, Ethical, and Regulatory Guidelines: Containment strategies and risk assessment of GMOs, Environmental concerns and biodiversity issues, Ethical implications of cloning and transgenic animals, Regulatory frameworks - Cartagena Protocol on Biosafety; Guidelines from DBT, GEAC (India), USDA, FDA (global), intellectual property rights (IPR) in biotech innovations; Patenting of GM organisms; Case studies - Golden Rice, Onco Mouse.

Activity: Hold a short debate on cloning ethics (pro vs. con).

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (20%), Assignments (30%) and Internal Examinations (50%)

References:

1. Park, S. (2021). *Plant tissue culture: Techniques and experiments* (4th ed.). Elsevier Science.
2. Kempken, F., & Jung, C. (2010). *Genetic modification of plants: Agriculture, horticulture and forestry*. Springer.
3. Mani, S., Singh, M., & Kumar, A. (2023). *Animal cell culture: Principles and practice*. Springer.
4. Hendricks, G. (2023). *Animal biotechnology and genetic engineering*. Alexis Press.
5. Uzochukwu, S., Esiobu, N., Okoli, A. S., et al. (2022). *Biosafety and bioethics in biotechnology: Policy, advocacy, and capacity building*. CRC Press.

E-Resources:

NPTEL: Cell Culture Technologies
https://onlinecourses.nptel.ac.in/noc22_bt64/preview
NPTEL: Basics of Crop Breeding and Plant Biotechnology
https://onlinecourses.nptel.ac.in/noc25_ag01/preview
NPTEL: Animal Biotechnology
https://onlinecourses.swayam2.ac.in/cec22_bt07/preview
NPTEL : Genetic Engineering & Applications
https://archive.nptel.ac.in/courses/102/103/102103013/

	Description of CO	PO	PSO1	PSO2
CO1:	Apply plant tissue culture techniques for plant propagation.	PO1(3), PO2(2)	2	3
CO2:	Understand gene transfer methods in plants and animals.	PO3(1), PO2(2)	2	2
CO3:	Perform animal cell culture and related biotechnological applications.	PO1(1), PO3(2)	3	2
CO4:	Analyze biosafety and ethical issues in biotechnology.	PO3(3)	1	2

BY25201	Separation Processes In Biotechnology	L	T	P	C
		3	0	4	5

Course Objective:
The course provides a foundation in bioseparation processes and enabling students to apply theoretical concepts through hands-on lab learning and introducing emerging industrial-scale techniques for product recovery, purification, and formulation.

Overview Of Downstream Processing

Introduction to downstream processing principles- Range and characteristics of bioproducts and bioprocesses- Downstream Process economics-Cost cutting strategies in downstream processing industry-Cell disruption for product release – mechanical methods and non mechanical methods.

Laboratory experiments:

1. Mechanical Cell Disruption – Ultrasonication
2. Non-Mechanical Cell Disruption – Osmotic Shock or Enzymatic Lysis

Solid-Liquid Separation Strategies

Introduction - Filtration process- filtration equipment's – Rotary drum filter, plate and frame filter press and leaf filter- constant pressure and constant rate- filter medium, specific cake resistance and total filtration cycle time calculation-Centrifugation – Basic principles, classification -Industrial centrifuges – Tubular bowl, Multichamber bowl and Disc bowl centrifuge- applications.

Product Isolation Techniques

Membrane based separation process principle – Types of membrane, – Structure and characteristics of membranes – Membrane modules – Types of membrane processing - Microfiltration, ultra filtration, dialysis and Reverse osmosis – Extraction – equipment for extraction – Aqueous two-phase extraction – Reverse micellar extraction – Protein precipitation – Methods of precipitation.

Laboratory experiments:

1. Extraction of Biomolecules Using Aqueous Two-Phase Systems
2. Precipitation of Biomolecule Using Salting In/Out techniques

Product Purification Strategies

Chromatography – Classification of chromatographic techniques – General description of column chromatography – Chromatographic terms and parameters – Normal-phase, reversed-phase chromatography, size exclusion chromatography, Ion exchange chromatography, hydrophobic and Bio-affinity chromatography – HPLC- Large scale chromatography.

Laboratory experiments:

1. Separation of Proteins by Gel filtration Chromatography
2. Separation of proteins based on their net charge using anion or cation exchange resins.

Product Finishing and Formulation

Drying – Mechanism, and applications, Types of dryers – Tray, spray, rotary drum and Tunnel dryer – Freeze drying – Principle, process, applications - Crystallization – mechanism–Types of crystallizers – Tank, scrapped surface, Oslo, Circulating-magma evaporator – Case studies - Major downstream processing steps in ethanol fermentation, Citric acid manufacture, production of an intracellular enzyme, production of an antibiotic.

Laboratory experiments:

1. Freeze-Drying of Biological Samples

Course Outcomes:

Upon completion of the course, students will be able to

1. Understand the fundamental principles and economic aspects of downstream processing in the bioprocess industry.
2. Analyze the characteristics of bioproducts and select appropriate cell disruption methods for product release.
3. Apply solid-liquid separation and membrane-based techniques for effective product isolation.
4. Demonstrate proficiency in chromatography techniques for purification and evaluate process performance.
5. Evaluate product recovery, drying, and formulation strategies with reference to industrial case studies and laboratory experiments.

Reference Books:

1. Belter, P.A., E.L. Cussler and Wei-Houhu "Bioseparations – Downstream Processing for Biotechnology", Wiley India Edition, 2011.
2. Nooralabettu Krishna Prasad., "Downstream Process Technology: A New Horizon in Biotechnology", Prentice Hall India,2010.
3. Sivasankar, B. "Bioseparations: Principles and Techniques". PHI, 2006.
4. Roger H., Paul W.T., Scott R.R. and Demetri P.P., "Bioseparations Science and Engineering", Oxford University Press, 2nd Edition, 2015.
5. Raja Ghosh "Principles of Bioseparations Engineering". World Scientific, 2006

E-RESOURCES:

NPTEL: https://onlinecourses.nptel.ac.in/noc24_bt55/preview

Assessment Weightage for Continous Assesment (%):

Assessment – I	Assessment – II	Activities	Practical	Total
30	30	10	30	100

Activity during Assessment-I **:** Seminar/Quiz/ Model making
Activity during Assessment-II **:** Flipped classroom/Seminar/ Model making

CO Mapping with PO:

Course Outcome	CO Description	Programme Outcome (PO)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand the fundamental principles and economic aspects of downstream processing in the bioprocess industry.	2	1	3	2	3	2
CO2	Analyze the characteristics of bioproducts and select appropriate cell disruption methods for product release.	3	1	3	2	3	2
CO3	Apply solid-liquid separation and membrane-based techniques for effective product isolation.	3	1	3	2	3	3
CO4	Demonstrate proficiency in chromatography techniques for purification and evaluate process performance.	3	1	3	2	3	2
CO5	Evaluate product recovery, drying, and formulation strategies with reference to industrial case studies and laboratory experiments.	3	2	3	2	3	3

3 – Strong; 2 – Moderate; 1– Weak; '-' No correlation

BY25202	Computational Biology	L	T	P	C
		3	0	4	5

Course Objective:

This course provides computational methods to analyze biological data, covering algorithms, tools, and modeling relevant to modern biotechnology. Hands-on activities develop students' problem-solving and research skills.

Introduction to Computational Biology and Biological Databases

Overview of Computational Biology - Types of biological data (genomic, proteomic, transcriptomic) - Major biological databases: GenBank, PDB, UniProt, EMBL, KEGG - Data retrieval and mining techniques.

Laboratory experiments:

1. Hands-on with NCBI, UniProt, and KEGG
2. Sequence retrieval and visualization

Sequence Analysis

Sequence alignment: global (Needleman-Wunsch), local (Smith-Waterman) - BLAST and FASTA algorithms - Multiple sequence alignment (Clustal Omega, MUSCLE) - Phylogenetic tree construction and analysis.

Laboratory experiments:

1. Use of BLAST, Clustal Omega
2. Building and interpreting phylogenetic trees using MEGA or similar tools.

Structural Bioinformatics

Protein structure basics: primary to quaternary - Protein structure prediction: homology modeling, ab initio, threading – Molecular dynamics and Simulations - Tools: SWISS-MODEL, PyMOL, GROMACS.

Laboratory experiments:

1. 3D visualization and structure modelling
2. Dynamics and simulations practice using open-source tools

Computer Aided Drug Design and Machine Learning

Drug discovery process: Target identification and validation, lead optimization and validation. Analog-Based drug design (Pharmacophores and QSAR) and Structure-based drug design (Docking, De Novo Drug Design, Virtual screening). Machine learning techniques: Artificial Neural Networks (ANNs) and Hidden Markov Models (HMMs), Applications in Protein Secondary Structure Prediction and Gene Finding.

Laboratory experiments:

1. Docking practice using open-source tools
2. ANNs and HMMs tools

Systems Biology and Omics Data Analysis

Gene expression analysis and microarray/RNA-seq data - Network biology and pathway analysis - Modeling biological systems: deterministic vs stochastic - Introduction to tools: Cytoscape, STRING

Laboratory experiments:

1. RNA-seq data analysis workflow
2. Network construction and analysis

Course Outcomes:

By the end of this course, students will be able to:

1. Understand core algorithms and data structures used in computational biology
2. Apply bioinformatics tools for sequence and structural analysis
3. Analyze biological data and design computational models
4. Reproduce and evaluate computational approaches used in recent research
5. Interpret the experimental data with computational approaches

Reference Books:

1. Bourne, P. E., & Weissig, H. (Eds.). Structural bioinformatics (2nd ed.). Wiley-Blackwell, 2010.
2. Compeau, P., & Pevzner, P. Bioinformatics algorithms: An active learning approach (Vol. 1). Active Learning Publishers, 2015.
3. Klipp, E., Liebermeister, W., Wierling, C., Kowald, A., & Herwig, R. Systems biology: A textbook (2nd ed.). Wiley-VCH, 2016.
4. Lesk, A. M. Introduction to Bioinformatics (5th ed.). Oxford University Press, 2019.
5. Mount, D. W. Bioinformatics: Sequence and genome analysis (2nd ed.). Cold Spring Harbor Laboratory Press, 2021

E-RESOURCES:

1. National Programme on Technology Enhanced Learning. (n.d.). *Bioinformatics – NPTEL course by IIT Madras*. NPTEL. https://nptel.ac.in/courses/102106065

Assessment Weightage (%):

Assessment – I	Assessment – II	Activities	Practical	Total
30	30	10	30	100

Activity during Assessment-I **:** Seminar/Quiz/ Model making/Assignment
Activity during Assessment-II **:** Flipped classroom/Seminar/ Case Study

CO Mapping with PO:

COs	**CO Description**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	Understand core algorithms and data structures used in computational biology	3	2	-	-	-	-
CO 2	Apply bioinformatics tools for sequence and structural analysis	2	3	2	-	2	-
CO 3	Analyze biological data and design computational models	2	-	3	3	-	-
CO 4	Reproduce and evaluate computational approaches used in recent research	-	2	2	3	3	2
CO 5	Interpret the experimental data with computational approaches	3	3	3	3	-	1

3 – Strong; 2 – Moderate; 1– Weak; '-' No correlation

BY25203	Metabolic Engineering	L	T	P	C
		3	0	0	3

Course Objective:

The course provides a comprehensive understanding of metabolic engineering networks through analysis using Metabolic pathway synthesis, Metabolic flux analysis, Metabolic control analysis. It improves the manipulation of regulatory networks and reproduce mathematic modelling for genome scale model and their improvement by interlinking various omics data.

Introduction to Cellular Metabolism

Transport Processes – Fueling reactions – Glycolysis, fermentative pathways – TCA cycle and oxidative phosphorylation, anaplerotic pathways –Catabolism of fats, organic acids, and aminoacids – Biosynthesis of aminoacids, nucleic acids, and fatty acids – Polymerization – Growth energetics.

Regulation, Manipulation and Synthesis of Metabolic Pathway

Regulation of enzyme activity – Regulation of enzyme concentration – Regulation of metabolic networks – Regulation at the whole cell level – Metabolic pathway manipulations – Enhancement of Product yield and productivity – Extension of substrate range, product spectrum and novel products (Antibiotics, Polyketides, Vitamins) – Improvement of cellular properties – Metabolic pathway synthesis algorithm – Lysine biosynthesis.

Analysis and Methods for The Metabolic Flux

Metabolic flux map – Fluxes through the catabolic pathways in microbes– Metabolic flux analysis for determined, over-determined and under-determined systems –Sensitivity analysis – Direct flux determination from fractional label enrichment – Applications involving complete enumeration of metabolite isotopomers – Carbon metabolite balances-GC-MS for metabolic flux analysis – genome wide technologies

Genome Based Metabolic Model Development

Development of Genomic scale metabolic model, Insilico Cells: studying genotype-phenotype relationships using constraint-based models, case studies in E. coli, S.cerevisiae metabolic network reconstruction methods, optimization of metabolic network, Identification of targets for metabolic engineering; software and databases for genome scale modelling

Metabolic Control and Industrial Case Studies

Fundamental of Metabolic Control Analysis (MCA), MFA, and MPA and their application, Multisubstrate enzyme kinetics, Metabolic engineering examples for bio-fuel, bio-plastic and green chemical synthesis , Study of genome scale model in various systems for the production of green chemicals using software tools

Course Outcomes:

After successful completion, students will be able to:

1. To understand various regulation aspects of metabolic network
2. To convert cellular networks into mathematical model
3. To apply pathway synthesis and flux analysis to manipulate metabolic network
4. To understand the control analysis of various factors of regulation
5. To design genome scale network for complete enumeration of metabolic engineering

Reference Books:

1.Christiana D. Smolke, " The Metabolic Pathway Engineering Handbook Fundamentals", CRC Press Taylor & Francis Group, 2010.
2. Cortossa, S., Aon, M.A., Iglesias, A.A. and Lloyd.D., "An Introduction to Metabolic and Cellular Engineering", 2nd Edition, World Scientific Publishing Co, 2011
3. Curran, C.P., "Metabolic Processes and Energy Transfers – An Anthology of Current Thought", The Rosen Publishing group, Inc., 2006.
4. Nielsen, J., Villadsen, J. and Liden, G., "Bioreaction Engineering Principles",3rd Edition, Springer, 2011
5. Stephanopoulos, G.N., Aristidou, A.A. and Nielsen.J., "Metabolic Engineering – Principles and Methodologies", Elsevier Science, 2001.

E-RESOURCES:

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

Assessment Weightage (%):

Component	Internal Assessment I	Internal Assessment II	Activity	Total
Weightage (%)	40%	40%	20%	100%

Activity for Assessment I : Assignment/ Quiz/Project based learning
Activity for Assessment II: Seminar/ Assignment/Flipped class room

CO Mapping with PO & PSO:

COs	CO Description	PO 1	PO2	PO3	PO4	PO5	PO6
CO1	To understand various regulation aspects of metabolic network	2	-	2	-	2	3
CO2	To convert cellular networks into mathematical model	2	1	3	-	2	3
CO3	To apply pathway synthesis and flux analysis to manipulate metabolic network	3	1	3	-	2	3
CO4	To understand the control analysis of various factors of regulation	3	1	3	-	2	3
CO5	To design genome scale network for complete enumeration of metabolic engineering	3	1	3	-	2	3
OVERALL CO		2.6	0.8	2.8	-	2	3

3 – Strong; 2 – Moderate; 1 – Weak; '—' No correlation

BY25301	Bioprocess and Bioproduct Development Laboratory	L	T	P	C
		0	0	6	3

Course Objective:

To provide hands-on experience in designing, optimizing, and evaluating sustainable bioprocesses and bioproduct development using renewable resources.

Laboratory experiments:

1. Determination of specific thermal death rate constant (k_d) for *E.coli.*
2. Optimization of fermentation parameters using RSM or Taguchi method.
3. High-cell-density fermentation using *E. coli* or *Saccharomyces cerevisiae.*
4. Fermentative Production of enzymes (e.g., protease, amylase, cellulase) using renewable agro-industrial residues as substrates.
5. Microbial production of antibiotics (e.g., streptomycin, penicillin, tetracycline)
6. Anaerobic digestion of organic biomass for biogas production and estimation of biomethane yield using food waste.
7. Development of a microbial/enzymatic route for conversion of waste into biofertilizer/ biopesticide.
8. Prototype development of a functional bioproduct (e.g., biodegradable film, antimicrobial gel, or biosorbent).
9. Techno-economic analysis and life cycle assessment (LCA) of the developed bioprocess or product.
10. Biodegradation of organic compounds

Total Periods: 90

Course Outcomes:

Upon completion of the course, students will be able to

1. Optimize culture media for sustainable fermentation using statistical tools.
2. Design and conduct high-cell-density fermentation for production of target bioproducts.
3. Perform high-cell-density fermentation for bioproduct synthesis.
4. Develop value-added products from microbial or enzymatic bioprocesses.
5. Evaluate techno-economic feasibility and environmental impact of bioprocesses.

REFERENCE BOOKS:

1. Shijie Liu, “Bioprocess Engineering: Kinetics, Sustainability, and Reactor Design”, 2nd Edition, Elsevier, 2020.
2. E.M.T. El-Mansi, C.F.A. Bryce, Arnold L. Demain, and A.R. Allman, “Fermentation Microbiology and Biotechnology”, 4th Edition, CRC Press, 2019.
3. Anuradha Mishra, “Practical Manual of Biotechnology and Bioprocess Engineering”, 1st Edition, I.K. International Publishing House, 2011.
4. S. Sivasankar, “Laboratory Manual for Biotechnology and Bioprocess Engineering”, 1st Edition, New Age International Publishers, 2012.

E-RESOURCES:

https://www.youtube.com/watch?v=5eKdZ0dVCCo&t=1s
https://www.youtube.com/watch?v=6patWVyxKoo&t=1s

Weightage for continuous assessment:

Evaluation of Student's work, Observation, record	Midterm Test	Total
75%	25%	100%

CO Mapping with PO:

Course Outcome	CO Description	Programme Outcome (PO)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Optimize culture media for sustainable fermentation using statistical tools.	3	-	2	-	3	-
CO2	Design and conduct high-cell-density fermentation for production of target bioproducts.	3	-	3	-	3	2
CO3	Perform high-cell-density fermentation for bioproduct synthesis.	3	-	3	-	3	3
CO4	Develop value-added products from microbial or enzymatic bioprocesses.	3	2	3	-	3	-
CO5	Evaluate techno-economic feasibility and environmental impact of bioprocesses.	3	3	3	2	3	3

3 – Strong; 2 – Moderate; 1 – Weak; '-'No correlation

BY25001	Plant Design and Process Economics	L	T	P	C
		3	0	0	3

Course Objective:

To equip students to design the essential elements of a chemical engineering process and economics and to simulate the complete plant and analyse process performance, identify opportunities, troubleshoot problems, and recommend changes.

Introduction to Plant Design

Basic consideration in Chemical Engineering plant design, Project identification, Preliminary techno-economic feasibility. Selection of process, Factors affecting process selection, Types of flow diagrams. Hazard identification and MSDS, Safer design

Cost estimation and Profitability

Estimation of capital costs, purchased equipment costs, the total capital cost of a plant, estimation of manufacturing costs, cost of labour, utility cost, raw material costs, Investment and the time value of money, Different types of interest, Cash flow diagrams, Inflation, Annuities, Depreciation, Taxation, Profitability analysis, Net present value, The rate of return, evaluation of equipment alternatives, Alternative investment & replacement methods for profitability evaluation, Economic consideration in process and equipment design, Inventory control.

Introduction to Process Synthesis and Analysis of Reactor design

Principles and hierarchical approach to process synthesis, Basic reactor principles, Reactor synthesis for complex reactions by attainable region fundamentals, case study, general procedure for reactor design and cost estimation.

Separation Process synthesis and Design Principles of Distillation column

Introduction and selection criteria for the separation process, Distillation column sequencing for ideal liquid mixtures, Separation system structure for non-ideal mixtures using distillation, Residue curves, Distillation models of standard versus special equipment

Heat Exchanger Network Synthesis

The introduction to pinch Technology, Composite curves, Problem table method, Targets for minimum utilities, maximum energy recovery design, heat exchanger network design.

Course Outcomes:

After successful completion, students will be able to:

1. Apply the strategies used in the design of chemical processes.
2. Evaluate basic economic analysis of a chemical plant to develop cost and profit analysis
3. Design reactor synthesis
4. Design the separation process based on distillation design as case study
5. Evaluate energy utilization involving heat exchanger design

References:

1. Seider, W. D., Seader, J. D., and Lewin D. R., Process Design Principles, Wiley, New York, 1999.
2. Peters, M.S, Timmerhaus, K.D., West, R.E, Plant design and economics for chemical engineers, 5th ed., McGraw Hill, 2004.
3. Douglas, J. M., Conceptual Design of Chemical Processes, 4th Ed., McGraw Hill, New York, 1988.
4. Coker, A. K., Ludwig's Applied Process Design for Chemical and Petrochemical Plants, Vol. 1, 4th Ed., Gulf, Houston, TX, USA, 2007
5. Online reference https://onlinecourses.nptel.ac.in/noc20_ch31

Assessment Weightage (%):

Component	Internal Assessment I	Internal Assessment II	Activity	Total
Weightage (%)	40%	40%	20%	100%

Activity for Assessment I - Assignment/ Quiz
Activity for Assessment II – Seminar/ Assignment

CO Mapping with PO & PSO:

	CO Description	PO 1	PO2	PO3	PO4	PO5	PO6
CO1	Apply the strategies used in the design of chemical processes.	2	2	2	1	2	3
CO2	Evaluate basic economic analysis of a chemical plant to develop cost and profit analysis	2	2	3	1	2	3
CO3	Design reactor synthesis	3	2	3	1	2	2
CO4	Design the separation process based on distillation design as case study	3	2	3	1	2	2
CO5	Evaluate energy utilization involving heat exchanger design	3	2	3	1	2	2
OVERALL CO		2.6	2	2.8	1	2	2.4

3 – Strong; 2 – Moderate; 1 – Weak

BY25002	Food Processing Technology	L	T	P	C
		3	0	0	3

Course Objective:

To introduce the students to know different techniques used for the processing and preservation of foods with quality and control.

Food Processing

Heat Processing using steam or water (Blanching, Pasteurization) – Heat sterilization (Evaporation and distillation) – Heat processing using hot air (Dehydration, baking and roasting) – Heat processing using hot oils – Processing by the removal of heat (chilling , Freezing) – High pressure processing of foods – Pulsed electric field processing of liquids and beverages – Non-thermal processing by radiofrequency electric fields.

Food Laws and Regulations

National food legislation, other food legislations/authorities and their role- essential commodities act, 1955, standard of weight and measures act, 1976, export(quality control and inspection) act, 1963,voluntary based product certifications (ISI mark of BIS and agmark), internationalorganization and agreements-food and agricultureal organization (FAO), worldhealth organization(WHO), codex alimentarius, codex India, joint FAO/WHOexpert committee on food additives(JECFA), world trade organization(WTO),sanitary and phytosanitary measures(SPS) and technical barriers to trade(TBT),international organization for standardization(ISO)Food safety and quality management systems: general principle of foodsafety risk management, hazard analysis critical control point system (HACCP),quality management system

Fermented Foods

Overview of fermented foods,Fruit-based,Dairy-based,Fish-based, Meat-based,Tea based, production of alcoholic and non alcoholic beverages,Advantages of fermented foods Health benefits of fermented foods – Nutritive value of fermented food,Biotechnological approaches to improve nutritional quality – Microbial changes in fermented food.

Food Preservation Techniques

Spoilage of food - Microbiology of water, meat, milk, vegetables – Food poisoning – Cold preservation – Heat conservation – Ionizing radiation – High pressure – Electric field – Chemical food preservation – Combination of techniques for food preservation – Natural antioxidants – Antimicrobial enzymes.

Food Quality and Control

Analysis of food – Major ingredients present in different product – Food additives, vitamins – Analysis of heavy metal, fungal toxins, pesticide and herbicide contamination in food – Microbial safety of food products – Chemical safety of food products – Good manufacturing practice.

Course Outcomes:

Upon completion of the course, students will be able to

1. Acquire knowledge about the techniques of recent methods of food processing.
2. Familiar with the various regulations and laws related to food.
3. Understand about the fermented food with health benefits.
4. Apply the gained knowledge in combined food preservation methods.
5. Analyse the quality of ingredients and good manufacturing practice.

Referencess:

1. Fellows, P.J., "Food Processing Technology: Principles and Practice", 3rd Edition, CRC Press, 2009.
2. Pometto A, Shetty K, Paliyath G and Levin R. E., "Food Biotechnology", 2nd Edition, CRC press, 2005.
3. Hutkins R. W., "Microbiology and Technology of Fermented Foods", IFT Press series, Volume 32 of Institute of Food Technologists Series, Wiley-Blackwell, 2006.
4. **Zeuthen P and Bogh-Sorensen, L., "Food Preservation Techniques", 1st Edition, CRC Press, 2003.**
5. Adams M., Adams M. R. and Robert Nout M. J., "Fermentation and food safety", Springer, 2001.

E-RESOURCES:

1. https://onlinecourses.nptel.ac.in/noc25_ag04/preview
2. https://nptel.ac.in/courses/103107088

Assessment Weightage (%):

Assessment – I	Assessment – II	Activities	Total
40%	40%	20%	100%

Activity during Assessment - I : Seminar/Quiz/Poster presentation
Activity during Assessment - II : Model making/Flipped classroom/Seminar

CO Mapping with PO:

COs	CO Description	PO1	PO2	PO3	PO4	PO5	PO6
CO1	Acquire knowledge about the techniques of recent methods of food processing	-	2	-	-	2	-
CO2	Familiar with the various regulations and laws related to food	-	2	2	-	-	-
CO3	Understand about the fermented food with health benefits	-	-	-	-	2	2
CO4	Apply the gained knowledge in combined food preservation methods	-	-	2	-	3	-
CO5	Analyse the quality of ingredients and good manufacturing practice.	3	2	-	-	-	-

3 – Strong; 2 – Moderate; 1 – Weak; '-' No correlation

BY25003	Cancer Biology and Therapeutics	L	T	P	C
		3	0	0	3

Course Objectives:

The course aims to provide an in-depth understanding of the molecular and cellular mechanisms underlying cancer development, progression, and metastasis. It also equips students with knowledge of current diagnostic tools and therapeutic strategies, including targeted therapy, immunotherapy, and personalized medicine.

Fundamentals of Cancer Biology

Cancer: Definition, causes, properties, classification, clonal nature – Cell Cycle: Regulation of cell cycle and check points- Oncogenes and protooncogenes (Ras, Myc) – Tumor suppressor genes (p53 and Rb) – Mutation phenotypes and DNA repair defect – Cancer risk factors - Cancer risk factors – Theory of carcinogenesis – Chemical carcinogenesis – Physical carcinogenesis : X-ray radiation – Mechanisms of radiation carcinogenesis.

Molecular Mechanisms and Signaling Pathways

Growth factors signaling: EGFR, HER2, PDGF pathways - Role in proliferation and angiogenesis – Apoptosis and cell death pathways (intrinsic and extrinsic pathways, Bcl-2 family of proteins, caspases – Tumor microenvironment (Stromal cells, CAFs , ECM remodeling - Role of hypoxia and VEGF – Metastasi – Epithelial – Mesenchymal transition (EMT) – Invation, intravasation and extravasation.

Immunotherapy and Personalized Medicine

Cancer immunology: immune evasion, immune check points - Immunotherapeutic strategies : immune checkpoints inhibitors (PD-1m CTLA-4) , CAR-T cell therapy – Cancer vaccines (HPV) – Personlized Medicine: tumor profiling and pharmocogenomcis, Companion diagnosis – Case studies of personalized treatment (breast cancer, liver cancer, lung cancer)

Cancer Therapeutics

Conventional therapies – Surgery, Chemotherapy: mechanism, type (alkylating, antimetabolites) , Radiation therapy: Principels, Targeted delivery – Targeted therapies – (Monoclonal antibodies and tyrosine kinase inhibitors) - Cancer Biomarkers - Detection of Cancers - Molecular imaging techniques - Gene therapy - Nanotechnology based delivery and CRISPR/ Cas9 in cancer.

Recent Advances and Translational Oncology

Cancer stem cells: Properties and markers, role of relapse and resistance – Drug resistance mechanism : MDR, tumor heterogeneity – Clinical trials: phases of clinical trails in oncology, FDA and EMA regulatios, Ethical and regulatory affairs – Pallatative Care - **AI** in cancer diagnosis

TOTAL: 45 PERIODS

Course Outcomes:

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

1. Understand the biological characteristics, classification, and molecular basis of cancer development and progression.
2. Analyze key oncogenic signaling pathways and regulatory mechanisms involved in cell cycle control, apoptosis, angiogenesis, and metastasis.
3. Evaluate various diagnostic methods, cancer biomarkers, and imaging techniques used in the detection and monitoring of cancer.
4. Compare traditional and modern therapeutic strategies, including chemotherapy, radiation, targeted therapy, and hormonal treatment.
5. Explain the principles of immunotherapy and personalized medicine, and assess their applications in clinical oncology.

Reference Books:

1. Pelengaris, Stella . and Khan, Micheal , "The Molecular Biology of Cancer", Blackwell Publishing, 2006.
2. Ruddon, W. Raymond, "Cancer Biology", 2nd Edition, Oxford University Press, 2023
3. Weinberg, R.A., "The Biology of Cancer", 2nd Edition Taylor & Francis, Garland Science, 2014.
4. Lauren Pecorina, "Molecular Biology of Cancer: Mechanisms, Targets and Therapeutics", 8th Edition,Oxford University Press,2021.
5. Fahima Dilnawar and Ajit Kumar, Artificial Intelligence Based Cancer Nanomedicine: Diagnostics, Therapeutics and Bioethics, Bentham Science Publisher, 2022.

E- Resources:

NPTEL SWAYAM- Cancer Fundaments by Mrs. Jyotisna Govil, Indian Cancer Society.
https://youtu.be/-MiJE7hPexc

MOOC – Coursera- Introduction to Cancer Biology, Johns Hopkins University.

Assessment Weightage:

Assessment I	Assessment II	Activity	Total
40%	40%	20%	100%

Activity during Assessment I – Model making/Seminar/Poster Presentation
Activity during Assessment II – Research paper reproduction**/**Quiz/ Flipped Classroom/ Project based Learning

COs Mapping with POs

			POs			
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	-	-	-
CO2	3	3	2	2	-	-
CO3	2	2	2	2	-	**-**
CO4	2	1	1	3	1	**-**
CO5	2	1	1	2	1	-

3- Strong, 2 -Moderate, 1-Weak, - No Correlation

BY25004	Enzyme Technology and Biocatalysis	L	T	P	C
		3	0	0	3

Course Objectives:

The students can learn fundamentals of enzyme kinetics for both single substrate and multi substrate enzyme catalysed reactions, different types of inhibition and gain the knowledge about the biocatalytic reactions and application of enzymes in various industries.

Kinetics of Single Substrate Enzyme Catalysed Reactions

Progress curve and determination of reaction velocity – Henri Michaelis-Menten equation – Briggs-Haldane modification of Michaelis-Menten equation – Salient Features of Michaelis-Menten Equation - Significance of Vmax, Km and Kcat – Experimental measurement of Vmax, Km and Kcat - Linearized form of Michaelis-Menten equations (Lineweaver-Burk plot, Eadie- Hofstee plot, Hanes-Wolff plot and Eisenthal-Cornish-Bowden direct plot) - Haldane relationship for reversible reactions.

Kinetics of Multi-Substrate Enzyme Catalysed Reactions

Ping-Pong bi-bi mechanism, Random order mechanism, Compulsory order mechanism – Steady state kinetics: General rate equation of Alberty, Primary plots for reactions with mechanisms following the general rate equation – Investigation of reaction mechanisms using steady state methods: The use of primary plots - Investigation of reaction mechanisms using non-steady state methods: Isotope exchange at equilibrium – Determine velocity equations using the King-Altman method.

Reversible and Irreversible Enzyme Inhibition

Overview of enzyme inhibition, Reversible enzyme inhibition: Competitive inhibition, Uncompetitive inhibition, Non-competitive inhibition, Mixed inhibition – Irreversible inhibition: Simple irreversible inhibition, Simple irreversible inhibition in the presence of substrate, Time dependent simple irreversible inhibition

Enzyme Biocatalysis

Basics of enzyme as biocatalysts - Hydrolytic enzymes – Ester bond, Amide, Epoxides, Nitriles, Reduction reactions –aldehydes, Ketones, C=C, Oxidation reactions – Alkanes, Aromatic, Baeyer-Villiger, Enzymes in organic synthesis – esters, amide, peptide - Retrosynthetic biocatalysis - Chemoenzymatic synthesis of natural products - Biotransformation of drugs (hydroxylation of Steroids) - Catalytic antibodies – Modified and Artificial enzymes

Industrial Enzymes

Enzymes for bioenergy - Enzymes for environment – Analytical applications of enzymes - Enzymes in dairy applications – Enzymes in pulp and paper processing – Enzymes in agriculture - Enzymes in animal nutrition – Enzymes in cosmetics – Clinical applications of enzymes – Applications of enzymes in pharmaceutical industry – Enzymes in medicine - Enzymes in leather industry

Course Outcomes:

Upon completion of the course, students will be able to

1. Learn the enzyme kinetics and identify the kinetic parameters
2. Gain the knowledge about the multisubstrate enzyme catalysed reactions
3. Evaluate the different types of enzyme inhibition
4. Acquire the knowledge about the biocatalytic reactions
5. Apply the concepts to use enzymes in various industries

Weightage for Continuous Assessment:

Internal Assessment I	Internal Assessment II	Activity	Total
40%	40%	20%	100%

Activity during Internal Assessment I : Seminar/ Quiz/ Model making/ Poster Presentation

Activity during Internal Assessment II: Reproduction of research paper/Flipped Classroom/Project based Learning/Case Study

Reference s:

1. Trevor Palmer and Philip L. Bonner, Enzymes: Biochemistry, Biotechnology, Clinical Chemistry, 2nd Edition, Wood Head Publishing Ltd, 2011.
2. Robert A.Copeland,"Enzymes: A Practical Introduction to Structure, Mechanism and Data Analysis", 2nd Edition, Wiley Publishing, 2000.
3. Aljendro G. Marangoni, "Enzyme Kinetics – A Modern Approach" John Wiley & Sons, 2013.
4. Klaus Buchholz, Volker Kasche, and Uwe T. Bornscheuer, Biocatalysts and Enzyme Technology, Wiley-Blackwell, 2012.
5. Wolfgang Aehle, Enzymes in Industry: Production and Applications, 3rd Edition, Wiley-VCH, 2007.

E-RESOURCES:

1. https://archive.nptel.ac.in/courses/102/102/102102033/
2. https://onlinecourses.swayam2.ac.in/cec24_bt15/preview

CO Mapping with POs and PSOs:

COs	CO Description	PO1	PO2	PO3	PO4	PO5	PO6
CO1	Learn the enzyme kinetics and identify the kinetic parameters	3	-	2	-	3	-
CO2	Gain the knowledge about the multisubstrate enzyme catalysed reactions	2	-	3	-	2	-
CO3	Evaluate the different types of enzyme inhibition	3	-	2	-	3	-
CO4	Acquire the knowledge about the biocatalytic reactions	3	1	2	1	1	2
CO5	Apply the concepts to use enzymes in various industries	3	1	2	2	-	2

3-Strong; 2-Moderate; 1-Weak; '-' No Correlation

BY25005	Industrial Fermentation Technology	L	T	P	C
		3	0	0	3

Course Objective:

To provide a comprehensive understanding of industrial fermentation processes, from microbial strain selection to large-scale production, media optimization, and future trends in sustainable bioprocessing.

Overview of Industrial Fermentation Processes

Introduction to industrial fermentation and its commercial applications; classification of industrial fermentations (batch, fed-batch, continuous); examples of major fermentation products (alcohols, organic acids, antibiotics, enzymes); key industrial microorganisms; economic and sustainability drivers in industrial biotechnology.

Strain Selection, Improvement, And Maintenance for Industrial Use

Criteria for selecting industrial production strains; preservation and genetic stability; industrial strain development—adaptive evolution, random mutagenesis, metabolic pathway engineering; intellectual property and patenting issues in microbial strain development; examples from major biotech companies.

Media Formulation and Raw Materials for Industrial Fermentation

Principles of media formulation for large-scale microbial fermentation; essential nutrients and their role in microbial growth and product formation - carbon, nitrogen, phosphorus, trace elements, and growth factors; types of industrial media - synthetic, semi-synthetic, and complex media; cost-effective media design using agro-industrial residues and waste streams (molasses, corn steep liquor, whey, bagasse hydrolysate); influence of media composition on metabolite yield and productivity.

Production of Industrial Products

Microbial production of alcohols (ethanol, butanol), organic acids (citric, lactic, acetic), amino acids (glutamic acid, lysine), solvents, and gases – Antibiotic production (penicillin, streptomycin) – Vitamins, enzymes, and polysaccharides – Food and beverage fermentation (dairy products, soy sauce, vinegar, beer) – Single-cell protein and probiotics.

Future Aspects of Fermentation Technology

Exploration of emerging trends and next-generation approaches in fermentation technology; integration of continuous fermentation and process intensification strategies; development of sustainable and circular bioeconomy through fermentation of waste and renewable feedstocks; role of precision fermentation in producing alternative proteins, bioplastics, and high-value nutraceuticals.

REFERENCE BOOKS:

1. Peter F Stanbury, Allan Whitaker, Stephen J Hall. “Principles of Fermentation Technology” Butterworth-Heinemann Press, 2016.
2. H. J. Peppler, D. Perlman “Microbial Technology: Fermentation Technology”. Academic Press, 2014
3. T. El-Mansi, C. Bryce, Arnold L. Demain, A.R. Allman “Fermentation Microbiology and Biotechnology. 2nd Edition,CRC Press, 2006.

4. Pandey A, Lasroche C, Soccol C. R and Dussop C. G. “Advances in Fermentation technology” Asia tech publishers Inc, 2008
5. Crueger, W., & Crueger, A. “Biotechnology: A Textbook of Industrial Microbiology” 2nd Edition, Panima publisher,2005

E-RESOURCE:

NPTEL: https://onlinecourses.nptel.ac.in/noc24_bt55/preview

Assessment Weightage for Continuous Assessment (%):

Assessment – I	Assessment – II	Activities	Total
40%	40%	20%	100%

Activity during Assessment-I **:** Seminar/Quiz/ Group discussion
Activity during Assessment-II **:** Flipped classroom/Seminar/ Model making

	Description of CO	PO1	PO2	PO3	PSO1	PSO2
CO1:	Understand the fundamentals of industrial fermentation processes, including types, products, key microbes, and commercial relevance.	1	–	3	2	–
CO2:	Analyze microbial strain selection, improvement techniques, and intellectual property considerations in industrial applications.	3	1	3	3	1
CO3:	Design cost-effective and efficient media for large-scale fermentation using synthetic and agro-industrial substrates.	3	1	3	3	2
CO4:	Evaluate microbial production of commercially important bio-products such as alcohols, acids, antibiotics, enzymes, and fermented foods.	2	1	3	3	1

BY25006	Biochemical Engineering	L	T	P	C
		3	0	0	3

Course Objective:

To equip students with advanced biochemical engineering principles involving thermodynamics, transport phenomena, enzyme and cell kinetics, and reactor analysis relevant to industrial bioprocess applications.

Thermodynamics in Biochemical Systems

Concepts of biochemical thermodynamics; Standard free energy changes and equilibrium constants; Redox reactions and bioenergetics; Gibbs energy in metabolic networks; Energy coupling and thermodynamic feasibility in biochemical pathways.

Transport Phenomena in Bioprocess Systems

Molecular diffusion in biological systems; Convective and diffusive mass transfer; Heat transfer in bioreactors; Momentum transfer in fermenters and pipelines; Transport limitations in immobilized systems and porous catalysts.

Enzyme Engineering and Kinetics

Mechanisms of enzyme catalysis; Enzyme inhibition, activation and allosteric behavior; Enzyme immobilization techniques and reactor configurations; Enzyme deactivation and operational stability; Industrial applications of enzymes in bioprocessing.

Multiphase Reactors and Non-Ideal Flow

Gas-liquid, liquid-solid, and solid-liquid bioreactors; Flow patterns: RTD analysis and non-ideal mixing; Residence time distribution and its impact on conversion; Design of packed-bed, trickle bed, and airlift reactors; Scale-down strategies for complex reactors.

Process Safety, Scale-Down and Sustainability in Biochemical Engineering

Risk assessment and hazard analysis in biochemical processes; Safety considerations in high-cell density and solvent-rich fermentations; Miniaturization and high-throughput reactor analysis; Process sustainability and life cycle analysis (LCA); Biochemical process intensification and hybrid reactor systems.

Course Outcomes:

Upon completion of the course, students will be able to

1. Analyze biochemical thermodynamic properties and their role in metabolic networks.
2. Apply principles of transport phenomena in the design of biochemical processes.
3. Evaluate enzyme kinetics and design biocatalytic processes.
4. Interpret flow behavior and design multiphase reactors for bioprocesses.
5. Integrate process safety and sustainability principles in biochemical engineering.

Reference Books:

1. Bailey, J.E. and Ollis, D.F., "*Biochemical Engineering Fundamentals*", 2nd Ed., McGraw-Hill, 1986.
2. Doran, P.M., "*Bioprocess Engineering Principles*", 2nd Ed., Academic Press, 2013.

3. Nielsen, J. and Villadsen, J., *Bioreaction Engineering Principles*, 3rd Ed., Springer, 2017.
4. Shuler, M.L. and Kargi, F., "*Bioprocess Engineering: Basic Concepts"*, 3rd Ed., Pearson, 2017.
5. Flickinger, M.C. (Ed.), "*Encyclopedia of Industrial Biotechnology: Bioprocess, Bioseparation, and Cell Technology*", Wiley, 2010.

E-Resources:

1. https://archive.nptel.ac.in/courses/103/105/103105054/

Weightage for continuous assessment:

Assessment – I	Assessment – II	Activities	Total
40%	40%	20%	100%

Activity during Assessment-I **:** Quiz/Flipped classroom/Poster presentation
Activity during Assessment-II **:** Model/Research paper reproduction/Project based learning

CO Mapping with PO:

CO's	CO Description	PO1	PO2	PO3	PO4	PO5	PO6
CO1	Analyze biochemical thermodynamic properties and their role in metabolic networks.	3	-	3	-	2	-
CO2	Apply principles of transport phenomena in the design of biochemical processes.	3	-	3	2	3	-
CO3	Evaluate enzyme kinetics and design biocatalytic processes.	2	-	3	-	3	-
CO4	Interpret flow behavior and design multiphase reactors for bioprocesses.	3	-	3	2	3	2
CO5	Integrate process safety and sustainability principles in biochemical engineering.	2	2	3	3	2	3

3 – Strong; 2 – Moderate; 1 – Weak; '-'No correlation

BY25007	Bioreactor Design and Control	L	T	P	C
		3	0	0	3

Course Objective:

The course provides a comprehensive understanding of different types of Bioreactors with its configuration and dynamics of operation with insight on the principle of transport phenomena. It also discusses the scaleup and scale down of Bioreactors with geometric and dynamic similitudes.

Basic Bioreactor Concepts

Bioreactor Operation Batch operation, semi-continuous and fed-batch operation, Continuous Operation- Chemostat, turbidostat, Continuous Fermentation with Biomass Recycle, Tanks-in-series, Tubular plug flow bioreactors.

Aeration and Agitation In Bioprocess Systems

Mass transfer in agitated tanks; Flow number and Power number and calculation of power requirement for mixing: Mixing time and residence time distribution; Gas liquid transfer in cellular system, Basic mass transfer concepts of bubble formation and factors affecting bubble size. Gas hold up and interfacial area calculation, concept of overall mass transfer coefficient Kla and its methods of calculation

Selection and Design of Bioreactors

Bioreactor Geometry- Reactor, impeller, sparger and baffle design; Materials of construction for bioprocess plants - Design considerations for maintaining sterility of process. Design consideration for plant and animal cell cultures

Bioreactor Scale-up and Scale-Down

Scale-up Techniques: Scale up by geometric similitude. constant power consumption per volume, constant mixing time, constant impeller tip speed, constant volumetric mass transfer co-efficient, Scale-down Related Aspects.

Bioreactor Instrumentation and Control

Physical and chemical sensors for medium and gases, online and offline sensors for cell and medium properties, computers and interfaces, Data analysis, Process control, Advanced control for batch and continuous process control.

Course Outcomes:

After successful completion, students will be able:

1. To familiarize on the basics of bioreactor concepts
2. To provide knowledge on the aeration and agitation in bioprocess systems
3. To impart knowledge on the selection and design of bioprocess equipment
4. To impart and enhance scale up and scale down issues
5. To understand the concepts of instrumentation and control in bioreactor

References:

1. Pauline M Doran, “Bioprocess Engineering Principles”, 2nd Edition, Academic Press, 2013.
2. Michael L. Shuler, Fikret Kargi, Matthew DeLisa, “Bioprocess Engineering: Basic Concepts”, 3rd Edition, Prentice Hall International Series, 2017.
3. Hall, Stephen J., Stanbury, Peter F., Whitaker, Allan, “Principles of Fermentation Technology”, 3rd edition, Butterworth– Heinemann, 2017.
4. James E. Bailey and David F. Ollis, “Biochemical Engineering Fundamentals”, 2nd Edition, McGraw Hill Education, 2017.
5. James M. Lee, Biochemical Engineering, Prentice, 2009

E resources : https://onlinecourses.nptel.ac.in/noc22_bt19/
https://archive.nptel.ac.in/courses/102/106/102106086/
https://www.youtube.com/@MarloesPeeters

Assessment Weightage for continuous Assessment (%):

Component	Internal Assessment I	Internal Assessment II	Activity	Total
Weightage (%)	40%	40%	20%	100%

Activity for Assessment I : Assignment/ Quiz/Project based learning
Activity for Assessment II : Seminar/ Assignment/ Flipped class room

CO Mapping with PO :

	CO Description	PO 1	PO2	PO3	PO4	PO5	PO6
CO1	To familiarize on the basics of bioreactor concepts	2	-	2	-	2	3
CO2	To provide knowledge on the aeration and agitation in bioprocess systems	2	1	3	-	2	3
CO3	To impart knowledge on the selection and design of bioprocess equipment	3	1	3	-	2	3
CO4	To impart and enhance scale up and scale down issues	3	1	3	-	2	3
CO5	To understand the concepts of instrumentation and control in bioreactor	3	1	3	-	2	3
OVERALL CO		2.6	0.8	2.8	-	2	3

3 – Strong; 2 – Moderate;1 – Weak; ‘—’ No correlation

BY25008	Applied Genomics and Proteomics	L	T	P	C
		3	0	0	3

Course Objective:

To provide students with foundational knowledge and analytical skills in genomics and proteomics, focusing on their applications in biotechnology, healthcare, and systems biology.

Fundamentals and Tools of Genomics

Genome organization and annotation - Next-generation sequencing (NGS) technologies - Comparative and functional genomics - Applications in diagnostics and precision medicine

Activities

- **Seminar**: Advances in human genome projects
- **Quiz**: NGS technologies and applications
- **Flipped Classroom**: Comparative genomics case study

Transcriptomics and Functional Genomics

Transcriptome profiling: microarrays, RNA-Seq - Gene expression quantification and normalization - Gene ontology and pathway enrichment analysis - Epigenetic regulation and analysis.

Activities

- **Case Study**: RNA-Seq workflow and interpretation
- **Poster Presentation**: Gene regulation mechanisms
- **Data Interpretation Exercise**: Expression data from public databases

Proteomics Techniques and Applications

Protein structure, domains, and interactions - Mass spectrometry (MALDI-TOF, LC-MS/MS) - 2D-PAGE and protein microarrays - Quantitative proteomics and biomarker discovery.

Activities

- **Model Making**: Protein structure or proteomics workflow
- **Seminar**: Proteomics in disease biomarker discovery
- **Research Paper Reproduction**: Mass spectrometry data analysis

Systems Biology and Omics Integration

Multi-omics data integration: genomics, transcriptomics, proteomics - Pathway and network analysis - Applications in drug discovery and synthetic biology - Challenges in big data analysis in life sciences.

Activities

- **Project-Based Learning**: Multi-omics analysis using online tools
- **Group Discussion**: Systems biology in personalized medicine
- **Paper Critique**: Systems biology approaches in published studies

Course Outcomes:

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

1. Explain advanced techniques used in genomics and proteomics
2. Analyse and interpret genomic and proteomic data
3. Apply knowledge to real-world problems in biotechnology and healthcare
4. Critically evaluate research papers and current trends in the field
5. Design the schemes for large scale protein profiling

References:

1. Brown, T. A. *Genomes 4* (4th ed.). Garland Science, 2017.
2. Campbell, A. M., & Heyer, L. J. *Discovering genomics, proteomics, and bioinformatics* (2nd ed.). Pearson, 2023.
3. Liebler, D. C. *Introduction to proteomics: Tools for the new biology* (2nd ed.). Humana Press, 2021.
4. Snyder, M., & Gerstein, M. *Genomics and proteomics in systems biology*. Cambridge University Press, 2020.
5. Twyman, R. M. *Principles of proteomics* (3rd ed.). Garland Science, 2019.

E-Resources:

1. National Programme on Technology Enhanced Learning. (n.d.). *Genomics and proteomics – NPTEL course by IIT Kharagpur*. https://nptel.ac.in/courses/102105085
2. European Bioinformatics Institute. (n.d.). *Train online – EMBL-EBI training resources*. https://www.ebi.ac.uk/training/online/
3. Coursera. (n.d.). *Genomic data science specialization*. Johns Hopkins University. https://www.coursera.org/specializations/genomic-data-science
4. Khan Academy. (n.d.). *Proteins and enzymes*. https://www.khanacademy.org/science/biology/macromolecules/proteins-and-amino-acids
5. Nature Education. (n.d.). *Scitable: Genomics and proteomics resources*. https://www.nature.com/scitable/

Assessment Weightage:

1. ***Internal Assessment-1 (40%):*** Covering Modules 1-2.
2. ***Internal Assessment-2 (40%):*** Covering Modules 3-4.
3. ***Activities-I (10%):*** Seminar/ Quiz/ Flipped Classroom/ Case Study/Poster Presentation/ Data Interpretation Exercise.
4. ***Activities-II (10%):*** Model Making/ Seminar/ Research Paper Reproduction/ Project-Based Learning/ Group Discussion/ Paper Critique.

CO MAPPING WITH PO:

	CO Description	**PO Mapping**
CO 1	Explain advanced techniques used in genomics and proteomics	PO1(3) PO2(2)
CO 2	Analyse and interpret genomic and proteomic data	PO1(2) PO2(3) PO3(2) PO5(2)
CO 3	Apply knowledge to real-world problems in biotechnology and healthcare	PO2(2) PO3(3) PO4(3)
CO 4	Critically evaluate research papers and current trends in the field	PO2(2) PO3(2) PO4(3) PO5(3) PO6(2)
CO 5	Design the schemes for large scale protein profiling	PO1(2) PO2(2) PO3(1) PO4(2) PO5(3) PO6(3)

3 – Strong; 2 – Moderate; 1 – Weak

BY25009	Bioprocess Modelling and Optimization	L	T	P	C
		3	0	0	3

Course Objective:

The course provides a comprehensive understanding of different types of modelling of bioreactors with its dynamics and kinetics of cellular growth with mass tranfer limitations. It discuss the applications of linear system analysis and advanced modelling techniques for bioprocess optimisation.

Modeling of Biological Systems

Modeling Principles, model development from first principles. Modeling approaches for Biological systems – structured and unstructured systems; Compartment models; Deterministic and stochastic approaches for modeling structured systems

Modelling of Diffusion Systems (Biofilm And Immobilized Enzyme Systems)

External mass transfer, Internal diffusion and reaction within biocatalysts, derivation of finite model for diffusion-reaction systems, dimensionless parameters from diffusion-reaction models,the effectiveness factor concept, case studies; oxygen diffusion effects in a biofilm, biofilm nitrification.

Modeling Bioreactor

Bioreactor modelling: Ideal and non-ideal bioreactors; Stirred tank models; characterization of mass and energy transfer distributions in stirred tanks, Tower Reactor Model; Flow modeling, bubble column flow models, mass transfer modeling, structured models for mass transfer in tower reactors, process models in tower reactors, airlift models

Linear System Analysis

Study of linear systems, linearization of non-linear systems; Simulation of linear models using MATLAB; Parameter estimation and sensitivity analysis; Steady state and unsteady state systems; stability analysis; Case study of recombinant protein production

Hybrid And Other Modeling Techniques

Advanced modeling techniques such as fuzzy logic, neural network, hybrid systems and fuzzy logic systems; case studies

Course Outcomes:

After successful completion, students will be able to:

1. Understand the modelling of biological systems and bioreactors
2. Design new models for biological systems, biofilm and immobilized enzyme systems.
3. Carry out simulation of models using software (MATLAB).
4. Analyze the simulation studies and stability and sensitivity of the system.
5. Apply advanced modelling techniques

References:

1. Michael L. Shuler, Fikret Kargi, Matthew DeLisa, “Bioprocess Engineering: Basic Concepts”, 3rd Edition, Prentice Hall International Series, 2017.
2. James E. Bailey and David F. Ollis, “Biochemical Engineering Fundamentals”, 2nd Edition, McGraw Hill Education, 2017.
3. Dr. Irving J. Dunn, Professor Dr. Elmar Heinzle, Dr. John Ingham, Dr. Jiří E. Přenosil, Biological Reaction Engineering, Dynamic Modelling Fundamentals with simulation Examples, Wiley-VCH Verlag GmbH & Co, 2003
4. B. Wayne Bequette, “Process Dynamics: Modelling, Analysis and Simulation”, Prentice-Hall, 1998.
5. Said S.E.H. Elnashaie, Parag Garhyan, “Conservation Equations and Modelling of Chemical and Biochemical Processes”, Marcel Dekker, 2003.

E resources : https://onlinecourses.nptel.ac.in/noc22_bt19/
https://archive.nptel.ac.in/courses/102/106/102106086/
https://www.youtube.com/@MarloesPeeters

Assessment Weightage (%):

Component	Internal Assessment I	Internal Assessment II	Activity	Total
Weightage (%)	40%	40%	20%	100%

Activity for Assessment I - Assignment/ Quiz
Activity for Assessment II – Seminar/ Assignment

CO Mapping with PO & PSO:

	CO Description	PO 1	PO2	PO3	PO4	PO5	PO6
CO1	Understand the modelling of biological systems and bioreactors	2	-	2	-	2	3
CO2	Design new models for biological systems, biofilm and immobilized enzyme systems.	2	1	3	-	2	3
CO3	Carry out simulation of models using software (MATLAB).	3	1	3	-	2	3
CO4	Analyze the simulation studies and stability and sensitivity of the system.	3	1	3	-	2	3
CO5	Apply advanced modelling techniques	3	1	3	-	2	3
OVER ALL CO		2.6	0.8	2.8	-	2	3

3 – Strong; 2 – Moderate; 1 – Weak

BY25010	Renewable Energy and Green Technology	L	T	P	C
		3	0	0	3

Course Objective:

To impart knowledge on renewable energy sources and green technologies for sustainable energy solutions.

Fundamentals of Energy and Sustainable Development

Global and Indian energy scenario – Energy demand and supply – Conventional and non-conventional sources – Environmental impacts of fossil fuels – Principles of energy conservation and energy efficiency – Sustainability indicators – Carbon footprint and climate change – Policies and international agreements related to renewable energy.

Solar Energy Systems

Solar radiation and its measurement – Solar geometry and estimation – Photovoltaic principles and materials – Solar cell characteristics and performance – PV system components and design – Solar thermal collectors and applications – Solar water heaters and solar cookers – Solar concentrators and CSP technologies – Emerging solar technologies.

Wind, Hydro, and Marine Energy Technologies

Wind characteristics and resource assessment – Aerodynamics of wind turbines – Types of wind energy systems – Wind farm design and economics – Hydropower classification and components – Small hydro systems – Ocean energy resources – Tidal energy, wave energy, and OTEC – Site selection and system limitations.

Biomass and Bioenergy Conversion

Biomass types and availability – Biochemical conversion: anaerobic digestion, fermentation – Thermochemical conversion: combustion, gasification, pyrolysis – Biogas plants and applications – Bioethanol and biodiesel production – Algal biofuels – Biomass gasifiers – Integrated biorefineries – Role of bioenergy in rural development.

Green Technologies and Future Energy Systems

Green building design and rating systems – Smart grid technologies – Electric vehicles and charging infrastructure – Energy storage systems: batteries, flywheels, supercapacitors – Hydrogen energy and fuel cells – Life cycle assessment of energy systems – Carbon credit mechanisms – Renewable energy policy and incentives – Future trends in green energy.

Course Outcomes:

Upon completion of the course, students will be able to

1. Understand the global energy scenario and the need for renewable energy alternatives.
2. Study the principles and applications of solar, wind, hydro, and ocean energy systems.
3. Explore bioenergy sources and technologies for biofuel production and waste-to-energy conversion.
4. Examine energy efficiency practices and green building technologies.
5. Analyze energy storage systems, smart grids, and policies supporting green energy adoption.

REFERENCES:

1. B.H. Khan, "Non-Conventional Energy Resources" 3rd Edition, McGraw Hill Education, 2017.
2. S.P. Sukhatme & J.K. Nayak "Solar Energy: Principles of Thermal Collection and Storage" 3rd Edition, Tata McGraw Hill, 2017.
3. Godfrey Boyle "Renewable Energy: Power for a Sustainable Future" 4th Edition, Oxford University Press, 2016.
4. D. Yogi Goswami & Frank Kreith "Energy Efficiency and Renewable Energy Handbook" 2nd Edition, CRC Press, 2015.
5. S.C. Bhatia "Green and Clean Technology: Innovations and Applications" 1st Edition, Woodhead Publishing, 2013.

E-Resources (eBooks / NPTEL / MOOCs)

NPTEL: https://onlinecourses.nptel.ac.in/noc22_hs43/preview

https://www.coursera.org/learn/renewable-energy-entrepreneurship

Assessment Weightage (%):

Assessment – I	Assessment – II	Activities	Total
40	40	10	100

Activity during Assessment-I **:** Seminar/Quiz// Group discussion
Activity during Assessment-II **:** Flipped classroom/Seminar

CO Mapping with PO:

Course Outcome	CO Description	Programme Outcome (PO)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand the global energy scenario and the need for renewable energy alternatives.	2	1	3	2	1	1
CO2	Study the principles and applications of solar, wind, hydro, and ocean energy systems.	1	1	3	2	1	1
CO3	Explore bioenergy sources and technologies for biofuel production and waste-to-energy conversion.	1	1	3	3	3	3
CO4	Examine energy efficiency practices and green building technologies	2	1	3	3	1	1
CO5	Analyze energy storage systems, smart grids, and policies supporting green energy adoption.	3	3	3	2	1	1

3 – Strong; 2 – Moderate; 1– Weak; '-' No correlation

BY25011	Synthetic Biology	L	T	P	C
		3	0	0	3

Course Objective:

This course introduces students to the foundational principles and tools of synthetic biology. It covers gene circuit design, genome engineering, minimal cells, standard biological parts and applications in medicine, energy and the environment.

Biological Components/Circuits

History, scope, development and major milestones of Synthetic biology – Principles of artificial gene synthesis, promoters, ribosomal binding sites (RBS), coding sequences and terminators – Logical operators – Repressilator, Toggle-switch, Mammalian tunable synthetic oscillator, coupled bacterial oscillator, Bacterial tunable synthetic oscillator, globally coupled bacterial oscillator.

Numerical Methods for Systems Analysis & Design

Fundamental on the theoretical and computational modelling of replicating systems – Bioinformatic analysis and characterisation of genes and biomolecules – Mathematical model of processes for metabolic pathways and genetic regulatory circuits – Parameter estimation in biochemical pathways, optimal experimental design, dynamic optimization of biosystems.

Fabrication of Genetic Systems

Introduction to Bio Bricks and standardization, assembly methods, induction and addition of measurable element, (Eg.GFP) to an existing natural biological circuit – overview and scope of Geno CAD – Clotho framework.

Case Studies In Engineered Systems

RNA-based regulatory system for independent control of transcription activities of multiple targets – Applications of Engineered Synthetic Ecosystems, pT181 antisense-RNA-mediated transcription attenuation mechanism and applications.

Applications, Biosafety, Biosecurity & IP

Recent Applications of Synthetic Biology, Quorum sensing and RNA riboswitches as a tool iGEM competitions – Gene therapies. Metabolic engineering – products, CAD of new pathways and multi-objective optimization – Bioproduction of chemicals, fuels, and pharmaceuticals – Biosecurity and biocontainment, Ethical, Legal, and Social Implications of Synthetic Biology – Public perception and acceptance of synthetic biology – Regulatory frameworks and ethical considerations & Intellectual property and patent issues.

Course Outcomes:

Upon completion of the course, students will be able to

1. Understand the engineering principles applied to biology.
2. Know the DNA assembly methods, gene circuit design, and biosystems modelling.
3. Analyze and design synthetic gene circuits using software tools.
4. Critically analyze the results and generate testable hypotheses for synthetic biology experiments.
5. Explore ethical, societal, and safety issues in synthetic biology.

Reference Books:

1. Jeffrey Carl Braman, “Synthetic Biology-Methods and Protocols”, 2nd Edition, Humana Press, 2024.
2. Vijai Singh, “New Frontiers and Applications of Synthetic Biology”, 1st Edition, Elsevier, 2022.

3. Daniel G Gibson, Clyde A Hutchison III, Hamilton O Smith and J Craig Ventor, “Synthetic Biology-Tool for Engineering Biological Systems”, CSH Press, 2017.
4. Huimin Zhao, “Synthetic Biology: Tools and Applications”, 1st Edition, Academic Press, 2013.
5. Paul Simon Freemont & Richard I. Kitney, “Synthetic Biology: A Primer”, 1st Edition, Imperial College Press,2012.

E-Resources:

NPTEL:
Introduction to Synthetic Biology:
https://nptel.ac.in/courses/102106102
Synthetic Biology by Braulio Ferreira de Souza Dias
https://www.cbd.int/ts/cbd-ts-82-en.pdf
Syntetic Biology: Parts, Devices and Applications by Christina Smolke
http://ndl.ethernet.edu.et/bitstream/123456789/76689/1/Christina%20Smoike_2018.pdf

Weightage for continuous assessment:

Assessment – I	Assessment – II	Activities	Total
40%	40%	20%	100%

Activity during Assessment-I **:** Seminar/Quiz/Poster presentation
Activity during Assessment-II **:** Model making/Flipped classroom/Seminar

CO Mapping with PO:

CO’s	CO Description	PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand the engineering principles applied to biology.	2	-	2	-	-	2
CO2	Know the DNA assembly methods, gene circuit design, and biosystems modelling.	2	-	2	2	-	3
CO3	Analyze and design synthetic gene circuits using software tools.	3	-	-	3	-	3
CO4	Critically analyze the results and generate testable hypotheses for synthetic biology experiments.	3	-	-	3	-	3
CO5	Explore ethical, societal, and safety issues in synthetic biology.	3	-	-	3	-	3

3 – Strong; 2 – Moderate; 1 – Weak; ‘—‘ No correlation

BY25012	Advances in Environmental Biotechnology	L	T	P	C
		3	1	0	3

Course Objectives:

To impart advanced knowledge of microbial processes and remediation of environmental pollutants, to develop the ability to analyse and design biological treatment systems using sustainable technologies.

Environmental Microbial Ecology and Bioremediation Fundamentals

Soil Microbial Diversity, Ecological Adaptations & Microbial Interactions, microbial symbiosis. Microbial Roles in Biogeochemical Cycles. Mechanisms of Biodegradation, xenobiotic degradation; Bioremediation Technologies, Bioaugmentation, Biosorption, Bioleaching – principles, advancements, and applications. Bioreactors for Bioremediation: Metabolic and Genetic Pathways for Pollutant Degradation: Case studies on hydrocarbons, pesticides, dyes, and heavy metals.

Pollution Control, Monitoring, and Wastewater Treatment Technologies

Environmental Monitoring & Assessment: Molecular and sensor-based methods for air, water, and soil pollution monitoring. Sampling and Analytical Techniques: Advanced biological, chemical, and physical tools (GC-MS, biosensors, qPCR). Air Pollution Mitigation: Biofilters, bio scrubbers, bio chimneys, and genetically engineered microbial systems. Modern Wastewater Treatment: Aerobic Systems: Activated sludge, membrane bioreactors (MBRs), sequencing batch reactors (SBRs), aerobic granular sludge. Anaerobic Systems: UASB, anaerobic digestion, microbial community management.

Industrial Waste Management and Resource Recovery

Biotreatment of Industrial Effluents: Wastewater from Dairy, Pulp & Paper, Textile, Tannery, Pharmaceuticals, Hospitals. Hazardous & Toxic Waste Management: Management of heavy metals, persistent organic pollutants. E-waste and Radioactive Waste: Microbial metal recovery, biosorption, and safety regulations. Resource Recovery & Circular Bioeconomy: Recovery of nutrients, bioenergy, biopolymers from industrial waste.

Molecular and Nano-biotechnological Tools in Environmental Management

Recombinant DNA Technology in Waste Management: Design of genetically modified microbes for enhanced degradation. Genetic and Biosensing Tools: Environmental genetic sensors and biosensors, real-time pollutant detection using synthetic biology tools. Metagenomics and Microbiome Engineering, Bioprospecting, Nano-adsorbents, nano-catalysts, Environmental risk assessment of nanomaterials. Phytoremediation and Rhizoremediation: Use of transgenic and native plants; plant-microbe synergy for metal and organic pollutant removal.

Bioenergy, Biorefineries and Sustainable Environmental Biotechnology

Alternative & Renewable Energy Sources: Algae-based fuels, hydrogen economy, microbial fuel cells (MFCs). Microbial and Enzymatic Conversion: Biomass to bioethanol, biobutanol, biodiesel, and biogas. Biorefinery Concepts: Integrated processing for simultaneous production of fuels, chemicals, and fertilizers. Bio composting & Vermiculture: Microbial succession and optimization techniques. Biofertilizers & Organic Farming: Energy Management & Environmental Safety: Energy audits, carbon footprint estimation, and regulatory standards.

Course Outcomes:

Upon completion of the course, students will be able to

1. Explain advanced bioremediation technologies and their molecular underpinnings.
2. Analyse environmental pollutants and propose modern control and monitoring methods.
3. Design eco-friendly solutions for industrial and hazardous waste treatment.
4. Apply molecular and nano-biotechnological tools in environmental monitoring and restoration.
5. Develop sustainable bioenergy systems and understand their integration in circular economy models.

Weightage for Continuous Assessment:

Internal Assessment I	Internal Assessment II	Activity	Total
40%	**40%**	**20%**	**100%**

Activity during Internal Assessment I: Seminar/ Quiz/ Model making/ Poster Presentation
Activity during Internal Assessment II: Reproduction of research paper/Flipped Classroom/Project based Learning/Seminar

REFERENCE BOOKS:

1. Vivek Kumar & Manoj Kumar, *Microbial Biotechnology for Sustainable Development*, Springer, 2021.
2. Bruce E. Rittmann and Perry McCarty, *Environmental Biotechnology*, 2nd Ed., McGraw-Hill, 2020.
3. Young-Cheol Chang, *Microbial Biodegradation of Xenobiotic Compounds*, Taylor & Francis, 2021.
4. Franklin Burton and H. David Stensel, *Wastewater Engineering: Treatment and Reuse*, McGraw-Hill, 2017.
5. Garima Kaushik, *Applied Environmental Biotechnology: Present Scenario and Future Trends*, Springer, 2015.
6. Shree Nath Singh (Ed), *Microbial Degradation of Xenobiotics*, Springer, 2012.

E-RESOURCES:

1. https://archive.nptel.ac.in/courses/102/105/102105088/
2. **https://archive.nptel.ac.in/courses/127/105/127105018/**

CO Mapping with POs:

COs	CO Description	Programme Outcome (PO)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Explain advanced bioremediation technologies and their molecular underpinnings.	-	3	2	2	-	1
CO2	Analyse environmental pollutants and propose modern control and monitoring methods.	2	3	2	1	1	2
CO3	Design eco-friendly solutions for industrial and hazardous waste treatment.	-	3	-	2	-	-
CO4	Apply molecular and nano-biotechnological tools in environmental monitoring and restoration	2	3	2	2	2	2
CO5	Develop sustainable bioenergy systems and understand their integration in circular economy models.	-	3	-	-	-	-
	OVERALL CO	2	3	2	2	2	2

Strong: 3; Moderate: 2; Weak: 1; '-' No Correlation

BY25013	Biophamaceuticals and Biosimilars	L	T	P	C
		3	0	0	3

Course Objectives:

The course aims to impart in-depth knowledge on the development, physicochemical and pharmacological properties, and regulatory preparation of biopharmaceutical drugs. It also focuses on advancements in drug delivery systems, biosimilars, and their clinical applications in modern therapeutics.

Drug and Discovery

Drug sources – Discovery and Development phases – Drugs and Cosmetics Act and regulatoryaspects – Role of patents in the drug industry – Biopharmaceutical classification system – Drug Target – Drug metabolism – Pharmacokinetics – Pharmacodynamics – Bioavailability – Bioequivalence – Toxicity studies – Pharmacogenomics.

Dosage Forms

Classification of dosage forms – Excipients – Formulation – Tablets, Capsules, Emulsion, Suspension, Lotion, Liniments, Ointments, Cream, Paste, Suppositories, Parenterals – Pressurized dosage forms – Packaging techniques.

.

Advanced Drug Delivery Systems

Controlled release dosage forms – Rationale – Principle and factor influencing – Design and Fabrication – Microencapsulation – Liposomes – Niosomes – Transdermal drug delivery – Ocular, Vaginal and Uterine controlled release**.**

Biosimilars

Biosimilar medicine – Importance – INN nomenclature system – Key trends in biosimilar productdevelopment – Production of biosimilar products – Difficulties with biosimilar drugs – Non clinicaland clinical study – Regulation and approval process – Future prospects.

Case Studies on Biopharmaceuticals

Erythropoietin – Insulin – Somatotropin – Interleukin – Interferon – GMCSF – Blood clotting Factors– Tissue plasminogen activator – Monoclonal antibodies and engineered antibodies.

Course Outcomes:

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

1. Understand the regulatory processes and legal requirements for drug development and approval.
2. Explain the formulation and therapeutic applications of current biopharmaceutical products.
3. Analyze emerging trends and technologies in pharmaceutical biotechnology.
4. Describe the development, regulation, and future potential of biosimilars.
5. Evaluate pharmaceutical parameters critical to the quality and commercialization of biotech products.

Reference Books:

1. Crommelin Dwan J.A., Robert D. Sindelar and Bernd Meibohm, “Pharmaceutical Biotechnology: Fundamentals and application”, Springer, 4th Edition, 2013.
2. Gary Walsh, “Pharmaceutical Biotechnology-Concepts and Application”, John Wiley and Sons Publishers, 1st Edition, 2007.
3. Loyd V. Allen, Jr.. Nicholas G. Popovich, Howard C. Ansel, “ Ansel’s Pharmaceutical dosage forms and Drug Delivery, Lippincott Willams and Wilkins, 9th Edition, 2011.
4. Hiten J. Gutka , Harry Yang and Shefali Kakar,” Biosimilars Regulatory, Clinical, and Biopharmaceutical Development” Springer, 2018,
5. Shein-Chung Chow, “Biosimilars: Design and Analysis of Follow-on Biologics”, CRC 50 Press, 3rd Edition, 2013.

E- Resources:

NPTEl :Spectroscopic Techniques for Pharmaceutical and Biopharmaceutical Industries by Dr. Shashank Deep, IIT Delhi
https://youtu.be/zVDMgoffmC0

Assessment Weightage:

Assessment I	Assessment II	Activity	Total
40%	40%	20%	100%

Activity during Assessment I – Model making/Seminar/Poster Presentation
Activity during Assessment II – Research paper reproduction**/**Quiz/ Flipped Classroom/ Project based Learning

CO Mapping with POs:

COs/POs			POs			
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	-	-	-
CO2	2	2	2	2		
CO3	3	-	1	-	3	**1**
CO4	3	3	1	3	3	**1**
CO5	2	2	2	2	2	2

3- Strong, 2 -Moderate, 1-Weak, - No Correlation

BY25014	Cell Culture Technologies	L	T	P	C
		3	0	0	3

Course Objective:

To provide students with in-depth knowledge of cell culture techniques and equip them with the skills necessary for applying cell culture in biotechnology

Fundamentals of Cell Culture

History and development of cell culture technology; differences between *in vivo* and *in vitro* systems; types of cell cultures - primary, secondary, continuous; laboratory setup, equipment, biosafety levels, and sterilization; culture media: components, preparation, and types (natural and synthetic); serum vs serum-free media; supplements and growth factors.

Animal Cell Culture Techniques

Isolation and establishment of primary cultures; Sub-culturing, passaging, and maintenance of cell lines; anchorage-dependent vs suspension cultures; cell line authentication and contamination control; cryopreservation and revival of cell lines; applications in vaccine production, cancer biology, and regenerative medicine, Bioreactor design for large-scale animal cell culture

Plant Cell and Tissue Culture

Totipotency and principles of plant tissue culture; callus culture, suspension culture, and organogenesis; micro propagation and somatic embryogenesis; hairy root cultures and secondary metabolite production; Agrobacterium-mediated transformation and bioreactor-based plant cell cultures; Isolation and culture of protoplasts; Somatic hybridization and cybrid formation; techniques for seedless fruit generation

Advanced Applications of Cell Culture

3D cell culture, organoids, and organ-on-a-chip systems; stem cell culture and differentiation protocols; cell-based assays for drug screening and cytotoxicity testing; cell culture in biopharmaceutical production (monoclonal antibodies, recombinant proteins); tissue engineering scaffolds and cell-matrix interactions; induced pluripotent stem cells; 3D bio printing in cell culture bioinks and scaffold materials, applications in tissue engineering and personalized medicine

Ethical and Safety Regulations for Cell Culture

Ethical Issues in Cell Culture - ethical sourcing and use of human and animal cells, stem cell research ethics (ESCs, iPSCs), 3Rs principle (Replacement, Reduction, Refinement) in animal cell use, consent, confidentiality, and rights in human tissue culture; regulatory frameworks - national and international guidelines and standards (WHO, ICMR, FDA, NIH), Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP), quality assurance and documentation for cell-based products.

COURSE OUTCOMES:

After completing the course, students will be able to

1. Apply cell culture techniques effectively in research and practical applications
2. Execute basic techniques for cultivating and maintaining animal cells in vitro
3. Utilize knowledge of epigenetic regulation to interpret gene expression patterns
4. Analyze the role of cell culture in biopharmaceutical production and tissue engineering.
5. Implement regulatory guidelines in cell culture practices.

Assessment Weightage (%) for Continuous Assessment:

Assessment – I	Assessment – II	Activities	Total
40%	40%	20%	100%

Activity during Assessment-I **:** Seminar/Quiz/Poster presentation
Activity during Assessment-II **:** Model making/Flipped classroom/Seminar

REFERENCE BOOKS:

1. Michael Aschner, Cristina Sunol, Anna K. Bal-Price. Cell Culture Techniques, Humana Press Inc., 2011

2. R. Ian Freshney, Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, (8th Edition), Wiley-Blackwell, 2021

3. *B. Homenick,* Plant Cell and Tissue Culture: A Tool in Biotechnology*, CRC Press (Springer), 2023*

4. Xianquan Zhan, Cell Culture: Advanced Technology and Applications in Medical and Life Sciences, IntechOpen publisher, 2022

5. G. Stacey, A. Doyle, P. Hambleton, Safety in Cell and Tissue Culture, Springer Dordrecht, 2012.

E-RESOURCES:

1. **NPTEL: Cell culture technologies**
   https://onlinecourses.nptel.ac.in/noc22_bt64/preview
2. https://archive.nptel.ac.in/courses/102/104/102104059/
3. **Visvesvaraya Technological University (VTU) - Cell culture technologies**
   https://online.vtu.ac.in/course-details/Cell-Culture-Technologies

CO Mapping with PO:

COs	CO Description	PO1	PO2	PO3	PO4	PO5	PO6
CO1	Apply cell culture techniques effectively in research and practical applications	3	3	-	2	3	2
CO2	Execute basic techniques for cultivating and maintaining animal cells invitro	2	3	-	-	3	2
CO3	Utilize knowledge of epigenetic regulation to interpret gene expression patterns	-	2	3	1	-	-
CO4	Analyze the role of cell culture in biopharmaceutical production and tissue engineering	2	2	2	3	3	1
CO5	Implement regulatory guidelines in cell culture practices	-	2	-	1	3	3

3 – Strong; 2 – Moderate; 1 – Weak; '-' No correlation

BY25015	Nanobiotechnology	L	T	P	C
		3	0	0	3

Course Objectives:

This course provides to learn the basics of nanomaterials, synthesis of nanomaterials using biological approaches and gain the knowledge about the DNA based nanomaterials, Protein based nanomaterials and their applications

Nanomaterials and Nanoscale Processes

Types of Nanomaterials (Quantum dots, Nanoparticles, Nanocrystals, Dendrimers, Polymeric nanoparticles, Buckyballs, Nanotubes) - Natural nanomaterials – Physicochemical properties of nanomaterials – Synthesis of nanomaterials using Top down and Bottom up approaches - Separation and Purification of nanomaterials and characterization of nanomaterials.

Synthesis of Nanomaterials Using Biological Approaches

Synthesis of Nanoparticles by Bacteria - Synthesis of Nanoparticles by viruses - Synthesis of Nanoparticles by Algae - Synthesis of Nanoparticles by fungai - Synthesis of Nanoparticles by yeast – Phytosynthesis of Nanomaterials - Synthesis of Nanoparticles by marine algae

Protein-Based Nanotechnology

Overview of protein nanotechnology – Nanotechnology with S-Layer protein – Engineered nanopores – Bacteriorhodopsin and its potential – Protein assisted synthesis of metal nanoparticles – Synthesis of protein-based nanoparticles – Protein nanopaticle-hybrids – Covalent and non-covalent protein nanoparticle conjugates – Protein-carbon nanotube conjugates.

DNA-Based Nanotechnology

DNA-based nanostructures – Biomimetic fabrication of DNA based metallic nanowires and networks – Self assembling DNA structures – DNA-nanoparticle conjugates – DNA-carbon nanotube conjugates – DNA templated electronics – DNA nanostructures for mechanics and computing – DNA nanomachine.

Applications of Nanotechnology

Applications of Inorganic Nanoparticles for Biotechnology: Magnetic nanoparticles for targeted therapies/delivery, gold nanoparticles for biosensors, quantum dots for biological imaging – Carbon nanotubes for imaging and cancer treatment – Applications of organic nanoparticles in nucleic acid delivery, Liposomes as biomimetic cell membranes – Nanoparticles for therapy: Hyperthermia using Inorganic nanoparticles, Nanosystems for drug delivery.

Course Outcomes:

Upon completion of the course, students will be able to

1. Learn about the nanomaterials, nanoscale process and characterization techniques
2. Gain the knowledge about the synthesis of nanomaterials using biological approaches
3. Develop the protein based nanomaterials and bionanohybrids
4. Design the DNA based nanomaterials and DNA templated electronics

5. Apply the concepts to use nanomaterials in imaging, drug delivery and treatment

Weightage for Continuous Assessment:

Internal Assessment I	Internal Assessment II	Activity	Total
40%	**40%**	**20%**	**100%**

Activity during Internal Assessment I : Seminar/ Quiz/ Model making/ Poster Presentation

Activity during Internal Assessment II: Reproduction of research paper/Flipped Classroom/Project based Learning/Case Study

REFERENCE BOOKS:

1. Niemeyer, C.M. and Mirkin, C.A., "Nanobiotechnology: Concepts, Applications and Perspectives", Wiley- VCH, 2006.
2. Jesus M. de la Fuente and Grazu, V., "Nanobiotechnology: Inorganic Nanoparticles Vs Organic Nanoparticles" Elsevier, 2012.
3. Zhypargul Abdullaeva, 'Synthesis of Nanoparticles and Nanomaterials: Biological Approaches' Springer, 2017.
4. Young-Chul Lee and Ju-Young Moon, "Introduction to Bionanotechnology, Springer, 2020
5. Shoseyov, O. and Levy I., "Nanobiotechnology: Bioinspired Devices and Materials of the Future", Humana Press, 2008.

E-RESOURCES:

1. https://archive.nptel.ac.in/courses/118/107/118107015/
2. https://nptel.ac.in/courses/102107557

CO Mapping with POs:

COs	CO Description	PO1	PO2	PO3	PO4	PO5	PO6
CO1	Learn about the nanomaterials, nanoscale process and characterization techniques	1	1	2	-	2	-
CO2	Gain the knowledge about the synthesis of nanomaterials using biological approaches	3	1	3	2	2	1
CO3	Develop the protein based nanomaterials and bionanohybrids	3	-	2	1	3	1
CO4	Design the DNA based nanomaterials and DNA templated electronics	2	-	2	1	2	2
CO5	Apply the concepts to use nanomaterials in imaging, drug delivery and treatment	3	1	2	2	2	2

3-Strong; 2-Moderate; 1-Weak; '-' No Correlation

BY25016	Biosensors and Diagnostic Applications	L	T	P	C
		3	0	0	3

Course Objective:

This course provides comprehensive knowledge on the design, principles, and diagnostic applications of biosensors, including emerging technologies like nanobiosensors and smart diagnostic tool.

Fundamentals of Biosensors

Introduction to biosensors – Various types of biochemical components and nanomaterials used in biosensor - Principles of biosensor functioning - Types of biological recognition elements – Classification of biosensors - Transducers: Electrochemical, optical, piezoelectric, and thermal - Signal detection and processing – Important characteristics of biosensor

Types of Biosensors

Enzymatic biosensors – Antibody based biosensors - Immunosensors - DNA/RNA-based biosensors - Microbial and whole-cell biosensors - Nanobiosensors and wearable biosensors – Biomimetic biosensors

Fabrication and Characterization

Fabrication of biosensor - Immobilized enzymes in biosensor – Nanocomposites used in biosensor - Materials for biosensor construction: Membranes, polymers, nanomaterials - Design and mechanism of function of different biosensors for diagnosing infectious and inflammatory diseases - Key methods used for Biosensor Characterization - Microfluidics and lab-on-a-chip systems.

Diagnostic Applications

Biosensing for Diagnosing Human Inflammatory Diseases, Biosensors for Diagnosing Infectious Diseases of Human, Biosensors for the detection of human infectious parasitic diseases, Biosensors in clinical diagnostics: Glucose, Cholesterol and Urea - Point-of-care testing devices - Biosensors in COVID-19 and pandemic preparedness - Nanobiosensors in diagnostics

Advances and Future Prospects

Recent advances in biosensor technology - AI and machine learning in biosensor data interpretation - IoT Enabled Enzyme Embossed Biosensor for Determination of Vitamin D Level - Integration with smartphones and IoT for diagnostics - Current Methods and Future of Tuberculosis (TB) Diagnosis, Commercialization and challenges in biosensor development

Reference Books:

1. A.P.F. Turner, I. Karube, and G.S. Wilson (Editors), 'Biosensors: Fundamentals and Applications', 1st Edition, Oxford University Press, 1987.
2. Alice Cunningham, Introduction to Bio Analytical Sensors, John Wiley & Sons, 1998.
3. Donald G Buerk, 'Biosensors: Theory and Application', CRC Press, 2009.
4. Giuseppe Palleschi (Editor), Biosensors and Modern Biospecific Analytical Techniques, 1st Edition, Elsevier, 2007.

5. Mohd. Mohsin, Ahmad Zaidi, and Chaudhary Nisar Ahmad (Editors), Nanobiosensors for Agricultural, Medical and Environmental Applications, 1st Edition, Springer, 2019.

E-RESOURCES:

1. https://onlinecourses.nptel.ac.in/noc24_bt65/preview
2. https://onlinecourses.nptel.ac.in/noc24_ge23/preview
3. https://onlinecourses.nptel.ac.in/noc20_bt22/preview

Weightage for Continuous Assessment:

Internal Assessment I	Internal Assessment II	Activity	Total
40%	40%	20%	100%

Activity during Internal Assessment I: Seminar/ Quiz/ Model making/ Poster Presentation

Activity during Internal Assessment II: Reproduction of research paper/Flipped Classroom/Project based Learning/Case Study

Description of CO	PO1	PO2	PO3	PSO1	PSO2
CO1: Understand the fundamental principles, components, and types of biosensors.	1	–	3	2	–
CO2: Analyze the working and applications of various transducers and biorecognition elements.	2	–	3	3	1
CO3: Demonstrate knowledge of biosensor fabrication and characterization methods.	3	–	3	3	2
CO4: Evaluate the use of biosensors in clinical diagnostics and point-of-care testing.	2	1	3	3	1

BY25017	Human Molecular Genetics	L	T	P	C
		3	0	0	3

Course Objective:

This course introduces the principles of human genetics, including Mendelian and non-Mendelian inheritance, chromosomal abnormalities, molecular genetics and the genetic basis of human diseases.

Introduction

History of genetics – Mendel's principles and experiments, Dominance, segregation, Independent Assortments, Penetrance and Expressivity – Multiple alleles, ABO blood groups, bombay phenotype, Epistasis, Pleiotropy – Simple single factor inheritance: autosomal dominant, autosomal recessive, x-linked dominant, x-linked recessive and Y-linked characters, mitochondrial inheritance – Sex chromosomes, Sex determination, Sex influenced and sex limited characters, Mosaicism, Dosage compensation, sex linkage and pedigree analysis.

Complex Traits

Characteristics of complex traits – Genetic architecture of complex traits – Differences between Mendelian and quantitative traits – Approaches to analysis of complex traits, 'Nature vs nurture', role of family and shared environment, monozygotic and dizygotic twins and adoption studies – Polygenic inheritance of continuous and discontinuous variation, Types of quantitative traits (threshold, meristic, metric) – Epigenetics and quantitative trait expression – Importance in agriculture, evolution, and medicine.

Cytogenetics

Origins and developments of cytogenetics – Chromosome morphology: arms, centromeres, telomeres, satellites – Human chromosomal pathologies: Numerical and Structural aberrations, common syndromes – Chromosome banding techniques, Euchromatin, heterochromatin, Human karyotype & ideogram – Amniocentesis, chorionic villi sampling – Nomenclature of aberrant karyotypes – Techniques in cytogenetics: FISH, GISH, CGH & SKY.

Gene Linkage and Mapping

Mechanism of crossing over during meiosis, Coupling and repulsion, Chiasma formation, types of crossing over – Concept of genetic maps, calculating recombination frequency, constructing linkage maps using two-point and three-point test crosses – Molecular linkage maps, Genetic polymorphism, use of molecular markers RFLPs, AFLPs, SNPs and STRP/SSRP – Mapping by using somatic cell hybrids.

Genetic Diseases

Classification of genetic diseases – Monogenic Disorders: Cystic fibrosis, Huntington's disease, Tay-Sachs, Sickle cell anemia, Colour blindness and Phenylketonuria – Chromosomal Disorders: Down syndrome, Turner syndrome, Klinefelter syndrome – Multifactorial Disorders: Diabetes, Cancer syndrome like BRCA, Lynch syndrome – Mitochondrial Disorders: Leber's hereditary optic neuropathy (LHON) – Genetic counselling.

Course Outcomes:

Upon completion of the course, students will be able to

1. Understand the concept of Mendelian and non-Mendelian genetics.
2. Know the concepts of complex traits inheritance and mechanism of sex determination.
3. Discuss clearly about the chromosomal pathologies and detection techniques.
4. Describe the genetic basis of selected single-gene, chromosomal, and multifactorial disorders.
5. Recognize ethical issues related to genetic testing, counseling, and privacy.

Reference Books:

1. Anthony Griffiths, John Doebley, Catherine Peichel, David A. Wassarman, "Introduction to Genetic Analysis", 12th Edition, Macmillan Learning, 2025.
2. Ricki Lewis, "Human Genetics-Concepts and Applications", 14th Edition, McGraw-Hill Education, 2023.
3. William S Klug, Michael Cummings, Charlotte A. Spence, Michael A Palladino and Darrell Killian, "Concepts of Genetics", 12th Edition, Published by Pearson, 2021.
4. Michael Goldberg, Janice Fischer, Leroy Hood and Leland Hartwell, "Genetics: From Genes to Genomes", 7th Edition, McGraw Hill Education, 2020.
5. Tom Strachan & Andrew Read, "Human Molecular Genetics", 5th Edition, CRC Press, Garland Science, 2019.

E-RESOURCES:

NPTEL:

1. Human Molecular Genetics: https://onlinecourses.nptel.ac.in/noc22_bt07/preview
2. Genetics & Genomics: https://onlinecourses.swayam2.ac.in/cec21_bt05/preview
3. McGraw-Hill Education: Human Genetics-Concepts and Applications By Ricki Lewis https://students.aiu.edu/submissions/profiles/resources/onlineBook/g7z8z2_Human_Genetics_Concepts_and_Applications-_11th_Edition.pdf
4. McGraw Hill Education: Genetics: From Genes to Genomes by Leland H Hartwell http://skgjx.whu.edu.cn/Public/upfile/article/202103031656469260.pdf
5. CRC Press, Garland Science: Human Molecular Genetics by Tom Strachan https://konkooran.ir/wp-content/uploads/2019/01/Human-Molecular-Genetics-5th-Edition.pdf

Weightage for continuous assessment:

Assessment – I	Assessment – II	Activities	Total
40%	40%	20%	100%

Activity during Assessment-I **:** Seminar/Quiz/Poster presentation
Activity during Assessment-II **:** Model making/Flipped classroom/Seminar

CO Mapping with PO:

CO's	CO Description	PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand the concept of Mendelian and non-Mendelian genetics.	1	-	2	-	-	2
CO2	Know the concepts of complex traits inheritance and mechanism of sex determination.	2	-	2	-	1	-
CO3	Discuss clearly about the chromosomal pathologies and detection techniques.	3	-	3	3	3	3
CO4	Describe the genetic basis of selected single-gene, chromosomal, and multifactorial disorders.	2	-	-	2	-	3
CO5	Recognize ethical issues related to genetic testing, counseling, and privacy.	3	1	-	2	-	2

3 – Strong; 2 – Moderate; 1 – Weak; '-' No correlation

BY25018	GMP and Validation In Bioprocess Industries	L	T	P	C
		3	0	0	3

Course Objective:

This course provides knowledge of current validation practice across the bioprocess industry and able to assess new process concepts and understand regulatory acceptability for bioprocess industries

Trends for Validating Biological Processes

Importance of process validation for manufacturing drugs and medical devices, Definitions,Process validation, Prospective Validation, Concurrent Validation, Retrospective Validation,Critical Process Parameters, Critical Quality Attributes, Scaled-down model, Worst-case,FDA Guidelines**.**

Process Validation: General Principles and Practices

General Considerations for Process Validation, Concept of Bioprocess in Bulk Drug Manufacturing, Concept of Biotechniques in industrial validation, Integration of various biotechniques to maintain quality in downstream processing, CGMP regulations for validating biopharmaceutical (drug) manufacturing.

Good Manufacturing Practice for Bioprocess Engineering

Statutory and regulatory requirements for process validation, Production Methods and Considerations, Automation and control issues, System functionality, Principles for Layout of Bulk Production Facilities, Green Field Development, Brown Field Development, cross-contamination from other sources and linked systems, Clean In Place techniques, interactions with shared systems

Approach to Process

Process Design, Process Qualification, Continued Process Verification, attributes relating to identity, strength, quality, purity, and potency; Information and data organization from laboratory-, pilot-, and/or commercial-scale studies, validation of computerized systems.

cases studies in process validation

Process validation for recombinant therapeutic proteins like erythropetin, insulin, GMCSF, viral, bacterial vaccines.

Course Outcomes:

Upon completion of the course, students will be able to

1. Understand the implications of validation for process development
2. Have knowledge about the general principles and practices of process validation of biopharmaceutical manufacturing processes.
3. Apply manufacturing practice for bioprocess engineering
4. Design, verify and validate process using case studies
5. Give solution for process validation in industrial processes

REFERENCE BOOKS:

1. Anurag S. Rathore, Gail Sofer, 'Process Validation in Manufacturing of Biopharmaceuticals', CRC Press, Third Edition, 2012.
2. Nash, R.A., 'Encyclopedia of Industrial Biotechnology: Bioprocess, Bioseparation, and Cell Technology Phamaceutical Process Validation', John Wiley, 1st Edition, 2010.

3. Ohannesian, L. and Streeter, A. eds 'Handbook of pharmaceutical analysis', CRC Press, 2001
4. Cloud, P, 'Pharmaceutical equipment validation: The ultimate qualification Guidebook', CRC Press, 1998

Assessment Weightage (%):

Assessment – I	Assessment – II	Activities	Total
40	40	20	100

Activity during Assessment I : Seminar/Quiz/Poster presentation
Activity during Assessment III : Model making/Flipped classroom/Seminar

CO Mapping with PO:

COs	CO Description	PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand the implications of validation for process development	-	2	-	2	-	-
CO2	Have knowledge about the general principles and practices of process validation of biopharmaceutical manufacturing processes.	2	3	-	-	3	2
CO3	Apply manufacturing practice for bioprocess engineering	2	3			3	2
CO4	Apply the gained knowledge in combined food preservation methods Design, verify and validate process using case studies	-	2	-	-	3	-
CO5	Give solution for process validation in industrial processes	3	2	2	2	-	-

3 – Strong; 2 – Moderate; 1 – Weak; '--' No correlation

BY25019	Translational Biotechnology and Entrepreneurship	L	T	P	C
		3	0	0	3

Course Objectives:

At the end of the course, students will be able to identify entrepreneurial opportunities and develop the skills required to start a small business.

Translational Biotechnology

Introduction to translational biotechnology, distinction between basic, applied and translational research, T0-T4 translational research frame work; bench- to-bedside and bench-to-market pathways: proof of concept and preclinical translation: translational biotechnology industry overview (include the commercialization pathways for drug, medical device, diagnostic companies) -case studies in translational biotechnology.

Introduction To Entrepreneurship Traits & Motivation

Entrepreneurship as a Career, Entrepreneur, Personality Characteristics of Successful. Entrepreneur, Knowledge and Skills Required for an Entrepreneur. Bioindustry- concepts and recent trends in the development of bioindustries; Growth of entrepreneurship, the marketing and selling of Biotechnology, Establishment and marketing of biotechnology company, Effective advertising.

Business Plan Preparation **9**

Criteria for Selection of Product-Ownership-Capital Budgeting Project Profile Preparation-Matching Entrepreneur with the Project-Feasibility Report Preparation and Evaluation Criteria. Finance and Human Resource Mobilization Operations Planning-Market and Channel Selection-Growth Strategies-Product Launching.

Launching Of Start-Up **9**

Importance types or requirements; sources: non-institutional and institutional: existing rural credit delivery system (multi-agency approach); Monitoring and Evaluation of business-Preventing Sickness and Rehabilitation of Business Units. Effective Management of small Business. Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India)

Entrepreneurial Development **9**

Entrepreneurship Development Training and Other Support Organizational Services-Central and State Government Industrial Policies and Regulations-International Sources of Product for Business. Self-employment schemes in relation to bioindustries, Problem and Solution of Entrepreneurship: Risk and benefit, Steps involved in commercialization of a biotechnological product, Case studies.

Weightage for Continuous Assessment:

Internal Assessment I	Internal Assessment II	Activity	Total
40%	40%	20%	100%

Activity during Internal Assessment I : Seminar/ Quiz/ Model making/ Poster Presentation

Activity during Internal Assessment II: Reproduction of research paper/Flipped Classroom/Project based Learning/Seminar

Text Books:

1. Hisrich, Entrepreneurship, Tata McGrawHill, NewDelhi, 2001.
2. S.S.Khanka, Entrepreneurial Development, S.ChandandCompany Limited, New Delhi, 2001.

References:

1. Bloxham: Scion. 8. Shimasaki, C. D. (2014). Biotechnology Entrepreneurship:Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
2. Adams, D. J., & Sparrow, J. C. (2008). Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. 9. 10. 11.
3. Onetti, A., &Zucchella, A. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.
4. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.
5. Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

E-Resources: https://nptel.ac.in/courses/127/105/127105007/
https://nptel.ac.in/courses/110/107/110107094/
https://nptel.ac.in/courses/110/106/110106141/

Description of CO	PO1	PO2	PO3	PSO1	PSO2
CO1: Understand the basic concepts of Entrepreneurship	1	–	2	–	2
CO2: Explain establishment and marketing of biotechnology company	2	1	3	2	3
CO3: Describe budgeting and project business plan preparation	3	2	3	2	3
CO4: Explain small business launching and management	2	1	3	1	3

BY25020	Regulatory Affairs in Biotechnology	L	T	P	C
		3	0	0	3

Course Objective:
To familiarize students with regulatory procedures governing the safety, quality, and efficacy of biotechnology products.

Introduction to Regulatory Affairs: Basics of regulatory affairs, importance of regulations in biotechnology, role of regulatory agencies, regulation of biotechnology products such as drugs, vaccines, and biologics, ethics and public safety, overview of biotechnology product life cycle.

Activity: Short discussion on why regulations are important in biotechnology.

Regulatory Organizations and Guidelines: International regulatory bodies such as the World Health Organization (WHO), national regulatory authorities including the Food and Drug Administration (FDA), and Central Drugs Standard Control Organization (CDSCO); roles and responsibilities of regulatory agencies; basic regulatory guidelines for approval of biotechnology products.

Activity: Prepare a comparative chart of FDA and CDSCO highlighting their roles, responsibilities, and regulatory guidelines for biotechnology products.

egulation of Biopharmaceutical Products: Biopharmaceuticals and biologics; regulation of vaccines, recombinant proteins, and monoclonal antibodies; biosimilars and their approval; quality, safety, and efficacy requirements; introduction to good manufacturing practices (GMP); post-marketing surveillance of biopharmaceuticals.

Activity: Case study on the approval of a vaccine or biosimilar, highlighting regulatory considerations for quality, safety, and efficacy.

Key Practices and Compliance in Biotechnology: Good Manufacturing Practices (GMP); Good Laboratory Practices (GLP); Good Clinical Practices (GCP); documentation and record keeping; quality assurance and quality control; basics of regulatory compliance; introduction to standard operating procedures (SOPs); basic concepts of biosafety and bioethics.

Activity: Group discussion on the importance of GMP in biotechnology industries.

Clinical Trials and Regulatory Approval: Basics of clinical trials; phases of clinical trials (Phase I–IV); ethical considerations; informed consent; regulatory approval process; post-marketing surveillance; introduction to clinical trial protocols; role of Institutional Review Boards (IRBs) or Ethics Committees**.**

Activity: Prepare a flowchart illustrating the phases of clinical trials.

Total Periods: 45

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Assignments (20%), Flipped Class (5%), Practical (30%), Internal Examinations (40%)

References:

Javed Ali & Sanjula Baboota (2021). *Regulatory Affairs in the Pharmaceutical Industry* (1st ed.). Elsevier/Academic Press.

John J. Tobin & Gary Walsh (2023). *Medical Product Regulatory Affairs* (2nd ed.). Wiley-VCH.

A. Singh et al. (2024). *Quality Control and Regulatory Affairs for Biopharmaceuticals* (1st ed.). NPH India

Daan J. A. Crommelin, Robert D. Sindelar & Bernd Meibohm (2024). *Pharmaceutical Biotechnology: Fundamentals and Applications* (6th ed.). Springer Cham.
E-Resources: NPTE: **Legal and Regulatory Issues in Biotechnology (IIT Kharagpur)** https://onlinecourses.nptel.ac.in/noc25_lw18/preview NPTE: Current Regulatory Requirements for Conducting Clinical Trials in India https://onlinecourses.nptel.ac.in/noc25_ge61/preview

	Description of CO	PO Mapping	PSO1	PSO2
CO1	Identify the roles of regulatory agencies in biotechnology	PO1(3), PO3(2)	3	3
CO2	Compare and evaluate national and international regulatory frameworks.	PO1(2), PO2(2), PO3(1)	2	2
CO3	Apply good practices (GMP, GLP, GCP) in biotechnology processes	PO1(3), PO3(3)	3	3
CO4	Design and utilize clinical trial plans and regulatory approval strategies.	PO1(2), PO2(2), PO3(2)	3	2
CO5	Develop post-marketing surveillance and compliance strategies for biopharmaceuticals	PO1(3), PO3(3)	3	3

BY25021 Artificial Intelligence In Healthcare	L	T	P	C
	3	0	0	3

Course Objective:

This course provides foundational knowledge of AI and ML techniques in healthcare, including their applications in EHRs, diagnostics, and drug discovery. It also addresses ethical, legal, and regulatory aspects for responsible AI integration in medical systems.

Fundamentals of AI In Healthcare

Introduction to Artificial Intelligence in Medicine, Definition and scope of AI in healthcare, Historical perspective and milestones in AI research, Fundamentals of Machine Learning- Supervised, unsupervised, and reinforcement learning, Deep Learning Architectures- Feedforward Neural Network, Convolutional Neural Network, Recurrent Neural Network

AI In Electronic Health Records

Introduction to AI in Electronic Health Records, EHR-Integrated Databases for AI Applications, Natural Language Processing (NLP) in Healthcare, Clinical Decision Support Systems (CDSS), Applications of NLP in electronic health records (EHR)

AI in Medicines

Introduction to AI in Drug Discovery; Personalized Medicine and Treatment Planning; Molecular modelling using ML for drug development- MD Simulation; Pharmacogenomics and precision medicine; Drug discovery and repurposing using AI approaches.

AI in Diagnostics

Introduction to AI in Medical Imaging, Image classification- segmentation and registration, Applications of AI in radiology, pathology, and ophthalmology, Early detection of diseases using AI algorithms, AI in Diagnostics and Disease Prediction.

Ethical Regulation of AI in Healthcare

Ethical, Legal, and Social Implications (ELSI) of AI in Medicine, Bias and fairness in AI algorithms, Privacy and security of healthcare data, Regulation and policy considerations for AI in healthcare.

Course Outcomes:

Upon completion of the course, students will be able to

1. Understand core AI and ML concepts used in healthcare.
2. Identify and compare different learning types and deep learning models.
3. Explore AI applications in EHR, NLP, and decision support systems.
4. Apply AI in drug discovery, modelling, and personalized treatments.
5. Evaluate diagnostic tools and address ethical and regulatory concerns in AI-based healthcare.

REFERENCE BOOKS:

1. Arvind Kumar Bansal, Artificial Intelligence in Healthcare, CRC Press, 2020.
2. Moumtzoglou Anastasius, Artificial Intelligence and Healthcare: Past, Present and Future, Springer, 2022.
3. Niklas Lidströmer and Ulrika Widström, Artificial Intelligence in Medicine: Applications, Implications, and Limitations, Elsevier, 2020.
4. Lei Xing and Maryellen Giger, Artificial Intelligence in Medicine: Technical Basis and Clinical Applications, Academic Press, 2020.

E-RESOURCES:

1. NPTEL: Artificial Intelligence in Drug Discovery and Development: https://onlinecourses.nptel.ac.in/noc25_bt27/preview
2. NIH – Artificial Intelligence and Machine Learning in Biomedical Research https://datascience.nih.gov/artificial-intelligence
3. PubMed Central – Articles on AI in Healthcare https://www.ncbi.nlm.nih.gov/pmc/?term=artificial+intelligence+in+healthcare
4. SpringerLink – Artificial Intelligence and Medicine https://link.springer.com/search?query=artificial+intelligence+in+healthcare

Weightage for continuous assessment:

Assessment – I	Assessment – II	Activities	Total
40%	40%	20%	100%

Activity during Assessment-I **:** Seminar/Quiz/Poster presentation
Activity during Assessment-II **:** Model making/Flipped classroom/Seminar

CO Mapping with PO:

CO's	CO Description	PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand basic AI and machine learning concepts in healthcare.	2	-	1	1	2	1
CO2	Describe AI applications in Electronic Health Records and NLP.	1	1	2	2	-	-
CO3	Analyse AI use in drug discovery and personalized medicine.	3	2	2	3	-	1
CO4	Evaluate AI techniques in medical imaging and diagnostics.	1	1	2	1	-	1
CO5	Discuss ethical, legal, and regulatory issues of AI in healthcare.	-	-	2	-	1	3

3 – Strong; 2 – Moderate; 1 – Weak; '-' No correlation

BY25022	IOT In Biotechnology	L	T	P	C
		3	0	0	3

Course Objective:

This course covers the basics of IoT and biosensors for biotechnology applications. Learners will understand how to connect devices, manage data flow, and analyze biological information. Real-world uses in medical, agricultural, and industrial fields will be demonstrated through hands-on projects.

IOT Fundamentals and Biosensors

Introduction to IoT architecture – overview of biosensors relevant to biotechnology such as optical, electrochemical, and piezoelectric sensors – signal conditioning and data acquisition – integration of biosensors with microcontrollers for real-time biological monitoring.

Smart Devices and Embedded Systems

Sensor interfacing for biological parameters like temperature, pH, dissolved oxygen, turbidity – actuator control systems in bioreactors and lab automation – embedded system programming for biotechnology processes – development of closed-loop feedback systems for process optimization.

Communication, Cloud, And Security

Wireless communication technologies including Wi-Fi, Bluetooth – IoT-enabled data transmission in biotech settings – cloud platforms such as Thing Speak for remote monitoring – data integrity and encryption techniques – authentication methods for secure biotech data handling.

Data Analytics and Iot-Based Decision Support

Introduction to machine learning applications for anomaly detection and pattern recognition – decision-making support systems in precision agriculture and biomedical monitoring - Time-series data logging and visualization – analytics techniques for biotechnology process monitoring.

Real-World Implementations in Biotechnology

IoT applications in remote healthcare monitoring and wearable biosensors – smart agriculture systems for soil and crop health management – industrial biotechnology solutions including fermentation process optimization – environmental biosensing for pollution and toxin detection.

Course Outcomes:

Upon completion of the course, students will be able to

1. Understand the architecture of IoT systems and biosensors relevant to biotechnology.
2. Gain skills in microcontroller-based sensor interfacing and automation for biotech processes.
3. Learn wireless communication, cloud integration, and security protocols for IoT in biotech.
4. Analyze and visualize biotech data using IoT platforms and apply machine learning for decision support.
5. Apply IoT solutions to real-world biotechnology problems through sensor integration and project development.

REFERENCE BOOKS:

1. Andrew Minteer, Data Analytics for the Internet of Things, 1st Edition, Wiley, 2020.
2. Dr. Alok Kumar Srivastav, Dr. Priyanka Das, and Ashish Kumar Srivastava, Biotech and IoT: An Introduction Using Cloud-Driven Labs, 1st Edition, Apress, 2024.
3. Jonathan W. Valvano, *Embedded Systems: Introduction to ARM Cortex-M Microcontrollers*, 2nd Edition, CreateSpace Independent Publishing, 2016.
4. Shampa Sen, Leonid Datta, and Sayak Mitra (Editors), *Machine Learning and IoT: A Biological Perspective*, 1st Edition, CRC Press (Taylor & Francis Group), 2021.
5. Thomas Erl, Zaigham Mahmood, and Ricardo Puttini, *Cloud Computing: Concepts, Technology & Architecture*, 1st Edition, Prentice Hall, 2013.
6. Valentina Emilia Balas, Le Hoang Son, Sudan Jha, Manju Khari, and Raghvendra Kumar (Editors), *Internet of Things in Biomedical Engineering*, 1st Edition, Academic Press (Elsevier Science), June 2019.

E-RESOURCES:

NPTEL

https://onlinecourses.nptel.ac.in/noc24_bt65/preview
https://onlinecourses.nptel.ac.in/noc24_cy13/preview

Weightage for Continuous Assessment:

Internal Assessment I	Internal Assessment II	Activity	Total
40%	40%	20%	100%

Activity during Internal Assessment I : Seminar/ Quiz/ Model making/ Poster Presentation

Activity during Internal Assessment II: Reproduction of research paper/Flipped Classroom/Project based Learning/Case Study

CO Mapping with PO:

CO's	CO Description	PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand the architecture of IoT systems and biosensors relevant to biotechnology.	2	1	-	2	1	-
CO2	Gain skills in microcontroller-based sensor interfacing and automation for biotech processes.	2	2	-	1	2	-
CO3	Learn wireless communication, cloud integration and security protocols for IoT in biotech	1	2	-	1	2	-

CO's	CO Description	PO1	PO2	PO3	PO4	PO5	PO6
CO4	Analyze and visualize biotech data using IoT platforms and apply machine learning for decision support	2	2	-	2	2	-
CO5	Apply IoT solutions to real-world biotechnology problems through sensor integration and project development.	2	1	-	2	1	-

3 – Strong; 2 – Moderate; 1 – Weak; '-' No correlation

BY25023	Regenerative Medicine	L	T	P	C
		3	0	0	3

Course Objective:

The course aims to provide foundational and applied knowledge in tissue engineering, focusing on cellular behavior, biomaterials, and regenerative processes. It also introduces students to the clinical applications,

Fundamentals of Tissue Engineering

Basic definition; current scope of development; use in therapeutics, cells as therapeutic agents, cell numbers and growth rates, measurement of cell characteristics morphology, number viability, motility and functions. Measurement of tissue characteristics ,appearance - Cell - ECM interaction - Mechanical measurements and physical properties. **Regenerative Capacity in various organisms :** Comparative regeneration in invertebrates and vertebrates , Examples: Planaria, salamanders, zebrafish, and humans.

Tissue Engineering and Regeneration

Tissue types and Tissue components, Tissue repair, Engineering wound healing and sequence of events - Cellular Sources - Matrices and Substrates - Desirable Properties of Implanted Substrates - Growth Factors and Cytokines in Tissue Engineering - Wound Healing - Fracture Healing -Vascularization and Neurotization - Mechanical Environment.

Biomaterials for Regenerative Medicine

Design Principles in Biomaterials and Scaffolds - Naturally Occurring Scaffold Materials - Synthetic Polymers - Hybrid, Composite, and Complex Biomaterials for Scaffolds -Surface Modification of Biomaterials - Histogenesis in Three-Dimensional Scaffolds - Biocompatibility and Bioresponse to Biomaterials - Proteins Controlled with Precision at Organic, Polymeric, and Biopolymer Interfaces for tissue engineering and regenerative Medicine.

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Stem Cell Biology and Regeneration

Genetic Approaches in Human Embryonic Stem Cells and Their Derivatives - Embryonic Stem Cells: Derivation and Properties - Multipotent Adult Progenitor Cells - Hematopoietic Stem Cell Properties, Markers, and Therapeutics - Mesenchymal Stem Cells - Regenerative Medicine for Diseases of the Retina, Liver- Cancer stem cells: Tissue engineering tools in cancer- GeneChips in Regenerative Medicine -Tissue Therapy: Regenerative Medicine for skeletal muscle, fetal tissue , skin cell-based therapy for patients with burn injuries.

Regulations and Ethics

Regulatory path from concept to Industry – Legislative authority , Product regulatory process , Product premarket submission, Science and product development , Tissue based product, Human cells, Tissue and Celluar product - Ethical Considerations - The Ethical Issues in Human Tissue Engineering -US Stem Cell Research Policy - Overview of FDA Regulatory Process -- Current Issues in US Patent Law.

Course Outcomes:

1. Describe the scope and application of tissue engineering in medicine.
2. Analyze tissue characteristics and cell interactions with materials.
3. Design scaffold materials based on regenerative needs.
4. Apply stem cell knowledge for clinical and therapeutic applications.
5. Navigate regulatory frameworks and ethical concerns in tissue engineering

Reference Books:

1. Meyer, U.; Meyer, Th.; Handschel, J.; Wiesmann, H.P. "Fundamentals of Tissue Engineering and Regenerative Medicine",1st Edition 2016.
2. Robert.P. Lanza, Robert Langer and Joseph Vacanti " Principles of Tissue Engineering". 5th Edition, Elesiver, 2020.
3. Bruce M. Carlson, "Principles of Regenerative Biology" 2nd ,Elesiver/Academic Press, 2007.
4. Mehdi Razavi, "Frontiers in Biomaterials:Stem Cell Biology and Regenerative Medicine" Bentham Books, 2007.
5. R. Lanza, J. Gearhart, B. Hogan, D. Melton, R. Pedersen, E. .l Thomas, J. Thomson, I. W.Gearhart, Essential of Stem Cell Biology, Elsevier Academic Press, 5th Edition , 2020.
6. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, "Biomaterials Science: An Introduction to Materials in Medicine", 4th Edition, Academic Press,2020.

E- Resources:

NPTEL SWAYAM- Tissue Engineering by Prof. Vignesh Muthuvijayan, IIT Madras
https://youtu.be/PR0vmcOW4nU
https://youtu.be/PR0vmcOW4nUhttps://youtu.be/PR0vmcOW4nU
https://www.classcentral.com/course/swayam-regeneration-biology-452164

Assessment Weightage:

Assessment I	Assessment II	Activity	Total
40%	40%	20%	100%

Activity during Assessment I – Model making/Seminar/Poster Presentation
Activity during Assessment II – Research paper reproduction**/**Quiz/ Flipped Classroom/ Project based Learning

COs Mapping with POs

			POs			
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	-	-	-
CO2	3	3	2	2	-	-
CO3	3	2	3	2	2	**-**
CO4	2	2	2	2	3	**-**
CO5	2	2	2	2	-	3

3- Strong, 2 -Moderate, 1-Weak, - No Correlation

BY25024	Programming For Biotechnologists	L	T	P	C
		3	0	0	3

Course Objective:
To equip biotechnologists with programming skills for computational problem solving in biological systems.

Introduction to Programming Concepts
Basics of programming languages (Python/R): Data types, variables, operators, control structures

Activities
Hands-on coding labs, problem-solving exercises

Data Structures and Algorithms
Lists, arrays, dictionaries, strings - Searching, sorting, recursion

Activities
Interactive coding sessions, group assignments, mini-projects

Bioinformatics Programming Applications
Sequence analysis (DNA, RNA, protein) - File handling (FASTA, GenBank formats)
Activities

Case studies, coding assignments using biological datasets

Statistical and Computational Methods
Biostatistics with programming (mean, variance, regression, ANOVA) - Simulation and modeling of biological processes

Activities
Lab demonstrations, project-based learning, peer discussions

Advanced Topics and Integration
Machine learning basics for biotechnology - Data visualization and reporting

Activities
Research paper reviews, coding hackathons, seminar presentations

Course Outcomes (COs)
By the end of the course, students will be able to:

1. Apply programming fundamentals to solve biological problems.
2. Implement data structures and algorithms for efficient biological data analysis.
3. Develop bioinformatics tools for sequence and structural data handling.
4. Use statistical and computational methods to model biological systems.
5. Integrate machine learning and visualization techniques for advanced biotechnological applications.

References:

1. Bassi, S. (2017). Python for bioinformatics (2nd ed.). Chapman & Hall/CRC.
2. Durbin, R., Eddy, S. R., Krogh, A., & Mitchison, G. (1998). Biological sequence analysis: Probabilistic models of proteins and nucleic acids. Cambridge University Press.
3. Sung, W.-K. (2009). Algorithms in bioinformatics: A practical introduction. Chapman & Hall/CRC.

4. Fulekar, M. H. (2009). Bioinformatics: Applications in life and environmental sciences. Springer.
5. Waterman, M. S. (1995). Introduction to computational biology: Maps, sequences, and genomes. Chapman & Hall/CRC.

E-Resources:

1. **NCBI (National Center for Biotechnology Information) –** https://www.ncbi.nlm.nih.gov
2. **EMBL-EBI (European Bioinformatics Institute) –** https://www.ebi.ac.uk
3. **Biopython Documentation –** https://biopython.org/wiki/Documentation
4. **R Bioconductor Project –** https://www.bioconductor.org
5. **Coursera Bioinformatics Courses –** https://www.coursera.org/browse/life-sciences/bioinformatics
6. **GitHub Bioinformatics Repositories –** https://github.com/topics/bioinformatics

Assessment Weightage:

Component	Description	Weight (%)
Continuous Assessment	Assignments, labs, projects, presentations	40
End-Semester Exam	Written exam covering all modules	60

CO MAPPING WITH PO & PSO:

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Apply programming fundamentals to solve biological problems	PO1(3) PO2(1) PO3 (2)	3	2
CO2	Implement data structures and algorithms for biological data analysis	PO1 (2) PO2 (1) PO3 (3)	3	2
CO3	Develop bioinformatics tools for sequence and structural data handling	PO1 (3) PO2 (3) PO3 (3)	3	2
CO4	Use statistical and computational methods to model biological systems	PO1 (3) PO2 (2) PO3 (3)	3	2
CO5	Integrate machine learning and visualization techniques for advanced biotech applications	PO1 (2) PO2 (2) PO3 (3)	3	3

(Scale: 3 – Strong; 2 – Moderate; 1 – Weak; '-' – No correlation)