गोंय विद्यापीठ
ताळगांव पठार,
गोंय - ४०३ २०६
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Goa University
Taleigao Plateau,Goa - 403 206
Tel : +91-8669609048
Email : registrar@unigoa.ac.in
Website : www.unigoa.ac.in

(Accredited by NAAC with Grade A+)

GU/Acad –PG/BoS -NEP/2025-26/35 Date: 21.04.2026

CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP/2025-26/295 dated 06.08.2025

In supersession to the above referred Circular, the syllabus of Semester III & IV of the **Master of Science in Biotechnology** Programme approved by the Standing Committee of the Academic Council in its meeting held 24th & 25th November 2025, is attached.

The syllabus of Semester I & II approved earlier by the Standing Committee of the Academic Council in its meeting held on 24th & 25th June 2025, is also attached.

The Dean & Vice-Dean (Academic) of the School of Biological Sciences and Biotechnology are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN V LAWANDE Digitally signed by ASHWIN V LAWANDE Date: 2026.04.21 15:14:59 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,

1. The Dean, School of Biological Sciences and Biotechnology, Goa University.
2. The Vice-Dean (Academic), School of Biological Sciences and Biotechnology, Goa University.

Copy to:

3. Chairperson, BoS in Biotechnology, Goa University.
4. Programme Director, M.Sc. Biotechnology, Goa University.
5. Controller of Examinations, Goa University.
6. Assistant Registrar Examinations (PG), Goa University.
7. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSITY

MASTER OF SCIENC IN BIOTECHNOLOGY

Effective from Academic Year 2025-26

ABOUT THE PROGRAMME

The M.Sc. The biotechnology program at Goa University is a two-year postgraduate course that integrates Microbiology, Biochemistry, Analytical techniques, genetic engineering, molecular biology, bioinformatics, IPR, and bioprocess technology. The program emphasizes on industrial, environmental, IPR and entrepreneurship skills and with support from Goa University Research Park Unit (GURU) and internship training in industry, the students pursue careers in biopharmaceuticals, genetic diagnostics, and biomanufacturing.

OBJECTIVES OF THE PROGRAMME

The primary objective of M.Sc. The biotechnology program aims to provide students with interdisciplinary knowledge in the field of Biotechnology and develop technical competence and skills, empowering them to pursue careers in research or industry sector. The PG programs enable the student to develop skills in Microbial and biochemical technology, molecular biology, computational biology, Recombinant DNA Technology, Tissue culture, nanotechnology and with additional electives covering genomics, synthetic biology, bioprocess engineering, and immunology, equipping students for jobs related to drug development, industrial biotechnology, and environmental sustainability.

PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO 1.	Core Disciplinary Knowledge: Demonstrate comprehensive understanding of genetic engineering, molecular biology, cell biology, developmental and bioprocess technology, forming the foundation for advanced biotechnology applications.
PSO 2.	Application of Modern Tools: Apply contemporary biotechnological tools and techniques, including CRISPR/Cas systems, recombinant protein production, and microbial strain engineering.
PSO 3.	Analytical Thinking: Critically analyze biochemical pathways, regulatory networks, and molecular interactions using experimental and computational approaches.
PSO 4.	Evaluation of Emerging Technologies: Assess the principles and applications of bioinformatics, synthetic biology, and biomanufacturing for translational research.
PSO 5.	Innovation & Research: Design and execute research strategies to develop novel biotechnological solutions, including engineered biomolecules, and microbial strains.
PSO 6.	Industrial & Healthcare Applications – Implement bioprocess and fermentation strategies for pharmaceuticals and sustainable biotech.
PSO 7.	Ethics, Policy, and Sustainability: Evaluate ethical, biosafety, and regulatory aspects of genetic modifications, biotechnology innovations, and their societal and environmental implications.
PSO 8.	Scientific Communication: Communicate scientific knowledge effectively through academic writing, presentations, and collaborative leadership in research and industry contexts.

PROGRAMME STRUCTURE
Master of Science in Biotechnology
Effective from Academic Year 2025-26

Bridge Courses*			
Sr. No.	**Course Code**	**Title of the Course**	**Credits**
1	**GBT-1000**	Concepts in Microbiology	2
2	**GBT-1001**	Fundamentals in Biochemistry	2
3	**GBT-1002**	Basics of Cell Biology and Genetics	2

*Students will be provided with the option to do any of the above bridge courses

SEMESTER I				
Discipline Specific Core (DSC) Courses (16 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**GBT-5000**	Advanced Genetics and Molecular Biology	3	400
2	**GBT-5001**	Cell and Developmental Biology	3	400
3	**GBT-5002**	Bio-analytical Techniques and their applications	3	400
4	**GBT-5003**	Concepts in Immunology	3	400
5	**GBT-5004**	Lab I: Cell and Molecular Biology	2	400
6	**GBT-5005**	Lab II: Bio-analytical Techniques and Immunodiagnostics	2	400
Total Credits for DSC Courses in Semester I			**16**	
Discipline Specific Elective (DSE) Course (4 credits)				
Sr. No.	**Course Code**	**Title of the Course** (Anyone option with 3 credit theory and respective one credit practical)	**Credits**	**Level**
1	**GBT-5201**	Computational biology and Data Analysis	3	400
2	**GBT-5202**	Lab III: Computational Biology and Data Analysis	1	400
3	**GBT-5203**	Environmental Biotechnology and Sustainability	3	400
4	**GBT-5204**	Lab IV: Environmental Biotechnology	1	400
Total Credits for DSE Courses in Semester I			**4**	
Total Credits in Semester I			**20**	

*For all practical (laboratory) courses enrolment in the corresponding theory paper is mandatory in the same semester

Semester II				
Discipline Specific Core (DSC) Courses				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**GBT-5006**	Biomanufacturing and Bioprocess Technology	3	500
2	**GBT-5007**	Recombinant DNA Technology	3	500
3	**GBT-5008**	Cell and Tissue Culture: Techniques and Application	3	500
4	**GBT-5009**	Plant and Animal Biotechnology	3	500
5	**GBT-5010**	Lab V: Recombinant DNA Technology and Bioprocess Technology	2	500
6	**GBT-5011**	Lab VI: Cell and Tissue Culture	2	500
Total Credits for DSC Courses in Semester II			**16**	
Discipline Specific Elective (DSE) Courses (4 credits)*				
Sr. No.	**Course Code**	**Title of the Course** (Anyone option with 3 credit theory and respective one credit practical)	**Credits**	**Level**
1	**GBT-5205**	IPR, Biosafety and Bioethics	3	400
2	**GBT-5206**	Lab VII: IPR database, Patent drafting, and Bioethics	1	400
3	**GBT-5207**	Systems Biology	3	400
4	**GBT-5208**	Lab VIII: Practical Approaches to Systems Biology	1	400
5	**GBT-5209**	Bionanotechnology	3	400
6	**GBT-5210**	Lab IX: Bionanotechnology	1	400
Total Credits for DSE Courses in Semester II			**4**	
Total Credits in Semester II			**20**	

*For all practical (laboratory) courses enrolment in the corresponding theory paper is mandatory in the same semester

Semester III				
Research Specific Elective (RSE) Courses (12 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	GBT-6000	Biostatistics in Biological Sciences	2	500
2	GBT-6001	Bioentrepreneurship	2	500
3	GBT-6002	Integrated Genomics and Proteomics	2	500
4	GBT-6003	Lab in Omics	2	500
5	GBT-6004	Stem Cell Biology and Regenerative Medicine	2	500
6	GBT-6005	Biology of Extremophilic Microorganism	2	500
7	GBT-6006	Internship*	2	500
8	GBT-6007	Fieldtrip	2	500
9	GBT-6008	Research Methodology	4	500
Total Credits for RSE Courses in Semester III			**12**	
Discipline Specific Vocational Elective (DSVE) Courses (8 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	GBT-6401	Enzymes: Chemistry and engineering	2T+2P	500
2	GBT-6402	Algal Biotechnology and Bioeconomy	2T+2P	500
3	GBT-6403	Biopharmaceutical Technology and Pharmacology	2T+2P	500
Total Credits for DSVE Courses in Semester III			**8**	
Total Credits in Semester III			**20**	

*(Internship is to be completed during the summer break after the second semester)

Discipline Specific Dissertation (DSD) (40 Credit Dissertation)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**GBT-6501**	Dissertation	40	500

Semester IV				
Generic Elective (GE) Courses (20 credits)				
Sr. No	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**GBT-6201**	Synthetic Biology	2	500
2	**GBT-6202**	Vaccine Technology	2	500
3	**GBT-6203**	Model Organisms for Genomic Research	4	500
4	**GBT-6204**	Trends in Sustainable Waste Resource Management	4	500
5	**GBT-6205**	Modern Agricultural Techniques and Livestock Management	4	500
6	**GBT-6206**	Microbiome	4	500
7	**GBT-6207**	Marine Bioremediation and Pollution Monitoring	4	500
Total Credits for GE Courses in Semester IV			**20**	

Discipline Specific Dissertation (DSD) (20 Credit Dissertation)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**GBT-6502**	Dissertation	20	500
Total Credits in Semester IV			**20**	

BRIDGE COURSES

Title of the Course	Concepts in Microbiology
Course Code	GBT-1000
Number of Credits	2
Theory/Practical	Theory
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	To understand: ● Key historical developments, terminologies, and the structure and function of microbial cells ● Microbial growth and nutrition ● The role of microorganisms in health, industry, and the environment, including extremophiles and pathogens.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Visualize the contribution of different scientist for the development of microbiology	PSO1
	CO 2. Describe the morphology, structure and organization of microbes	PSO1, PSO2
	CO 3. Explain the microbial growth phases, kinetics and nutrition	PSO1, PSO2, PSO3
	CO 4. Summarize the diversity of microorganisms in different environments and their	PSO2, PSO3, PSO4

	application			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	a) **A brief history of microbiology**: Discovery of the microbial world, controversy over spontaneous generation, the role of microorganisms in the causation of disease, development of various microbiological techniques, establishment of various branches of microbiology with special reference to the pioneering work by various scientists. b) **An overview of the organization and cell structure of Prokaryotes and Archaea**: **Cell organization**: Cell size, shape, and arrangement, glycocalyx, capsule, flagella, fimbriae, and pili. **Cell-wall**: Composition and detailed structure of gram-positive and gram-negative cell walls, Archaebacterial cell wall, Gram and acid-fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall. **Cell Membrane**: Structure, function, and chemical composition of bacterial and archaeal cell membranes. **Cytoplasm**: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome, and plasmids; Endospores c) **Modern /contemporary microbiology in the 21st century**: - An overview of the Scope of Microbiology	**15**	CO1, CO2	K1, K2
Module 2:	**Growth and nutrition** Microbial nutrition: i) autotrophic & heterotrophic modes, ii) **Culture media**: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media. **Bacterial growth kinetics**: i) growth curve, the mathematical expression of growth & measurement of growth ii) synchronous growth iii) factors affecting growth. **Microbial taxonomy**: i) nomenclature ii) polyphasic identification, traditional &	**15**	CO3, CO4	K1, K2

	molecular, iii) Bergey's manual. **General characteristics and functions of**: -Algae, Fungi, Cyanobacteria, Bacteria, Viruses, Viroids & prions.; Specialized microorganisms: - Extremophiles, Anaerobes.			
Pedagogy:	Lectures, tutorials, assignments			
Texts:	1. Atlas, R. M. (1997). *Principles of Microbiology* (latest edition). Wm. C. Brown Publishers. 2. Black, J. G. (2008). *Microbiology: Principles and Explorations* (7th ed.). Prentice Hall. 3. Madigan, M. T., Aiyer, J., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2024). *Brock Biology of Microorganisms* (16th ed.). Pearson. 4. Pelczar Jr., M. J., Chan, E. C. S., & Krieg, N. R. (2023). *Microbiology* (5th ed.). Tata McGraw-Hill. 5. Srivastava, S., & Srivastava, P. S. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht 6. Stanier, R. Y., Ingraham, J. L., Wheelis, M. L., & Painter, P. R. (2005). *General Microbiology* (5th ed.). Macmillan. 7. Tortora, G. J., Funke, B. R., Case, C. L., Weber, D., & Bair, W. (2024). *Microbiology: An Introduction* (14th ed.). Pearson Education. 8. Willey, J. M., Sherwood, L. M., & Woolverton, C. J. (2016). *Prescott's Microbiology* (10th ed.). McGraw-Hill Education. 9. Reed, G. (1987). *Prescott & Dunn's Industrial Microbiology*. CBS Publishers.			
References/ Readings:	1. https://pmc.ncbi.nlm.nih.gov/articles/PMC7123386/. 2. www.researchgate.net/figure/A-comparison-of-a-few-traits-of-bacteria-archaea-and-eukarya_tbl1_313744700 3. https://pmc.ncbi.nlm.nih.gov › articles › PMC7173489			

Title of the Course	Fundamentals in Biochemistry
Course Code	GBT-1001
Number of Credits	2
Theory/Practical	Theory
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	● The course is designed to impart understanding of basic biochemical foundations that underpin all living organisms, ● To understand concepts about pH, buffering, bioenergetics, nucleotides, amino acids, carbohydrates, lipids, proteins, enzyme function, enzyme kinetics, metabolism, molecular biology and protein chemistry. ● To build upon the knowledge of basic biochemical principles with an emphasis on different metabolic pathways and their integration. ● To understand the structure-function relationships of biomolecules.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand and describe the structure, function, and interrelationships of carbohydrates, lipids, proteins, and nucleic acids.	PSO1
	CO 2. Gain knowledge of enzymes, their mechanisms of action, and their role in catalyzing biochemical reactions. and learn about enzyme inhibitors and their importance in drug development.	PSO1, PSO2

	CO 3. Understand the role of hormones in regulating various physiological processes, including metabolism and reproduction.		PSO1, PSO2, PSO3	
	CO 4. Understand key metabolic pathways, including carbohydrate, lipid, and protein metabolism, and understand how they are regulated.		PSO2, PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	● Biochemistry: the molecular logic of life. ● Amino acids, proteins, nucleic acids, carbohydrates, and lipids. ● Vitamins and hormones. ● Forces that stabilize biomolecules: electrostatic and Vander Waal's interaction, hydrogen bonding. Interactions with solvents, Hydrophobic effect. ● Basic Thermodynamics: Laws of thermodynamics. Concepts of ΔG, ΔH, and ΔS. ● Chemical kinetics: Concepts of Order and molecularity of a chemical reaction. Derivation of first and second-order rate equation, measurement of rate constants. Concept of activation energy. ● Enzymology: Introduction and classification of enzymes. Types of enzymatic reaction mechanisms, Enzyme kinetics, enzyme inhibition, Regulatory enzymes. Isozymes, Zymogen and Ribozyme. Examples of enzymatic reactions.	**15**	CO1, CO2, CO3	K1,K2
Module 2:	● Basic concepts and design of metabolism - glycolysis, gluconeogenesis ● Pyruvate oxidation, Citric acid cycle, Oxidative phosphorylation; the importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation, inhibitors of electron transport chain. ● Glyoxylate cycle ● The pentose phosphate pathway ● Fatty acid synthesis, β-oxidation; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and the mevalonate pathway	**15**	CO3,CO4	K1, K2

	• Amino acid metabolism; nucleotide metabolism • Photosynthesis and photorespiration			
Pedagogy:	Lectures, tutorials, assignments			
Texts:	1. R. L . Miesfeld, M. M. McEvoy, Biochemistry. Worldwide publisher, 2020. 2. D.L. Nelson, Lehninger Principles of Biochemistry. W.H. Freeman & Co., 2017. 3. D. Papachristodoulou, A. Snape, W. H. Elliott, and D. C. Elliott, Biochemistry and Molecular Biology. Oxford University publisher, 2018. 4. L. Stryer, J. Berg, J. Tymoczko, G.Gatto. Biochemistry New York, Freeman publisher.,2019. 5. D. Voet, J.G. Voet, W.P.Charlotte, Principles of Biochemistry. Wiley publisher, 2012. 6. D. Voet, J.G. Voet, W.P.Charlotte, Fundamentals of Biochemistry. Life at the molecular level. Wiley publisher, 2018.			
References/ Readings:	1. E. E. Abali, S. D. Cline, D. S. Franklin, S. M. Viselli, Lippincott Illustrated Reviews: Biochemistry Wolters Kluwer publisher, 2021. 2. R. . Murray, et al. Harper's llustrated Biochemistry McGraw Hill publisher, 2022.			
Web Resources:	1. https://bio.libretexts.org/Bookshelves/Biochemistry/Fundamentals_of_Biochemistry_(Jakubowski_and_Flatt) 2. https://archive.org/details/FundamentalsBiochemistry4e_201802 3. https://labalbaha.wordpress.com/wp-content/uploads/2014/04/fundamentals-of-biochemistry.pdf			

Title of the Course	Basics of Cell Biology and Genetics
Course Code	GBT-1002
Number of Credits	2
Theory/Practical	Theory
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To provide a foundational understanding of cell biology by exploring the structure, function, and interactions of cellular components essential for comprehending advanced biological systems. • To introduce the structure and function of prokaryotic and eukaryotic cells, including organelles and membranes. • To highlight the roles of biomolecules such as DNA, RNA, and proteins in cellular processes and understand the molecular basis of gene expression, including transcription, translation, and regulation. • To provide information of the key cellular processes such as the cell cycle, cell signalling, and transport mechanisms.	
Course Outcomes:	At the end of the course, the students will be able to:	**Mapped to PSO**
	CO 1. Explain basic fundamental concepts and principles of cell biology, cell theory and cell evolution.	PSO1, PSO2

	CO 2. Describe the structure and function of major cellular components to develop a foundational understanding of advanced cellular processes.		PSO1, PSO2, PSO3	
	CO 3. Explain genetic principles, DNA structure, and chromosome organization		PSO1, PSO2	
	CO 4. Apply – Utilize RNA and ribosome functions in gene regulation and expression		PSO1, PSO2	
	CO 5. Evaluate chromosomal aberrations, polyploidy, repetitive DNA's role in genome stability and mutation		PSO1, PSO2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Biochemical organisation of the cell; diversity of cell size and shape; cell theory, and the emergence of modern Cell Biology. Principles underlying microscopic techniques for the study of cells. Structure and diversity of biological membranes; mechanisms of membrane transport. Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane assembly. Basic cell organelles, structure and function: Cytoskeleton, nucleus, mitochondria, Golgi bodies, endoplasmic reticulum, lysosomes, Chloroplast, peroxisomes, vacuoles. Cell motility.	**15**	CO1, CO2	K1, K2
Module 2:	Mendelian Genetics and Population genetics, Discovery of DNA structure, Structure of DNA - A,B, Z and triplex DNA, Chromosome structure, Telomere, Centromere, Types of RNA, Structure of RNA, Ribosomes, Types of DNA repetitive sequences in DNA, Heterochromatin, Euchromatin, Plasmid as extrachromosomal DNA, DNA polyploidy, Chromosomal aberration and genetic diseases	**15**	CO3, CO4, CO5	K1, K2
Pedagogy:	Lectures, tutorials, assignments			
References/ Readings:	1. Amon, M. Krieger, H. Lodish, , A. Bretscher , C. A. Kaiser, A.Berk , K. C. Martin, H. Ploegh, Molecular Cell Biology. United Kingdom: W. H. Freeman, 2016.			

	2. C. Smith, Wood Cell Biology, Chapman Hall, 2005. 3. G. M. Cooper and R. E. Hausman, The Cell: A Molecular Approach. United States: Sinauer Associates, 2013.

SEMESTER I

Discipline Specific Core (DSC) Courses

Title of the Course	Advanced Genetics and Molecular Biology
Course Code	GBT-5000
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	This course explores molecular mechanisms governing genetic information, focusing on DNA mutation, repair, and transfer in prokaryotic and eukaryotic systems. It covers chromosome organization, gene regulation, transcriptional and translational control, and the central dogma of molecular biology. Students will examine epigenetic regulation, genetic variation, and gene editing technologies, including CRISPR and non-coding RNA applications. Emphasis is placed on DNA replication, cell cycle checkpoints, and nucleocytoplasmic trafficking, providing insights into development	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain fundamental genetic mechanisms like DNA repair, mutation, and horizontal gene transfer in prokaryotes and eukaryotes.	PSO1, PSO2

	CO 2. Apply molecular biology principles to analyze chromosome organization, gene regulation, and RNA transport.		PSO1, PSO2, PSO3	
	CO 3. Evaluate epigenetic regulation and its impact on gene expression, development, and human health.		PSO1, PSO2, PSO3	
	CO 4. Analyze gene editing technologies like CRISPR and non-coding RNA for clinical applications.		PSO1, PSO2, PSO3	
	CO 5. Assess DNA replication fidelity and cell cycle checkpoints in genome stability.		PSO1, PSO2, PSO3	
	CO 6. Design experimental approaches for gene regulation and nucleocytoplasmic trafficking		PSO1, PSO2, PSO3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	DNA: Physical and Chemical agents in Mutation and DNA repair in prokaryotes and eukaryotes. Horizontal gene transfers in prokaryotes and eukaryotes, Transposons, Encoding genetic information and decoding the codon, Central Dogma: Flow of Genetic information, polymerases, Transcriptional and Translational Control.	**15**	CO1, CO2	K2, K3
Module 2:	Chromosome organization, DNA Topology, Mitochondria and chloroplast genome, Nuclear envelope and nucleocytoplasmic trafficking, RNA transport, Structure and role of transcription factors, Genetic variation,	**15**	CO3, CO4	K2, K3
Module 3:	DNA replication and cell cycle checkpoints, Overview of Gene regulation, Mechanisms of Epigenetic regulation, Role of epigenetics in development/ differentiation and human health, Gene editing and silencing: Non-coding RNA and CRISPR in gene regulation and clinical application	**15**	CO5, CO6	K2, K3, K4
Pedagogy:	Lectures, tutorials, assignments			
Texts: **References/ Readings:**	1. D. P. Clark, N. J. Pazdernik and M. R. McGehee, Molecular Biology (3rd) Elsevier Inc, 2019. 2. W. Klug, M. Cummings and C. Spencer, Concepts of Genetics (12ed), Pearson publishers, 2019. 3. E. S. Goldstein , T. Stephen, J. Kilpatrick and J. Krebs, Lewin's gene XII, Bartlett Publishers, 2017. 4. H. F. Lodish, A. Berk, C. Kaiser, M. Krieger and A. Bretscher, Molecular Cell Biology (8 ed) Freeman MacMillan publisher, 2016.			

	5. P. J. Russell, iGenetics: A Molecular Approach, Pearson publisher, 2016. 6. G. arp, J. wasa and W. Marshall, arp's Cell and Molecular Biology: Concepts and Experiments, (8 ed) Wiley Publisher, 2016. 7. M. Strickberger, Genetics, (3 ed) by Pearson publishers, 2015. 8. M. J. Simmons and P. Snustad, Principles of Genetics (7 ed), Wiley Student Edition, 2015. 9. J. D. Watson, T A Baker, S P Bell, A Gann, M Levine and R Losick, Molecular Biology of the Gene, Cold Spring Harbor Laboratory Press, New York, 2014. 10. R. F. Weaver, Molecular Biology (5th ed) McGraw Hill HigheR Education publisher, 2012.
Web Resources:	1. https://dnalc.cshl.edu/ 2. https://csh.com.sg/

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Title of the Course	Cell and Developmental Biology
Course Code	GBT-5001
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	• To enable students to critically understand the structural and molecular dynamics of cellular and developmental processes, and relate these to human health, disease, and therapeutic strategies. • To develop the ability to apply, analyse, and communicate key concepts of cellular and developmental biology across model systems using experimental and visual tools relevant to research and biotechnology.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Critically analyze the structural and functional dynamics of cellular organelles and their roles in maintaining cellular homeostasis and contributing to human diseases.	PSO1, PSO7
	CO 2. Interpret and evaluate molecular mechanisms underlying cell signaling, cytoskeletal dynamics, and intercellular communication, with relevance to therapeutic targeting in biotechnology and biomedical research.	
	CO 3. Describe and explain the basic concepts of development and compare and contrast	

	embryonic development across various model organisms (e.g., *Drosophila*, *Xenopus*, *C. elegans*, zebrafish, and mouse).			
	CO 4. Analyse the role of gene expression and signaling pathways (e.g., Hox genes, Wnt, Hedgehog, Notch) in developmental processes and evaluate experimental techniques (e.g., fate mapping, lineage tracing, gene knockouts) used to study developmental biology.			
	CO 5. To examine the genetic and molecular mechanisms underlying floral induction, photoperiodism, and vernalization.			
	CO 6. Discuss the implications of developmental biology in health and disease, including teratogenesis, stem cell therapy, and congenital disorders and Communicate developmental biology concepts effectively using scientific terminology and appropriate diagrams or models.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1.1. Organelle dynamics and intracellular trafficking: Nucleus, Mitochondria, Ribosome, Endoplasmic reticulum, Golgi apparatus, lysosome, Peroxisome, vacuoles, plastids. 1.2. Organelleopathy ● Mitochondrial Dysfunction in Metabolic and Neurodegenerative Disease ● Endoplasmic Reticulum Stress and Its Role in Disease ● Peroxisomes in Lipid Metabolism and Reactive Oxygen Species Detoxification. ● The Role of Exosomes and Extracellular Vesicles in Intercellular Communication and Disease Progression 1.3. Cytoskeletal Architecture and Cell Motility. 1.4. Cellular communication: General principles of cell communication, cell adhesion and roles of different adhesion molecules, tight junctions, communicating junctions, integrins, neurotransmission, and its regulation.	**15**	CO1, CO2	K1, K2, K3

	1.5. Cell signalling and Signal transduction mechanisms. 1.6. Programmed cell Death, Aging and Senescence.			
Module 2:	2.1. Cancer Biology 2.2. Introduction to Developmental Biology: Significance of developmental Biology, Model organisms and plants used in developmental Biology: Xenopus, Drosophila, C. elegans, Sea Urchin, Chick, Mouse, Zebra fish, Arabidopsis Thaliana, Rice; Basic concepts and overview of Developmental Biology in animals and plants. 2.3. Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination. 2.4. Morphogenesis and organogenesis in animals: Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.	**15**	CO3, CO4	K1, K2, K3
Module 3:	3.1. Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum.Floral induction and organ identity: floral integrator genes, ABCDE model. 3.2. Difference between Plant and Animal Developmental Biology 3.3 Developmental Plasticity and environmental modulation : Photomorphogenesis: Circadian rhythms, Phytochromes; Themosensory flowers and Vernalisation 3.4. Developmental process-oriented disorders and Teratogens: Environmental influence on development, cancer as a developmental disorder, Teratogens: endocrine	**15**	CO3, CO4, CO5 & CO6	K1, K2, K3, K4, K5, K6

	disrupters, alcohol, Retinoic acid and Congenital abnormalities, genetic disorders in development. 3.5. Experimental Techniques in Developmental Biology: Design of CRISPR-Cas9 gene editing strategies, Lineage tracing and fate mapping, Transcriptomics in developmental studies.			
Pedagogy:	Lectures, tutorials, assignments			
Texts: **References/ Readings:**	1. Amon, M. Krieger, H. Lodish, , A. Bretscher , C. A. Kaiser, A.Berk , K. C. Martin, H. Ploegh, Molecular Cell Biology. United Kingdom: W. H. Freeman, 2016. 2. C. Smith, Wood Cell Biology, Chapman Hall, 2005. 3. G. M. Cooper and R. E. Hausman, The Cell: A Molecular Approach. United States: Sinauer Associates, 2013. 4. S. F. Gilbert, Developmental biology. Sinauer Associates, Inc, 2010. 5. J.D. Watson, M. Levine, T. A. Baker, A. Gann, S. P. Bell, R.L. Watson, Molecular Biology of the Gene, Pearson Education, 2014. 6. G. Karp, J. Iwasa, W. Marshall, Cell Biology Global Edition. United States: Wiley, 2018. 7. S. T. Kilpatrick, Krebs, J. E., Goldstein, E. S., Lewin, GENES XII. Japan: Jones; Bartlett Learning, 2017. 8. H. Lodish, and B. Arnold, Molecular Cell Biology, W.H. Freeman & Company, 2000. 9. T. D.Pollard, , W. C. Earnshaw, J. Lippincott-Schwartz, G. Johnson , Cell biology E-book. Elsevier Health Sciences, 2016. 10. J. M. W. Slack, Essential Developmental Biology. Germany: Wiley, 2009. 11. Smith & Wood., Cell Biology, Chapman & Hall London, 2005. 12. M. A. Subramanian, Developmental Biology. India: MJP Publisher, 2022. 13. B. M. Turner, Chromatin and gene regulation: molecular mechanisms in epigenetics. John Wiley; Sons, 2008. 14. L. Wolpert, Developmental Biology: A Very Short Introduction. OUP Oxford, 2011 15. Hake, S., & Zambryski, P.*Plant development*. Cold Spring Harbor Laboratory Press. 1997. 16. Leyser, O., & Day, S.*M echanisms in plant development*. Blackwell Publishing, 2003. 17. Taiz, L., Zeiger, E., Møller, I. M., & Murphy,A. *Plant physiology and development* . Sinauer Associates, 2015.			

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Title of the Course	Bio-analytical Techniques and their Applications
Course Code	GBT-5002
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	The course is designed to provide a • broad exposure to basic techniques used in modern biological science and biotechnology research. • To impart a basic conceptual understanding of the principles of analytical techniques and emphasize the biochemical/bioanalytical utility of the same. • To gain the clear understanding of all analytical techniques such that the barrier to implementing the same is abated.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand the basic concepts and principles of bio-analytical instruments.	PSO1, PSO2
	CO 2. Learn and apply various tools and techniques used for research in biological science.	PSO1, PSO2
	CO 3. Understand the application of advanced bio-analytical instruments in research and data publication.	PSO1, PSO2

	CO 4. Comprehend the advances in instrumentation in biological science areas.		PSO2	
	CO 5. Evaluate the use of appropriate tools/techniques in research.		PSO2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	● Beer-Lambert law, Electromagnetic radiations applicable in various spectroscopic techniques. ● Various energy sources used in spectroscopy techniques ● UV/Visible spectroscopy and its applications in biological sample analysis, ● Fluorescence spectroscopy, Fluorescence correlation spectroscopy, Fluorescence cross-correlation spectroscopy, Application in biochemical methods and molecular dynamics. ● Nuclear magnetic resonance (NMR) Spectroscopy. Application of NMR in biomolecule characterization, identification and molecular confirmation. ● Centrifuge: Basic concepts of centrifugation. Calculation of g-value from RPM. Types of rotors used in centrifuge machines ● Differential centrifugation, Density gradient centrifugation. Rate zonal centrifugation, Isopycnic centrifugation. ● Chromatography Techniques: Paper, TLC, Column, Affinity, Ion-Exchange, Size exclusion, Differential, GC, HPLC.	**15**	CO1, CO2, CO4, CO6	K1, K2, K3, K4 K5
Module 2:	● Microscopy and bioimaging applications. ● Abbey's law of diffraction, Resolution, Magnification, ● Common light sources used in microscopy, ● Types of photon detector and their working mechanism ● Wide-field microscopy, Phase-contrast microscopy, ● Fluorescence microscopy techniques and their principles. ● Emission, Excitation, Quenching, Quantum Yield and Stock shift. ● Confocal microscopy.	**15**	CO1, CO2, CO3. CO4, CO6	K1, K2, K3, K4 K5

	• Spinning-disk microscopy and their applications in biological imaging • Flow Cytometry/FACS			
Module 3:	• Nanoscopy Imaging and super-resolution imaging techniques and their applications: • STORM imaging and PALM imaging, • Light-sheet microscopy imaging and their applications in cell biology study • Atomic force microscopy for biological sample study • Scanning electron microscopy, • Transmission electron microscopy applications in biological material analysis • X-ray diffraction, Protein crystallography and applications • Cryo-electron microscopy and application in molecular structure identification	**15**	CO1, CO2, CO3. CO4, CO5, CO6	K1, K2, K3, K4 K5
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion			
Texts: **References/ Readings:**	1. C.R. Cantor and P.R. Schimmel, Biophysical Chemistry, 2nd Edn., 1982. 2. M.A. Subramaniam, Biophysics: Principle & techniques. MJP Publishers, 2021. 3. K. Salman, and Z. Diaz, Principal and Techniques of Bioinstrumentation. Intelliz Publisher, 2016. 4. J. Frank, Three-Dimensional Electron Microscopy of Macromolecular Assemblies. Academic Press., 2006. 5. I. Tinoco, K. Sauer, J. Wang, and J. Puglisi, Physical Chemistry: Principles and Applications in the Biological Sciences. Prentice Hall, Inc. 2013 6. A. Cooper, Biophysical Chemistry. Royal Society of Chemistry, 2011. 7. K. E. Van-Holde, C. Johnson, Principles of Physical Biochemistry, 3rd Edn. Prentice Hall, 2010. 8. Fatima Merchant, Kenneth Castleman, Microscope Image Processing, Second edition, Academic press, 2022.			
Web Resources:	1. Microscopy Imaging Techniques 2. Imaging & Microscopy - Wiley Analytical Science 3. IDR: Image Data Resource 4. Home | Microtutor 5. ImageJ 6. How to Use a Centrifuge: 14 Steps (with Pictures) - wikiHow			

	7. Microscope Image Processing | ScienceDirect

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Title of the Course	Concepts in Immunology
Course Code	GBT-5003
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	• To provide foundational understanding of immune system components and antigen recognition mechanisms. • To equip students with the ability to analyze and apply immunological principles in understanding immune responses, tolerance, and disease processes relevant to biomedical research.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Identify key cells, organs, and molecular components of the immune system and describe their roles in innate and adaptive immunity	PSO1, PSO2, PSO3
	CO 2. Illustrate the structural and functional organization of MHC molecules and explain how antigens are processed and presented to lymphocytes.	PSO1, PSO2, PSO3
	CO 3. Compare the maturation pathways and activation mechanisms of B and T lymphocytes.	PSO1, PSO2, PSO3
	CO 4. Demonstrate the mechanism of antigen-antibody interactions and evaluate the function	PSO1, PSO2, PSO3

	of immunoglobulins in humoral immune responses			
	CO 5. Gain knowledge on undesirable immunological reactions and their complications in health management and transplantation.		PSO1, PSO2, PSO3	
	CO 6. Interpret clinical immunological disorders such as hypersensitivity and autoimmunity, and apply immunodiagnostic approaches in biomedical contexts		PSO1, PSO2, PSO3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to Immunology** ● History of immunology ● Innate immunity: components, features, and processes ● Acquired immunity: specificity, memory, recognition of self vs. non-self ● Complement system: Nature, components of the complement. **Immune System Architecture** ● Hematopoiesis and differentiation ● Myeloid and lymphoid lineages ● Cells of the immune system: B cells, T cells, macrophages, dendritic cells, NK cells, mast cells, eosinophils ● CD markers and lymphocyte subpopulations ● Organization of lymphoid organs: Thymus, Bone marrow, Spleen, Lymph nodes, MALT, GALT, SALT **Antigen Recognition and Presentation** ● Nature of antigens, haptens, epitopes, carriers, superantigens, and adjuvants ● Major Histocompatibility Complex (MHC): o Discovery, structure (Class I and II), and peptide-binding o Role in immune response and restriction ● Antigen processing and presentation to CD4+ and CD8+ T cells	**15**	CO1, CO2	K1, K2

	● Antigen receptors (BCR, TCR) and accessory molecules of T cells			
Module 2:	**Humoral Immunity** ● Immunoglobulins: structure, types, distribution, and functions ● Antibody production: primary vs. secondary responses ● Antibody diversity: Somatic recombination, V (D) J recombination, Combinatorial diversity, Junctional diversity. **Cell-Mediated Immunity** ● T cell subsets (Th1, Th2, Th17, Treg) and their roles ● Antibody-dependent cell-mediated cytotoxicity (ADCC) **Lymphocyte Maturation and Activation** ● General features of lymphocyte maturation ● Gene rearrangements of antigen receptors in B & T cells ● B and T cell maturation pathways ● T cell activation: o Signal transduction pathways (Ras/Rac, Calcineurin, PKC) o Activation of transcription factors (NFAT, AP-1, NF-κB) ● B cell activation: o BCR signaling and coreceptors o Role of CD40 and T-B cooperation o Bidirectional molecular interactions	**15**	CO3, CO4	K2,K3
Module 3:	**Clinical Immunology and Biomedical Diagnostics** ● **Hypersensitivity** (HS), Types, clinical diseases. ● **Cancer Immunology**: Common types of Cancer, Malignant transformation of Cells, Tumor Antigens, Cancer immunotherapy ● **Autoimmunity:** Introduction, classes of autoimmunity diseases(Hashimoto disease, thyrotoxicosis, Systemic lupus erythematosus, Autoimmune haemolytic anaemia, Rheumatoid arthritis).	**15**	CO5, CO6	K4, K5

	• **Transplantation**: Terminology, Auto graft, Isograft, Allograft, Xenograft, Immunological basis of transplantation reactions, GVH reaction. • **Immunosuppression:** General mechanisms of immunosuppression, immunosuppression drugs. • **Immune Deficiencies**: Introduction, primary and secondary deficiencies. T-cell, B-cell and combined immune deficiencies, Compliment system deficiency. AIDS, SCID • **Immunological techniques**. Radioimmunoassay: RIA, ELISA, ELISPOT, Western Blot. Immuno-fluorescence based imaging techniques, flow cytometry, magnetic activated cell sorting.			
Pedagogy:	Lectures/Tutorials/Assignments/Seminar			
Texts: **References/ Readings:**	1. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2016). *Basic immunology: Functions and disorders of the immune system* (5th ed.). Elsevier. ISBN 9780323390828 2. Murray, P. R., Rosenthal, K. S., & Pfaller, M. A. (2016). *Medical microbiology* (8th ed.). Elsevier. ISBN 9780323299565 3. Murphy, K., & Weaver, C. (2017). *Janeway's immunobiology* (9th ed.). Garland Science/Taylor & Francis Group. ISBN 9780815345053 4. Burton, D. R., Delves, P. J., Martin, S. J., & Roitt, I. M. (2011). *Roitt's essential immunology* (Includes desktop edition). Wiley. ISBN 9781405196833 5. Brostoff, J., Male, D. K., & Roitt, I. M. (2001). *Immunology*. Mosby. ISBN 9780723431893 6. Luttmann, M., Bratke, K., Kupper, M., & Myrtek, D. (2006). *Immunology*. Academic Press. ISBN 9780120885442 7. Owen, J.A., Punt, J., Stranford, S. A., & Jones, P.(2013) *Kuby immunology* (7th ed.). W. H. Freeman. ISBN-10: 1-4641-3784-6 8. Kimball, J. W. (1990). *Introduction to immunology*. Macmillan. ISBN 9780023646119 9. Weir, D. M. (Ed.). (1996). *Weir's handbook of experimental immunology* (Vols. 1– 4).Wiley. ISBN 9780865427984			

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Title of the Course	Lab I: Cell and Molecular Biology
Course Code	GBT-5004
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To develop practical skills in cell biology techniques, including microscopy, cell organelle staining, cell fractionation, and analysis of mitosis, meiosis, and karyotyping for understanding cellular structure and function. • To train students in evaluating cell health and behaviour through viability assays, apoptosis detection, and flow cytometry, and prepare them for applications in biomedical and research settings. • To provide students with experimental knowledge of molecular biology • To understand the concept of mutation and gene transfer processes	
Course Outcomes		**Mapped to PSO**
	CO 1. Demonstrate the use of various imaging techniques to study cell morphology and structure using phase contrast, fluorescence, SEM, and TEM.	PSO1, PSO2, PSO3
	CO 2. Perform cell organelle-specific staining methods to visualize mitochondria, nucleus, golgi bodies and cell fractionation to isolate nuclei, mitochondria, and other organelles.	PSO1, PSO2, PSO3

	CO 3. Assess and interpret cell viability and cytotoxic effects using MTT and Trypan Blue assays, Detect and analyze apoptosis using DNA laddering or Annexin V-FITC/PI staining techniques.		PSO1, PSO2, PSO3	
	CO 4. Conduct essential molecular biology experiments, genomic/metagenomic DNA isolation and RNA extraction using molecular techniques and quantification, and interpret gel electrophoresis results		PSO1, PSO2, PSO3	
	CO 5. Perform gene transfer methods (conjugation, transformation) and mutagenesis for genetic modifications in prokaryotes.		PSO1, PSO2, PSO3	
	CO 6. Design and implement mutation screening protocols (UV/chemical mutagenesis, replica plating) for auxotroph identification.		PSO1, PSO2, PSO3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1.1 Cell Imaging Techniques for Cell morphological characterisation: Phase contrast and fluorescent Microscopy, Scanning and Transmission Electron Microscopy 1.2 Cell organelles staining techniques: Mitochondria, Nucleus, Golgi bodies 1.3 Cell fractionation / Isolation of the cell organelles: Nuclei, Mitochondria and other organelles 1.4 Cell Viability Test: MTT or Trypan Blue 1.5 Detection of Apoptosis by DNA laddering or Annexin V staining 1.6 Flow cytometry demonstration 1.7 Mitosis and Meiosis 1.8 Karyotyping demonstration	**30**	CO1, CO2, CO3, CO4, CO5	K3, K4, K5, K6
Module 2:	2.1 Genomic DNA isolation 2.2 UV/Chemical mutagenesis isolation of amino acid auxotroph by replica plating. 2.3 Gene transfer by conjugation 2.4 Gene transfer by transformation 2.5 Metagenomic DNA isolation	**30**	CO4, CO5, CO5	K4, K5, K6

	2.6 RNA isolation			
Pedagogy:	Hands-on experiments in the laboratory, online videos.			
Texts: **References/ Readings:**	1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell* (6th ed.). Garland Science. 2. Bozzola, J. J., & Russell, L. D. (1999). *Electron Microscopy: Principles and Techniques for Biologists* (2nd ed.). Jones & Bartlett Learning. 3. Pendergrass, W., Wolf, N., & Poot, M. (2004). Efficacy of MitoTracker Green and CMXRosamine for mitochondrial staining in live cells. *Cytometry Part A*, 61(2), 162–169. https://doi.org/10.1002/cyto.a.20033 4. Kapuscinski, J. (1995). DAPI: A DNA-specific fluorescent probe. *Biotech Histochemistry*, 70(5), 220–233. https://doi.org/10.3109/10520299509108199 5. Cole, N. B., Sciaky, N., Marotta, A., Song, J., & Lippincott-Schwartz, J. (1996). Reversible assembly of GFP-tagged Golgi elements in living cells. *The Journal of Cell Biology*, 134(4), 757–773. https://doi.org/10.1083/jcb.134.4.757 6. Graham, J. M. (2002). Isolation of mitochondria from tissues and cells by differential centrifugation. *Current Protocols in Cell Biology*, 3(1), 3.3.1–3.3.15. https://doi.org/10.1002/0471143030.cb0303s00 7. Mosmann, T. (1983). Rapid colorimetric assay for cellular growth and survival: Application to proliferation and cytotoxicity assays. *Journal of Immunological Methods*, 65(1–2), 55–63. https://doi.org/10.1016/0022-1759(83)90303-4 8. Strober, W. (2001). Trypan blue exclusion test of cell viability. *Current Protocols in Immunology*, Appendix 3B. https://doi.org/10.1002/0471142735.ima03bs21 9. Wyllie, A. H. (1980). Glucocorticoid-induced thymocyte apoptosis is associated with endogenous endonuclease activation. *Nature*, 284(5756), 555–556. https://doi.org/10.1038/284555a0 10. Koopman, G., Reutelingsperger, C. P. M., Kuijten, G. A. M., Keehnen, R. M. J., Pals, S. T., & van Oers, M. H. J. (1994). Annexin V for flow cytometric detection of phosphatidylserine expression on B cells undergoing apoptosis. *Blood*, 84(5), 1415–1420. https://doi.org/10.1182/blood.V84.5.1415.bloodjournal8451415 11. Robinson, J. P. (Ed.). (2018). *Current Protocols in Cytometry*. Wiley. 12. Shapiro, H. M. (2003). *Practical Flow Cytometry* (4th ed.). Wiley-Liss. 13. Rooney, D. E. (2001). *Human Cytogenetics: Constitutional Analysis* (Vol. 1, 3rd ed.). Oxford University Press.			

	14. Barch, M. J., Knutsen, T., & Spurbeck, J. L. (1997). *The ACT Cytogenetics Laboratory Manual* (3rd ed.). Lippincott-Raven. 15. R.K. Sharma and S.P.S Sangha, Basic Techniques in Biochemistry and Molecular Biology Dream Tech Press, 2020. 16. S. K. Gakhar, M. Miglani and A Kumar, Molecular Biology: A Laboratory Manual. Rupa Publications, 2019. 17. Hofmann, Wilson and Walkers Principles and Techniques Of Biochemistry And Molecular Biology, Cambridge University Press, 2018. 18. R. Green and J. Sambrook, Molecular Cloning: A Laboratory Manual (Fourth Edition): Three-volume set, 2012. 19. S. John Vennison, Laboratory Manual for Genetic Engineering 1st Edition, PHI Learning, 2009.

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Title of the Course	Lab II: Bioanalytical Techniques and Immunodiagnostics
Course Code	GBT-5005
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	The objective of this laboratory course is to • To equip students with practical skills in immunodiagnostic techniques for interpreting immune interactions in diagnostics and research. • Teach the utility of experimental methods/analytical techniques in a problem-oriented manner.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply immunodiffusion and agglutination techniques to detect and quantify antigen-antibody interactions in various immunodiagnostic formats.	PSO1, PSO2
	CO 2. Analyze antigenic similarities and concentration gradients using radial and double immunodiffusion assays.	
	CO 3. Evaluate the sensitivity and specificity of different immunoassays.	

	CO 4. Demonstrate the utility of analytical techniques in a problem-oriented manner.			
	CO 5. Hands-on-training of instrumentation techniques for biological science applications			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. UV-Visible spectroscopy instrument demonstration and experimentation 2. Chromatography Techniques: Paper, TLC, Affinity, Ion-Exchange, Size exclusion, Differential, GC, HPLC. 3. Biochemical assays using ELISA plate reader. 4. Fluorescence spectroscopy assay 5. Compound microscope demonstration and appropriate sample analysis under bright-field 6. Analysis of a biological specimen by SEM 7. Demonstration of fluorescence microscopy and imaging of fixed stained and live cells 8. Density gradient ultracentrifugation	**30**	CO1, CO2, CO3	K3, K4, K5
Module 2:	**Immunodiagnostics** 1. Determination of Antibody titre using Double Immunodiffusion assay. 2. Assessment of Similarity between antigens using Ouchterlony's Double Diffusion Test. 3. Estimation of Antigen Concentration using Radial Immunodiffusion. 4. Quantitative Precipitation Assay 5. DOT ELISA 6. Latex Agglutination 7. Immunoelectrophoresis 8. Rocket Immunoelectrophoresis 9. Slide / Tube agglutination Tests	**30**	CO4, CO5	K3, K4, K5

Pedagogy:	Hands-on experiments in the laboratory, Demonstrations, tutorials
Texts:	1. G. John Biological Centrifugation CRC Press, 2020. 2. B. S. Prakash, Bisen, Laboratory Protocols in Applied Life Sciences., Taylor and Francis Publisher, 2014. 3. K. Ulrich, Fluorescence microscopy: From Principle to application, Wiley Int., 2017. 4. K. Wilson, J. Walker, (Eds)., Principles and techniques of biochemistry and molecular biology. Cambridge university press, 2010. 5. G.P. Talwar, S.K Gupta. A Handbook Of Practical And Clinical Immunology Vol I CBS Publishers, 2017. 6. K.R. Joshi, N.O. Osama, Immunology. 5th Edition, Agrobios Ltd, India, 2012. 7. F.C. Hay, O. M.R. Westwood, Practical Immunology, 4th edition, 2008. 8. B. Detrick, R.G. Hamilton, J.D. Folds, et al. eds. Manual of Molecular and Clinical Laboratory Immunology. 7th ed. Washington, DC: ASM Press, 2006.

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Discipline Specific Elective Courses

Title of the Course	Computational Biology and Data Analysis
Course Code	GBT-5201
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	• To provide foundational and advanced knowledge of computational tools and techniques—including biological databases, sequence analysis, structural bioinformatics, and drug design—for understanding molecular biology and biomolecular interactions. • To develop practical skills in omics data analysis, machine learning, and systems biology, enabling students to analyze complex biological datasets, build predictive models, and derive integrative, systems-level insights.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Demonstrate understanding and application of biological databases, sequence analysis, and phylogenetic methods.	PSO1, PSO3, PSO4
	CO 2. Interpret and analyze protein structures and predict their conformations using	PSO3, PSO4

	bioinformatics tools and modeling techniques.			
	CO 3. Apply structural bioinformatics and chemoinformatic techniques to design biologically active molecules and understand drug-target interactions.		PSO3, PSO4, PSO5	
	CO 4. Execute NGS and omics data analysis pipelines and interpret transcriptomic, genomic, and functional annotation outputs.		PSO3, PSO4	
	CO 5. Employ data mining and machine learning methods to extract patterns, classify biological datasets, and evaluate model performance.		PSO3, PSO4	
	CO 6. Integrate multi-omics data and visualize biological networks to infer functional and systemic insights in computational biology.		PSO3, PSO4, PSO5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to Biological Databases:** Classification of databases—primary, secondary, and specialized (NCBI, ENSEMBL, RefSeq, UniProt, Expression Atlas, HMDB or KEGG, PDB). **Sequence Analysis and Alignment:** Basics of sequence formats, annotation, and description. Principles of sequence alignment—local vs. global (BLAST, Smith-Waterman, Needleman-Wunsch), Pairwise and multiple sequence alignment (Clustal, MUSCLE), Scoring matrices (PAM, BLOSUM), distance matrices, substitution scores, gap penalties, Statistical significance and evolutionary rationale behind sequence alignments, Motif and pattern identification. **Phylogenetics and Molecular Evolution:** Concepts of molecular evolution and tree-building., Methods: UPGMA, Neighbor-Joining, Maximum Parsimony, Maximum Likelihood, Bayesian inference, Tree evaluation and visualization tools, Comparative discussion of algorithms and their applications in molecular systematics. **DNA Barcoding and Molecular Taxonomy:** Principles and workflow of DNA barcoding, Tools and databases, BOLD, NCBI Taxonomy, and CBOL guidelines, Applications in species identification, biodiversity studies, and taxonomy, Limitations and considerations in marker choice and data analysis.	**15**	CO1, CO5	(K1, K2, K3, K4)

Module 2:	**Protein Structure Hierarchy and Classification:** Overview of protein structural organization—primary, secondary, tertiary, and quaternary structures. Introduction to structural classification databases such as CATH (Class, Architecture, Topology, Homologous superfamily), SCOP (Structural Classification of Proteins), FSSP (Families of Structurally Similar Proteins). **Structural Bioinformatics and Molecular Modelling:** Fundamentals of molecular representation using external and internal coordinates. Introduction to molecular mechanics and force fields. Visualization and simulation of protein 3D structures. Analysis of peptide bonds, torsion angles, and the Ramachandran map. Anatomy of protein domains and folds. **Protein Structure Prediction Methods:** Principles of protein folding and sequence–structure relationships. Approaches to structure prediction such as Homology (Comparative) Modeling, Fold Recognition and Threading, Ab initio Modeling, Emerging AI-based approaches (e.g., AlphaFold), Overview of CASP (Critical Assessment of Structure Prediction) benchmarks. **Computational Design Applications:** In silico design of proteins, enzymes, and synthetic promoters. **Chemoinformatics and Drug Discovery:** Introduction to chemical structure databases (e.g., NCI, PubChem). Fundamentals of receptor-ligand interactions. Structure-Based Drug Design (Binding site identification, docking, and virtual screening), Ligand-Based Drug Design (SAR, QSAR modeling, and pharmacophore development).	**15**	CO2, CO3	(K2, K3, K4, K5, K6)
Module 3:	**Next-Generation Sequencing (NGS) Data Handling:** Overview of sequencing platforms; file formats including FASTQ, BAM, SAM, and VCF; data preprocessing and quality control. **Genome Assembly and Annotation Pipelines:** Sequencing technologies; short-read vs. long-read platforms, Concepts: read trimming, genome complexity, contigs, scaffolds, N50, and coverage, Overview of genome annotation methods (gene prediction, functional annotation). **Transcriptome Data Analysis:** Quality assessment using FastQC, read alignment	**15**	CO4, CO5, CO6	(K3, K4, K5, K6)

	using HISAT2 or STAR, transcript quantification, and differential gene expression analysis. **Functional Enrichment and Pathway Analysis:** Gene Ontology annotation; KEGG and Reactome-based biological pathway analysis for interpretation of gene expression changes. **Omics Data Integration:** Brief overview of analytical workflows in metagenomics, proteomics, and metabolomics for comprehensive biological insights. **Network Biology:** Introduction to gene and protein interaction networks; network visualization and basic analysis for understanding system-level organization. **Exploratory Data Analysis:** Techniques such as boxplots, principal component analysis, and correlation matrices for pattern discovery and data quality assessment. **Machine Learning:** Supervised, semi-supervised, and unsupervised learning approaches, Clustering methods and dimensionality reduction techniques for high-dimensional biological data.			
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion			
Texts: **References/ Readings:**	1. Mount, D. W. (2004). Bioinformatics: Sequence and Genome Analysis (2nd ed.). Cold Spring Harbor Laboratory Press. 2. Lesk, A. M. (2019). Introduction to Bioinformatics (5th ed.). Oxford University Press. 3. Xiong, J. (2006). Essential Bioinformatics. Cambridge University Press. 4. Bourne, P. E., & Weissig, H. (Eds.). (2003). Structural Bioinformatics. Wiley-Liss. 5. Leach, A. R. (2001). Molecular Modelling: Principles and Applications (2nd ed.). Pearson. 6. Gasteiger, J., & Engel, T. (Eds.). (2003). Chemoinformatics: A Textbook. Wiley-VCH. 7. Deonier, R., Tavaré, S., & Waterman, M. (2005). Computational Genome Analysis: An Introduction. Springer. 8. Berrar, D., Dubitzky, W., & Granzow, M. (2003). A Practical Approach to Microarray Data Analysis. Springer. 9. Chicco, D., & Jurman, G. (2021). Machine Learning and Data Mining in Bioinformatics. Springer.			
Web Resources:	1. https://pubchem.ncbi.nlm.nih.gov 2. https://usegalaxy.org 3. https://www.coursera.org/specializations/genomic-data-science			

	4. https://www.ebi.ac.uk/training/online/ 5. https://www.ensembl.org 6. https://www.genome.jp/kegg

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Title of the Course	Lab III: Computational Biology & Data Analysis
Course Code	GBT-5202
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	• To enable hands-on experience with key bioinformatics databases, UNIX/Linux environments, and structure-based drug design for real-world biological problem-solving. • To develop practical proficiency in computational tools for biological data analysis, including sequence alignment, gene prediction, phylogenetics, and protein structure modelling.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Recall and Apply shell commands essential for data handling, database navigation and retrieve information from public databases.	PSO1, PSO2
	CO 2. Involves analytical thinking to compare sequences, build evolutionary trees, and understand gene structure across organisms.	PSO3, PSO4
	CO 3. Requires critical assessment of structural bioinformatics outputs and their biological relevance, particularly in drug discovery contexts.	PSO3, PSO4, PSO6

	CO 4. Demonstrates students' ability to integrate multiple tools and concepts to develop novel workflows or protocols in a lab or research context.		PSO4, PSO5, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Basic UNIX/Linux shell commands essential for handling biological data, navigating file systems, and running command-line bioinformatics tools. 2. Hands-on introduction to databases (NCBI, UniProt, PDB, KEGG, etc.) for navigation and data retrieval. 3. Use of different BLAST algorithms; analysis and interpretation of alignment scores, E-values, and identity matrices. 4. Multiple sequence alignment and phylogenetic analysis of nucleotide and protein sequences using tools like ClustalW, MEGA, or PhyML. Comparison of different tree-building methods. 5. Application of ab initio gene prediction programs such as GeneMark and Genscan for prokaryotic and eukaryotic gene structure identification. 6. Use of tools like Primer3, NEB Cutter, and online resources for PCR primer design and identification of restriction enzyme cleavage sites. 7. Perform assembly and genome annotation 8. Construction, visualization, and annotation of 3D protein structures using molecular viewers such as RasMol or Swiss-PDBViewer. 9. Introduction to structure-based drug design; docking ligands to protein targets using SwissDock and interpretation of docking scores and poses.	**30**	CO1, CO2, CO3, CO4	(K1, K2, K3, K4, K5, K6)
Pedagogy:	Practical/ tutorials/assignments/Hands-on- training			
Texts: **References/ Readings:**	1. A.D. Baxevanis, G.D. Bader, D.S. Wishart, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins Wiley Publisher, 2020. 2. S. Shui Qing, Bioinformatics: A Practical Approach (Chapman; Hall/CRC Mathematical and Computational Biology), 2007. 3. N.C. Jones, and P.A. Pevzner; Introduction to Bioinformatics Algorithms; Ane Books, India, 2004.			

	4. D.W. Mount, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press, 2001. 5. Zhumur Ghosh & Bibekanand Mallick, *Bioinformatics: A Practical Guide in the Post-Genomic Era* (2nd ed.). Oxford University Press. 2022
Web Resources:	https://info-ee.surrey.ac.uk/Teaching/Unix/ https://www.genome.jp/kegg https://www.ebi.ac.uk/training/online/ https://www.ncbi.nlm.nih.gov/home/tutorials/ https://www.coursera.org/specializations/bioinformatics

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Title of the Course	Environmental Biotechnology and Sustainability
Course Code	GBT-5203
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To impart knowledge on Biotechnological applications. • To understand the application of biotechnological techniques to solve the environmental challenges. • To understand the impact of genetic manipulation, genomics, and proteomics in environmental biotechnology. • To study the application of new techniques that drive the refinement and improvement of existing biotechnological methods and tools. • Case studies in the context of real problems, enabling the students to better understand how the theory is applied in practice, evaluate the environmental pollution and decide about treatment methods.	
Course Outcomes:	Students will be able to	**Mapped to PSO**
	CO 1. Understand and relate the biotechnology knowledge to environmental challenges.	PSO4, PSO5
	CO 2. Apply their knowledge to analyse environmental pollution.	

	CO 3. Evaluate the environmental pollution and decide about treatment methods.			
	CO 4. Apply their knowledge for the application of sustainable biotechnological processes			
	CO 5. Create solutions for betterment of the environment and sustainable development of the society.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	● Environmental Biotechnology and Sustainability: Scope and applications, Basics of ecosystem structure and function ● Environmental Monitoring: Monitoring environmental pollution-Air, water and soil sampling, Analyses of samples. Physical, chemical, biological and molecular methods for the measurement of pollution. ● Bioindicators, Robust techniques and innovative new concepts for identifying and screening of toxins and pathogens in the environment (genetic and biochemical kits and reagents, and cellular models), e-DNA and Nucleic acid based techniques for analyses of diversity, structure and dynamics of microbial community in wastewater treatment, ● Biomarkers, Toxicity testing using biological materials.	**15**	CO1, CO2	K1, K2, K3
Module 2:	● Sewage Treatment: Sewage treatment methods, Recovery of Nitrogen and Phosphorus, Sludge treatment and disposal. ● Solid waste treatment: Waste Management for Sustainable Development, Anaerobic digestion, Vermicomposting. ● Biotechnology and Sustainable techniques: Genetically manipulated organisms, Nanotechnology in wastewater treatment units, Application of nanomaterials in environmental remediation, Potential modification of wastewater treatment by employing nanomaterials, ● Removal of pollutants using nanofiltration techniques, Nanomembranes in wastewater treatment, Nanomaterial based disinfection. ● Bioremediation: Bioremediation strategies, Phytoremediation; Bioremediation	**15**	CO2, CO3	K1, K2, K3

	Techniques, constructed wetland, Metal Bioremediation, Biochemical Pathways of degradation, Plastic degradation			
Module 3:	• Sustainability: Plant and microbes as a source of chemicals, Microbial polymers, Biodegradable plastic, Biofuels, Bioleaching, Carbon Storage and Capture (sequestration, conversion to useful biopolymers, etc.) • Biotechnology of the Marine Environment: Bioprospecting, Marine Pollution and its control. • Sustainable Development and Environment friendly practices • Case studies: Bioremediation, Carbon Storage and Capture, Bioenergy.	**15**	CO3, CO4, CO5	K3, K4 K5, K6
Pedagogy:	Lectures/tutorials/assignments/ online/self-study			
Texts:	1. Scragg, A. (2005). Environmental Biotechnology. Pearson Education Limited, Oxford University Press. Second edition. 2. Rehm, H. J. and Reed, G. (Eds.). (1999). Biotechnology, a comprehensive treatise. 3. Chaterjee, A. K. (2000). Introduction to environmental biotechnology. PHI, India, 4. Colin, M. (2011). Marine Microbiology: Ecology and applications. Second edition. Garland science. 5. Satyanarayana, T. Johri, B. and Anil, T. (Ed.). (2012). Microorganisms in Environmental Management. Springer Publishers. 6. King, R. B., Sheldon, J. K., and Long, G. M. (2019). Practical Environmental 7. Willey, J. M., Sherwood, L. M., Woolverton, C. J. (2017). Prescott,s Microbiology. (10th Ed.). Mcgraw-Hill Education.			
References/ Readings:	1. Bioremediation: The Field Guide, Lewis Publishers. CRC Press. 2. Meena, S. M. and Naik, M. M. (Ed.). (2019). Advances in Biological Science Research: a practical approach. (1st Ed.). Elsevier.			
Web Resources:	1. https://www.epa.gov/ 2. https://cpcb.nic.in/ 3. https://goaspcb.gov.in/other-publications/ 4. https://gwmc.goa.gov.in/download/-			

Title of the Course	Lab IV: Environmental Biotechnology
Course Code	GBT-5204
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To impart students with the hands-on experience in basic experimental analysis and the use of biological agents. • To understand emerging treatment processes carried out for the wastewater and organic solid waste analysis	
Course Outcomes:		**Mapped to PSO**
	CO 1. To analyse municipal wastewater	PSO1, PSO2, PSO4, PSO5
	CO 2. To analyse solid organic waste	
	CO 3. Analyse and evaluate the process of organic waste treatment.	
	CO 4. To relate the knowledge of Environmental Biotechnology with organic waste analysis.	

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Estimation of Total solids and Volatile solids in organic waste 2. Biochemical methane potential assay 3. COD analysis of the wastewater 4. BOD analysis of the wastewater 5. Total Organic Carbon analysis in wastewater 6. Total Nitrogen analysis in wastewater 7. Total Phosphorus analysis in wastewater 8. Struvite precipitation from wastewater and its analysis by XRD	**30**	CO1, CO2, CO3, CO4	**K2** **K3** **K4** **K5** **K6**
Pedagogy:	Hands-on experiments in the laboratory, online videos.			
Texts:	1. APHA. "Standard Methods for Examination of Water and Wastewater", American Public Health Association WWA, Washington, D.C., 2005. 2. Angelidaki I , Alves M, Bolzonella D, Borzacconi, L. Campos, J.L., Guwy, A.J., Kalyuzhnyi, S., Jenicek P., and Van Lier, J.B., Defining the Biomethane Potential (BMP) of Solid Organic Wastes and Energy Crops: A Proposed Protocol for Batch Assays. Water Science & Technology, 2009.			
References/ Readings:	Scragg, A. (2005). Environmental Biotechnology. Pearson Education Limited, Oxford University Press. Second edition.			
Web Resources:	1. https://www.epa.gov/ 2. https://cpcb.nic.in/ 3. https://goaspcb.gov.in/other-publications/ 4. https://gwmc.goa.gov.in/download/-			

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SEMESTER II

Discipline Specific Core Courses

Title of the Course	Biomanufacturing and Bioprocess Technology
Course Code	GBT-5006
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	GBT-1000, GBT-1001	
Course Objectives:	To enable students to understand bioprocess principles, bioreactor and downstream operations, and design optimized biotechnological processes for industrial and research applications.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Describe the principles of bioreactor design and operation, and differentiate between types and modes of fermentation processes (batch, fed-batch, and continuous).	PSO1, PSO2
	CO 2. Apply knowledge of microbial isolation, screening, preservation, and media formulation for optimizing industrial bioprocesses.	PSO1, PSO2, PSO3

	CO 3. Analyze the strategies for strain improvement and demonstrate understanding of microbial production processes for industrially significant products such as alcohol, organic acids, antibiotics, amino acids, biopharmaceuticals, and biomass.		PSO3, PSO4, PSO5	
	CO 4. Explain and assess key downstream processing operations such as separation, purification, drying, crystallization, and packaging of bioproducts.		PSO4, PSO5, PSO6	
	CO 5. Evaluate the design and application of immobilized cell systems and assess the impact of effluent treatment and disposal methods on environmental sustainability.		PSO4, PSO5, PSO6, PSO7	
	CO 6. Monitor and control bioprocess parameters such as aeration, agitation, sterilization, and measurement systems to ensure optimal bioprocess performance.		PSO4, PSO5, PSO6, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Basic Principles of Biochemical Engineering and Fermentation Processes**: ● Bioreactors, bioreactor design, criteria, operation and types of bioreactors. ● Concepts of basic modes of fermentation: batch, fed- batch and continuous ● Isolation, screening, and preservation of industrially important microbes ● Design and formulation of Media for industrial bioprocess ● Scale up fermentation processes ● Air and media sterilization. ● Aeration and agitation in bioprocess. ● Measurement and control of bioprocess parameters.	**15**	CO1, CO2	K1, K2, K3, K4, K5
Module 2:	**Industrial production of chemicals:** ● Strain improvement for increased yield and other desirable characteristics ● alcohol (beer), biopharmaceuticals (vaccines) ● organic acids (citric acid) ● antibiotics (Penicillin/streptomycin) ● amino acids (lysine/glutamic acid)	**15**	CO2, CO3	K2, K3, K4, K5

	● Bioprocess for the production of biomass: yeast and mushrooms			
Module 3:	**Downstream Processing:** ● Steps involved in Downstream processing; bio-separation, filtration, centrifugation, sedimentation, flocculation, cell disruption, liquid- liquid extraction. ● Purification by chromatographic techniques ● Drying and crystallization. ● Immobilization of microbial cells, immobilized reactors & their applications. ● Handling and Disposal of industrial effluent	**15**	CO4, CO5, CO6	K1, K2, K3, K4, K5, K6
Pedagogy:	Lectures, tutorials, assignments.			
Texts:	1. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology* (3rd ed.). Butterworth-Heinemann. 2. Peppler, H. J., & Perlman, D. (Eds.). (1979). *Microbial technology: Fermentation technology* (2nd ed.). Academic Press. 3. El-Mansi, E. M. T., Bryce, C. F. A., Demain, A. L., & Allman, A. R. (Eds.). (2006). *Fermentation microbiology and biotechnology* (2nd ed.). CRC Press. 4. Chen, H. (2013). *Modern solid state fermentation: Theory and practice*. Springer. 5. Smith, J. E. (2009). *Biotechnology* (5th ed.). Cambridge University Press. 6. Todaro, C. M., & Vogel, H. C. (2014). *Fermentation and biochemical engineering handbook* (3rd ed.). William Andrew Publishing. 7. Lancini, G., & Lorenzetti, R. (2013). *Biotechnology of antibiotics and other bioactive microbial metabolites*. Springer. 8. Palmer, T., Bonner, P., (2008) *Enzymes Biochemistry, Biotechnology, Clinical chemistry*, Wood Head Publishing, 2nd Edition			
References/ Readings:	1. Pauline M. Doran, Bioprocess Engineering Principles. Academic Press, 1995 2. Rao D.G., Introduction to Biochemical Engineering. Tata McGraw-Hill, 2005			
Web Resources:	1. https://www.openaccessjournals.com/journals/pharmaceutical-bioprocessing-citations-report.html			

	2. www.wildfermentation.com/JohnSchollarandBenedikteWatmore,PracticalFermentation-atechnicalguide 3. web.mit.edu/professional/short.../fermentation_technology.html 4. https://4lfonsina.wordpress.com/wp-content/uploads/2012/11/industrial-microbiology-an-introduction-0632053070-wiley.pdf

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Title of the Course	Recombinant DNA Technology
Course Code	GBT-5007
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	GBT-5000	
Course Objectives:	To understand: • Various enzymes and techniques for manipulating DNA. • Various DNA vectors and their use in creating recombinant DNA molecules • Recombinant DNA modification techniques and heterologous gene expression used for creating applications for biological research and biotechnology industries.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the role of DNA modifying enzymes in recombinant DNA technology.	PSO1, PSO2
	CO 2. Utilize linkers, adaptors, and hybridization probes for molecular cloning and hybridization respectively	PSO1, PSO2
	CO 3. Evaluate genomic analysis techniques like DNA fingerprinting and sequencing	PSO1, PSO2

	CO 4. Assess the efficiency of PCR variants and molecular diagnostic approaches		PSO1, PSO2	
	CO 5. Design experiments using CRISPR and gene therapy applications.		PSO1, PSO2	
	CO 6. Implement advanced cloning vectors for recombinant DNA research.		PSO1, PSO2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	DNA modifying enzymes used in recombinant DNA technology: Type II restriction enzymes, Klenow fragment, T4/T7 DNA polymerases, Reverse transcriptase, Ligases, Kinases, phosphorylases, Terminal transferases, thermostable polymerases, Nucleases, reverse transcriptase. Use of linkers and adaptors in cloning, Non-radiolabeled probes in hybridization.	**15**	CO1, CO2	K1, K2, K3
Module 2:	Southern and Western Blotting, DNA fingerprinting, DNA foot-printing, NGS sequencing, Variants of PCR techniques, real-time PCR, M13 and Phage Display, cDNA library, PCR and applications, Gene therapy, CRISPR application in health.	**15**	CO3, CO4, CO5	K3, K4
Module 3:	Cloning Vectors: - pET Series Vectors,- Gateway Cloning Vectors,- BAC & YAC Vectors,- Lentiviral Vectors, CRISPR-Based Vectors, Golden Gate Cloning Vectors, Expression Vectors, TALEN vectors, Synthetic Biology Vectors, Vectors for gene silencing.	**15**	CO6	K5 K6
Pedagogy:	Lectures, Tutorial			
Texts: **References/ Readings:**	1. T. A. Brown, Gene Cloning and DNA Analysis: An Introduction, Wiley-Blackwell Publishers, 2016. 2. T. A Brown, Genomes, New York: Garland Science Publisher, 2017. 3. J. W. Dale, M. von Schantz and N. Plant, From Genes to Genomes: Concepts and Applications of DNA Technology, Wiley Blackwell publisher, 2011. 4. H. K. Das, Textbook of Biotechnology, Wiley Publisher, 2017. 5. M. R. Green and J. Sambrook, Molecular Cloning: A Laboratory Manual.CSH Press, 2012. 6. V. Hunter and F. Strickland, Applications of Recombinant DNA Technology. ED-TECH Press, 2018. 7. A. J. Nair, Introduction to Biotechnology and Genetic Engineering. Laxmi Publications Pvt. Ltd, 2008. 8. S. Primrose and R. B. Twyman, Principles of Gene Manipulation and Genomics, Blackwell Publishing Limited, 2006.			

	9. M. K. Sarwar, I. A. Khan and D. Barp, Applied Molecular Biotechnology: The Next Generation of Genetic Engineering CRC Press, 2016. 10. V. Singh and P Dhar, Genome Engineering via CRISPR-Cas9 System, Elsevier Publisher, 2020.

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Title of the Course	Cell and Tissue Culture: Techniques and Application
Course Code	GBT-5008
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	GBT-5000, GBT-5001, GBT-5002	
Course Objectives:	The aim of the course is • Student will learn about cell culture set-up, laboratory design, own safety during work and environment safety • To learn experimental aspects of cell culture, maintenance and handling of cell lines and cultures • To bring together cellular, biochemical, anatomical, histological, physiological and evolutionary medical views of stem cells • To obtain a coherent picture of stem cell and their use in experimental and clinical context	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the principles, applications, and laboratory practices of cell culture, including aseptic techniques and media preparation.	PSO1, PSO2
	CO 2. Perform key procedures for cell line maintenance, including thawing, subculturing,	PSO2, PSO3

	cryopreservation, and contamination control.			
	CO 3. Describe and apply advanced cell culture methods such as 3D cultures, co-cultures, and transfection techniques.		PSO1, PSO2, PSO3	
	CO 4. Understand the basics of stem cell biology and their culture methods		PSO1, PSO2	
	CO 5. Application of stem cells in regenerative medicine to treat disease		PSO1, PSO2, PSO3	
	CO 6. Recognize quality control, regulatory guidelines, international status, and emerging technologies in cell culture, stem cell biology and regenerative medicine		PSO1	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	● Introduction to Cell Culture, History and applications of cell culture. ● Equipment required to set-up laboratory and their functions ● Laboratory setup: ● Small, Mid-size and Large-size laboratory design and setup. ● Types of cell cultures: primary cells, continuous cell lines, stem cells, Plant tissue culture ● Overview of aseptic techniques and contamination control ● Cell culture media: composition, preparation, and storage and use	**15**	CO1, CO2	K1, K2, K3
Module 2:	● Cell line maintenance, handling, Primary and secondary cell culture ● Culture, thawing, subculturing, and cryopreservation techniques of various cell lines ● Cell counting and viability assays (e.g., trypan blue exclusion, live/dead staining), morphological characterization, scoring, and authentication of cell lines ● Detection and management of contamination (bacterial, fungal, mycoplasma) ● 3D cultures, organoid culture, co-culture systems, advanced cell culture applications, and organoids. ● Transfection techniques and genetic manipulation, Microinjection,	**15**	CO1, CO2, CO3	K2, K3, K4, K5

	Electroporation.			
Module 3:	● Definition, stem cell origins and plasticity, classification. ● Source of stem Embryonic and adult stem cells; Stem cell differentiation; ● Stem cells maintenances and cryopreservation, ● Induced Pluripotent stem cell technology (iPS technology) ● Stem cell regulation, Tumor stem cells, ● Overview of embryonic and adult stem cells for regenerative medicine. ● Stem cell-based therapies, case studies ● Ethical considerations, Govt. regulations, international regulations on stem cell study	**15**	CO1, CO2, CO3	K1, K2, K3, K4, K5
Pedagogy:	Lectures/tutorials/assignments			
Texts: **References/ Readings:**	1. Wilson And Walkers Principles And Techniques Of Biochemistry And Molecular Biology 8Ed (Sae) (Pb 2023) 2. A.D. Hoffman, Stem Cell Transplantation Biology Process Therapy, Willy- VCH, 2006. 3. J. Collins, Stem cells: From basic to advanced principles, Hayle Medical,2017. 4. R. Lanza, Essential of Stem Cell Biology, Academic Press, 2006. 5. R. Lanza, Essential stem cell methods, Elsevier, 2009. 6. R. Lanza, Principle of Tissue Engineering, AP publisher, 2011. 7. R. Lanza, Essential of Stem cell Biology, Elsevier publisher, 2013.			
Web Resources:	1. Animal Cell Culture: Types, Cell Lines, Procedure, Uses 2. Animal Cell Culture Guide | ATCC 3. Preparation of a universally usable, animal product free, defined medium for 2D and 3D culturing of normal and cancer cells - PMC 4. The Cell Image Library			

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Title of the Course	Plant and Animal Biotechnology
Course Code	GBT-5009
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	GBT-5000	
Course Objectives:	● Understand and apply genetic engineering techniques for trait improvement, stress resistance, and value addition in plants and animals. ● Critically evaluate and design biotechnological strategies for transgenics, molecular pharming, and biofactory applications in agriculture and biomedicine.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the principles and techniques of genetic modification in plants and animals.	PSO1, PSO2
	CO 2. Compare different vector systems and gene delivery methods used in plant and animal biotechnology.	PSO1, PSO2
	CO 3. Analyze strategies for enhancing stress tolerance and productivity in transgenic plants.	PSO3, PSO5
	CO 4. Evaluate biotechnological approaches for trait improvement and disease modeling in	PSO1, PSO4, PSO6

	animals.			
	CO 5. Design biofactory-based systems for producing high-value biomolecules in plants and animals.		PSO2, PSO5, PSO6	
	CO 6. Assess ethical, regulatory, and societal implications of transgenic technologies and molecular pharming.		PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Plant Biotechnology** **Principles and tools of plant genetic transformation:** Agrobacterium-mediated, biolistic, electroporation. **Development of transgenic plants:** Selection markers, gene stacking, tissue-specific promoters. **Genetic engineering for biotic and abiotic stress tolerance:** Insect/pest resistance (Bt), virus- and fungus-resistance genes, tolerance to drought, salinity, temperature extremes, and flooding. **Metabolic engineering:** Modification of seed storage proteins, production of vitamins and nutraceuticals (Golden Rice), engineering of secondary metabolites. **Biofactories and synthetic biology:** Production of industrial enzymes, pharmaceuticals, and biofuels using transgenic plants and plant cell cultures.	**15**	CO1, CO2, CO4, CO6	K1, K2, K4, K5
Module 2:	**Animal Biotechnology** **Gene transfer methods:** Microinjection, retroviral vectors, electroporation, liposome-mediated delivery, transposons. **Transgenic animal models:** Mice, poultry, fish; their applications in disease research, functional genomics, and toxicity testing. **Cloning and gene editing:** SCNT (Somatic Cell Nuclear Transfer), CRISPR/Cas systems in livestock. **Biopharming and therapeutic protein production in animals:** Recombinant proteins in milk, eggs.	**15**	CO1, CO2 CO3, CO5, CO6	K1, K2, K3, K4

	Gene targeting, positive and negative selection, and knockouts for functional genomics. Xenotransplantation and ethical considerations. Animal biotechnology in agriculture: Milk enhancement, disease resistance, growth traits.			
Module 3:	**Applications of plant and animal biotechnology** **Section A:** • Plant Biotechnology Applications • Post-harvest biotechnology: Shelf-life extension, anti-bruising traits. • Plant tissue culture and micropropagation: Somaclonal variation, virus-free plant generation. • Genome editing tools in plants: CRISPR/Cas9, TALENs applications. • Case studies: GM crop, Herbicide-resistant crop, virus-resistant papaya, stress-tolerant rice and tomato lines, GM crop. **Section B:** • Animal Biotechnology Applications • Assisted reproductive technologies: IVF, embryo transfer, sex selection. • Genomic selection and marker-assisted breeding. • Regulatory frameworks and biosafety issues in transgenic animals and plants. • Case studies of regulatory approval (e.g., AquAdvantage salmon,).	**15**	CO1, CO2, CO3, CO4, CO5, CO6	K3, K5, K6
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion			
Texts: **References/ Readings:**	1. Singh, B.D. (2012). Biotechnology: Expanding Horizons (4th ed.). Kalyani Publishers. ISBN: 978-9327222982. 2. Slater, A., Scott, N.W., & Fowler, M.R. (2008). Plant Biotechnology: The Genetic Manipulation of Plants (2nd ed.). Oxford University Press. ISBN: 978-0199282616. 3. Stewart Jr., C.N. (2016). Plant Biotechnology and Genetics: Principles, Techniques, and Applications (2nd ed.). Wiley-Blackwell. ISBN: 978-1118820124.			

	4. Verma, A.S., & Singh, A. (Eds.) (2020). Animal Biotechnology: Models in Discovery and Translation (2nd ed.). Academic Press. ISBN: 978-0128117101.
	Scientific journals: Plant Biotechnology Journal, Journal of Biotechnology, Animal Biotechnology, Biotechnology Advances, Frontiers in Bioengineering and Biotechnology.
Web Resources:	1. http://www.fao.org/biotech 2. https://www.ncbi.nlm.nih.gov/books 3. https://epgp.inflibnet.ac.in 4. https://www.ncbi.nlm.nih.gov/pmc/

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Title of the Course	Lab V: Recombinant DNA Technology and Bioprocess Technology
Course Code	GBT-5010
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	GBT-5000, GBT-5002	
Course Objectives:	The students will • Understand cloning strategies and expression of foreign genes • Setting up reactions for DNA manipulation. • To interpret the results of DNA manipulation studies and use • Learn appropriate tools for the validation of recombinant DNA.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Execute plasmid DNA isolation, restriction mapping, PCR techniques, and recombinant screening.	PSO1, PSO2
	CO 2. Evaluate RT-PCR, real-time PCR, and affinity-based recombinant protein purification	PSO1, PSO2, PSO3
	CO 3. Design CRISPR-based vectors for mutagenesis, demonstrating gene editing	PSO1, PSO2, PSO3

	applications.			
	CO 4. Describing the designs and operational principles of a bioreactor and demonstrating the ability to monitor the bioprocess data.		PSO1, PSO2, PSO3	
	CO 5. Executing fermentation protocols for the production of industrially important bioproducts using submerged and solid substrate fermentation technology.		PSO1, PSO2, PSO3	
	CO 6. Designing an integrated bioprocess workflow by combining the upstream and downstream processing approaches.		PSO1, PSO2, PSO3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1.1 Plasmid DNA isolation 1.2 Restriction mapping 1.3 PCR amplification 1.4 Reverse transcriptase PCR 1.5 Real-time PCR 1.6 Cloning and ligation, and selection /screening of recombinants 1.7 Cloning in expression vectors 1.8 Purification of recombinant proteins by affinity, 1.9 Tutorial on designing CRISPR-based vectors for mutagenesis	**30**	CO1, CO2, CO3	K1, K2, K3, K4, K5, K6
Module 1:	2.1 Bioreactor Design and Bioprocess Monitoring 2.2 Production of model bioproducts using Fermentation technology (Submerged fermentation): Alcohol, lactic acid, citric acid, antibiotics; Solid substrate fermentation: Mushroom cultivation 2.3 Fermentation using agro-industrial waste 2.4 Preparation of an edible fermented product 2.5 Scale up operations and Yield optimisation: Effect of different parameters and Response surface methodology	**30**	CO4, CO5, CO6	K2, K3, K4, K5, K6

	2.6 Downstream processing and product recovery: Bio separations, cell or product harvesting (Centrifugation and filtration) 2.7 Analytical techniques for purifications and fermentation monitoring: Column chromatography, HPLC, Spectrophotometry.			
Pedagogy:	Hands-on experiments in the laboratory, online videos.			
Texts: **References/ Readings:**	1. S. Carson, *Manipulation and expression of recombinant, DNA a laboratory manual* Elsevier Academic Press, 2006. 2. M.R Green and J. Sambrook, *Molecular Cloning: A Laboratory Manual* Three-volume CSH Press, 2012. 3. J.S. Vennison, *Laboratory Manual for GENETIC ENGINEERING*, PHI Learning, 2009. 4. Stanbury, P. F., Whitaker, A., & Hall, S. J. *Principles of Fermentation Technology*. Elsevier (2017). 5. Shuler, M. L., & Kargi, F. *Bioprocess Engineering: Basic Concepts*. Pearson, 2017. 6. Doran, P. M. *Bioprocess Engineering Principles*. Academic Press, 2013. 7. Crueger, W., & Crueger, A. *Biotechnology: A Textbook of Industrial Microbiology*, Panima Publishing, 2017. 8. Waites, M. J., Morgan, N. L., Rockey, J. S., & Higton, G. *Industrial Microbiology: An Introduction*, Wiley-Blackwell, 2009. 9. Demain, A. L., & Sanchez, S. *Manual of Industrial Microbiology and Biotechnology* (3rd ed.). ASM Press, 2009.			

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Title of the Course	Lab VI: Cell and Tissue Culture
Course Code	GBT-5011
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To gain a comprehensive understanding of the growth and development of plants *in vitro*. • To understand the fundamentals of animal cell culture, and the growth and maintenance of animal cells lines under aseptic conditions.	
Course Outcomes:	The students will be able to	**Mapped to PSO**
	CO 1. Demonstrate understanding of the fundamental media components and growth parameters essential for culturing plant tissues and animal cell lines.	PSO1, PSO2
	CO 2. Explain the core concepts of pluripotency and totipotency and their significance in cell and tissue culture.	PSO2, PSO3
	CO 3. Develop skills to initiate, grow, and maintain plant and animal cells or explants under sterile, aseptic conditions.	PSO1, PSO2, PSO3

	CO 4. Apply modern techniques such as somatic embryogenesis and cell suspension culture for plant propagation.		PSO1, PSO2, PSO3	
	CO 5. CO5. Identify sources of contamination and implement appropriate safety protocols and precautionary measures in plant and animal cell culture practices.		PSO2, PSO3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• Preparation of starting material (Solutions, media, cell sample etc.) • Thaw and culture, sub-culture, maintenance • Contamination check and • Precautions (Bacterial, fungal and mycoplasma test based on staining/PCR) • Confluency check, total cell count, live/dead staining and counting • Animal cell culture: Secondary cell culture CHO, HeLa and non-cancerous cell lines HEK293, COS-7, MDCK etc. • Cell stock preparation (glycerol stock), storage, freezing • Transfection and co-transfection: Calcium phosphate method and Lipofection • Cell fixation and staining: Immunolabeling, mounting, microscopy imaging.	**30**	CO1, CO2, CO3, CO4, CO5	K3, K4, K5
Module 2:	• Tissue culture media preparation, contamination and precautions in plant tissue culture • Callus induction from different explants such as rice and carrot • Plantlet regeneration. • Somatic embryogenesis • Single cell suspension. • Protoplast isolation	**30**	CO1, CO2, CO3, CO4, CO5	K3, K4, K5
Pedagogy:	Hands-on experiments in the laboratory and demonstrations.			
Texts:	1. I.R. Freshney and A. Capes-Davis, Freshney's Culture of Animal Cells: A Manual of Basic Technique and			

References/ Readings:	Specialized Applications, Wiley Blackwell Publisher, 2021. 2. I.R. Freshney and J.R.W. Masters, Animal cell culture – A Practical Approach Oxford University Press, 2000. 3. H. Sherathiya, Practical manual for Plant Tissue Culture: Basic Techniques of Plant Tissue Culture and Molecular Biology. Grin Verlag, 2013. 4. R. Smith, Plant tissue culture Techniques and experiment. Academic Press, 2012.
Web Resources:	Animal Component–Free Cell Culture Media | ATCC lebt108.pdf

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Discipline Specific Elective Courses

Title of the Course	IPR, Biosafety and Bioethics
Course Code	GBT-5205
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To provide basic knowledge on intellectual property rights and their implications in biological research and product development. • To learn biosafety and risk assessment of products derived from biotechnology and the regulation of such products. • To become familiar with ethical issues in biological research. • To learn the consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing, and GMOs	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the rationale for and against IPR and patents;	PSO6

	CO 2. Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations		PSO6	
	CO 3. Understand different types of intellectual property rights		PSO6	
	CO 4. Gain knowledge on national and international regulations of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of GMOs		PSO4, PSO6	
	CO 5. Describe the major competing ethical theories and apply ethical theory to contemporary moral issues that arise out of recent developments in the life sciences that affect public policy.		PSO3, PSO4	
	CO 6. Analyze and assess moral beliefs about abortion, human reproduction, decisions of life and death, mental illness and other related issues.		PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• Different types of IP: patents, trademarks, copyright, industrial design, traditional knowledge, geographical indications, Trade Secrets. • Basics of patents: types of patents; • Concept of 'prior art': invention in context of "prior art"; • Precautions before patenting-disclosure/non disclosure • Patent application- forms and guidelines, fee structure, time frames; • Types of patent applications: provisional and complete specifications; • PCT and conventional patent applications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; • Patent databases - IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; • WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) • International framework for the protection of IP	**15**	CO1, CO2, CO3	**K1** **K2** **K3** **K4** **K5**

	• National Bio-diversity Authority (NBA) and other regulatory bodies, protection of new GMOs; • History of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; • Country-wise patent searches (USPTO, EPO, India); analysis and report formation. • International patenting-requirement, procedures and costs; financial assistance for patenting • Publication of patents-gazette of India, status in Europe and US; • Patent infringement- meaning, scope, litigation, case studies and examples; • Commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists university/organizational rules in India and abroad, collaborative research - backward and forward IP; • Benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.			
Module 2:	• Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals. • Definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools. • International regulations – Cartagena protocol; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India	**15**	CO4	**K1** **K2** **K3** **K4** **K5**

	- containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labelling – Food Safety and Standards Authority of India (FSSAI).			
Module 3:	• Introduction, ethical conflicts in biological sciences - interference with nature Bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. • Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare • Scientific Misconduct and Publication ethics. • Agricultural and environmental ethics - Genetically engineered food, environmental risk, labelling and public opinion. • Sharing benefits and protecting future generations • Protection of environment and biodiversity • Biopiracy	**15**	CO5, CO6	**K1** **K2** **K3** **K4** **K5**
Pedagogy:	Lectures, tutorials, Case studies, assignments			
Texts:	1. L. Bently and B. Sherman, Intellectual property law. Oxford University Press, 2008. 2. L. Bently, Intellectual property law Oxford University Press., 2008. 3. T. M. Cook, A User's Guide to Patents Tottel Publishing., 2007. 4. W. Craig, M. Tepfer, G. Degrassi, & D. Ripandelli, An Overview of General divisions/csurv/geac/annex-5.pdf F, 2009. 5. Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9. 6. D. O. Fleming, D. L. Hunt, Biological safety: principles and practices ASM Press., 2000. 7. P. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub., 2001.			

	8. Grubb P. W. Grubb P. L. Thomsen, P. R., Patents for Chemicals, Pharmaceuticals and Biotechnology: Fundamentals of Global Law, Practice and Strategy Oxford University Press., 2010. 9. J. Rajmohan. Biosafety and bioethics Gyan Publishing House., 2006. 10. F. Karen . Greif and Jon F. Merz, Current Controversies in the Biological Sciences – Case Studies of Policy Challenges from New Technologies, MIT Press 11. Keith F, CRC handbook of laboratory safety. A.CRC Press.,2000. 12. H. Kuhse, Bioethics: An Anthology. Malden, MA: Blackwell., 2010. 13. Laws. Snow White Publication Oct., 2007. 14. K. Singh. Intellectual property rights in Biotechnology. A status report New Delhi Biotech Consortium, India, 1993. 15. N.S. Sreenivasulu, and C.B. Raju, Biotechnology and Patent laws: patenting living beings Manupatra Publishers, 2008. 16. Wegner H. Patent law in Biotechnology, chemicals & pharmaceuticals. Stockton Press, 1994. 17. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J.W., Burachik, M., Gray, A., Wu, World Intellectual Property Organisation. 18. World Health Organization. Laboratory biosafety manual. WHO press, 2004. 26. World Trade Organisation. http://www.wto.org
References/ Readings:	1. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/ 2. Recombinant DNA Safety Guidelines, Department of Biotechnology, Ministry of Science and Technology, Govt. of India, 2017. Retrieved from https://dbtindia.gov.in/ 3. National Biodiversity Authority. http://www.nbaindia.org 18. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI.
Web Resources:	1. http://www.wipo.int 2. International Union for the Protection of New Varieties of Plants. http://www.upov.int 3. National Portal of India. http://www.archive.india.gov.in

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Title of the Course	Lab VII: IPR database, Patent drafting, and Bioethics
Course Code	GBT-5206
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	GBT-5205			
Course Objectives:	focusing on IPR databases, patent drafting, and bioethics would encompass practical exercises, real-world case studies, and hands-on drafting of patent applications, while also exploring ethical considerations within the field along with discussions on ethical dilemmas in bioethics.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Understand and apply IPR principles			
	CO 2. Manage IPR databases			
	CO 3. Develop patent drafting skills			
	CO 4. Comprehend bioethical issues in IPR and apply IPR principles in practical scenarios			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	• IPR databases: Patent databases, their features, and usage; Patent Searching Techniques, searching for patents based on keywords, inventors, and patent numbers, Conducting thorough prior art searches for a given invention. • Analysis of search results: Identifying relevant prior art and understanding its significance. • Prior Art Analysis: Preparing prior art analysis reports for various inventions. • Patent Drafting: Drafting a basic patent application for a hypothetical invention • Drafting Claims: Drafting claims for various inventions, including those with multiple embodiments. • Patent Drafting Techniques: Drafting and revising patent applications for real-world inventions. • Bioethics: Analyzing case studies involving bioethical dilemmas in patenting inventions, Analyzing the ethical implications of patenting inventions with global impact.	**30**	CO1, CO2, CO3, CO4	K2, K3, K4, K5, K6
Pedagogy:				
Texts:	Indian Patent Law and Practice" by K.C. Kankanala, A.K. Narasani, and V. Radhakrishnan. "WIPO Patent Drafting Manual" and "Patent Application Drafting: A Practical Guide" by Morgan D. Rosenberg			
References/ Readings:	Manual Of Patent Practice And Procedure The Patent Office, India. https://www.ipindia.gov.in/writereaddata/Portal/IPOGuidelinesManuals/1_59_1_15-wo-ga-34-china.pdf			
Web Resources:	1. World Intellectual Property Organization (WIPO). (n.d.). PatentScope. Retrieved from https://www.wipo.int/webdb/en/ 2. https://www.uspto.gov/ 3. https://patents.google.com/ 4. Official website of Intellectual Property India			

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Title of the Course	Systems Biology
Course Code	GBT-5207
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	GBT-5000, GBT-5201	
Course Objectives:	• Introduce systems biology principles, network modeling, and dynamic simulation approaches to understand biological complexity across scales. • Equip students with practical skills to analyze and integrate multi-omics data for reconstructing and interpreting biological networks in health, agriculture, and biotechnology.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the core concepts of systems biology and distinguish between reductionist and systems-level approaches.	PSO1, PSO3
	CO 2. Analyze the structure and properties of biological networks using topological descriptors such as degree, centrality, and modularity.	PSO3, PSO4
	CO 3. Develop and simulate basic mathematical models of biological systems using	PSO3, PSO5

	deterministic, stochastic, and logic-based frameworks.			
	CO 4. Perform network reconstruction and visualization using public databases and tools.		PSO2, PSO4	
	CO 5. Process and analyze multi-omics datasets using standard pipelines for genomics, transcriptomics, proteomics, and metabolomics.		PSO2, PSO3	
	CO 6. Integrate multi-omics data to construct biological networks and interpret their functional implications through case studies in health and agriculture.		PSO3, PSO4, PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to Systems Biology:** Systems-level understanding vs. reductionism**,** Historical context and paradigm shift**,** Applications in medicine, agriculture, and synthetic biology. **Biological Networks:** Architecture and Properties, gene regulatory, protein–protein interaction, metabolic, signaling, Components: nodes, edges, hubs, modules, motifs, Topological properties: degree distribution, clustering, centrality, random vs. scale-free networks. **Network Dynamics and Emergent Properties:** Feedback loops, noise, robustness, bistability, modularity, oscillations, Time-scale separation and adaptation. **Modeling Frameworks:** Deterministic vs. stochastic modelling, Boolean and logic-based models, ODE-based models (basics), Constraint-based modeling: flux balance analysis (FBA). **Tools and Databases for Network Analysis:** Databases: STRING, BioGRID, IntAct, Reactome, Visualization: Cytoscape, Gephi, Network reconstruction from transcriptome/proteome data.	**15**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5
Module 2:	**High-throughput Omics Overview:** Genomics, transcriptomics, proteomics, metabolomics, epigenomics, interactomics, Platforms: NGS, MS, LC-MS, NMR, ATAC-seq, ChIP-seq. **Data Processing Pipelines:** Genomics: sequencing (Sanger, NGS, PacBio/Nanopore), assembly, annotation, variant calling, Transcriptomics: RNA-Seq	**15**	CO4, CO5, CO6	K1, K2, K3, K4, K5, K6

	(HISAT2, STAR, DESeq2), Proteomics: MS workflows, quantification, PTM analysis, Metabolomics: GC-MS/LC-MS, preprocessing, interpretation, Epigenomics: bisulfite seq, ChIP-Seq, ATAC-seq basics. **Network Construction from Omics Data:** Co-expression and interaction networks, Graph measures: centrality, modularity, motifs, Specialized networks (e.g., primary vs. secondary metabolism). **Multi-Omics Integration:** Challenges: scale, heterogeneity, normalization, Tools: OmicsNet, MixOmics, PaintOmics, Standards: FAIR principles, Case studies in multi-omics integration.			
Module 3:	**Biological Pathways and Simulation:** Pathway types: metabolic, regulatory, signaling, Databases: KEGG, Reactome, WikiPathways, Modeling dynamics: ODEs, stochastic models (Gillespie), Simulation tools: COPASI, CellDesigner. **Gene Regulatory and Co-expression Networks:** TFs, cis-regulatory elements, target genes, Network inference: Pearson/Spearman, mutual information (ARACNe, CLR), ML-based (LASSO, GENIE3), Module detection: WGCNA, Functional enrichment: GO, KEGG. **Metabolic Modeling and Engineering:** Primary vs. secondary metabolism, Constraint-based modeling: COBRA toolbox, Pathway Tools, Applications in metabolic engineering and synthetic biology. **Applications and Case Studies:** Disease systems biology (cancer, diabetes), Host-pathogen interaction modelling, Plant systems biology (stress responses, flowering), Microbiome and microbial consortia modelling, Emerging fields: single-cell systems biology, spatial omics, Classic case studies: *E. coli* metabolism, yeast cell cycle, immune signaling dynamics.	**15**	CO2, CO3, CO5, CO6	K3, K4, K5, K6
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion			
Texts: **References/ Readings:**	1. **Alon, U. (2019).** *An Introduction to Systems Biology: Design Principles of Biological Circuits* (2nd ed.). Chapman and Hall/CRC. 2. **Kitano, H. (Ed.). (2001).** *Foundations of Systems Biology*. MIT Press.			

	3. **Klipp, E., Liebermeister, W., Wierling, C., Kowald, A., & Herwig, R. (2016).** *Systems Biology: A Textbook* (2nd ed.). Wiley-VCH. 4. **Palsson, B. Ø. (2015).** *Systems Biology: Constraint-based Reconstruction and Analysis* (2nd ed.). Cambridge University Press. 5. **Zhang, W., & Shmulevich, I. (2009).** *Computational Systems Biology*. Academic Press.
Supplementary Reading	Scientific journals: BMC Systems Biology, Frontiers in Systems Biology.
Web Resources:	1. https://www.ebi.ac.uk/biomodels/ 2. https://www.omicsnet.ca/ 3. https://string-db.org/

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Title of the Course	Lab VIII: Practical Approaches to Systems Biology
Course Code	GBT-5208
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	GBT-5000, GBT-5001, GBT-5201, GBT-5202	
Course Objectives:	To equip students with hands-on skills in modeling, simulating, and analyzing dynamic biological systems and networks using experimental and publicly available data.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply simulation tools to model stress-response and oscillatory dynamics in biological systems.	PSO3, PSO5
	CO 2. Analyze gene expression data to construct gene regulatory networks and interpret regulatory interactions.	PSO3, PSO4
	CO 3. Evaluate metabolic network properties across species to assess complexity and identify central biochemical nodes.	PSO3, PSO4
	CO 4. Create pathway enrichment visualizations and simulate ligand-receptor binding to	PSO3, PSO4, PSO6

	explore functional implications in systems-level contexts.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module:	1. Environmental perturbation and stress-response modelling using ROS or stress-related marker. 2. Measurement of oscillatory behaviour in biological systems. 3. Construction of a gene regulatory network (GRN) from publicly available expression data. 4. Compare metabolic networks for two or more species and compare network complexity or central enzymes. 5. Simulate drug-receptor binding kinetics to model ligand-receptor interaction. 6. Pathway enrichment and data visualization.	**30**	CO1, CO2, CO3, CO4	K3, K4, K5, K6
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion			
Texts: References/ Readings:	1. Kitano, H. (Ed.). (2001). *Foundations of Systems Biology*. MIT Press. 2. Klipp, E., Liebermeister, W., Wierling, C., Kowald, A., & Herwig, R. (2016). *Systems Biology: A Textbook* (2nd ed.). Wiley-VCH. 3. Alon, U. (2006). *An Introduction to Systems Biology: Design Principles of Biological Circuits.* Chapman & Hall/CRC. 4. Palsson, B. (2015). *Systems Biology: Constraint-Based Reconstruction and Analysis* (2nd ed.). Cambridge University Press. 5. Jiang, X. & Kim, S. (2022). *Network Biology: Methods and Applications.* Springer.			
Web Resources:	BioModels Database – https://www.ebi.ac.uk/biomodels/ Cytoscape – https://cytoscape.org/ COPASI (COmplex PAthway SImulator) – https://copasi.org/ MetaboAnalyst – https://www.metaboanalyst.ca/ Gene Expression Omnibus (GEO) – https://www.ncbi.nlm.nih.gov/geo/			

Title of the Course	Bionanotechnology
Course Code	GBT-5209
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	• To provide a general and broad introduction to the multi-disciplinary field of bionanotechnology. • To study the application of bionanotechnology	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the emergence and significance of bionanotechnology and describe the fundamental scientific principles governing the properties of materials at the nanoscale.	PSO1, PSO2, PSO5, PSO7
	CO 2. Apply knowledge of nanomaterials synthesis, characterization, and utilization in product development and healthcare applications.	PSO1, PSO2, PSO5
	CO 3. Analyze the potential risks and biological impacts of nanomaterials on living systems and human health.	PSO1, PSO2, PSO5

	CO 4. Evaluate the life cycle of nanoparticles and assess their environmental implications and associated safety considerations.		PSO1, PSO2, PSO5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• Introduction, concepts, historical perspective; • Different formats of nanomaterials • Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, • Thin films; Colloidal nanostructures; Self-assembly, Nanovesicles; Nanospheres; Nanocapsules • Nanomaterial synthesis methods: Bottom-up synthesis methods of nanofabrication: Basic concept and synthesis of metallic and non-metallic nanomaterials. • Top-down methods of nanomaterial synthesis: Lithography, optical lithography, electron beam lithography and 3D nanofabrication methodology, UV lithography, scanning probe methods – dip pen nanolithography • Biosynthesis/Green synthesis of nanomaterials and nanostructures • Characterization of nanomaterial: atomic force microscopy, Scanning tunnelling microscopy of surface characterization. Dynamic light scattering, fluorescence characterization, Electron microscopy methods	**15**	CO1, CO2	K1, K2, K3, K4
Module 2:	• Biologically originated nanomaterial: Lipid Bilayers, liposomes, neosomes, Phytosomes, scaffolds, protein motor. • DNA Nanotechnology: Applications of DNA Nanotechnology: DNA based artificial membrane channel, DNA origami, DNA lattice nanostructure, Biomimetic fabrication of DNA based metallic nanomaterial and nanonetwork, nanocascade.	**15**	CO1, CO2, CO3	K3, K4, K5, K6

	• Protein nanotechnology: Peptide and protein nanotechnology, virus nanostructures and applications, cases and catalytic protein nanomaterial, Enzymes - Biomolecular motors. • Biological Interactions with Materials Introduction, Biocompatibility, Cellular uptake mechanisms Toxicity, Cytotoxicity, Hypersensitivity, Carcinogenicity, , Inflammation, Granulation Tissue Formation, Interactions with Proteins. • Biocompatibility of Nanomaterials Surface and Bulk Properties of Bio materials, Surface immobilized biomolecules. • Application of nano scaffolds in synthesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.			
Module 3:	• Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages. • Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli-responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development. • Nanotoxicology, Basics of nanotoxicity, in vitro and in vivo toxicity testing, Mechanism of Nanotoxicity, Reactive oxygen species meditated NSP toxicity, Cellular Nanotoxicology, Potential Mechanism of Nanomaterials, Immunotoxicity. • Introduction to risk associates and Safety of nanomaterials, Models and assays for Nanotoxicity assessment • Environmental fate of nanomaterials	**15**	CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
Pedagogy:	Lectures/ video tutorials/assignment/Models			
Texts:	Edition to be specified or latest edition as applicable.			
References/ Readings:	1. Young-Chul Lee , Ju-Young Moon, Introduction to Bionanotechnology, Springer Nature, 2020 2. Nadrin C. Seeman, Structural DNA Nanotechnology, Cambridge University Press, 2016			

	3. K. Chittaranjan, D. S. Kumar, M. V. Khodakovskaya, Plant Nanotechnology Principles and Practices. Springer, 2016. 4. T. H. Grey, Bioconjugate Techniques, Elsevier, 2013. 5. M. Kuno, Introductory Nanoscience, Physical and Chemical Concepts. Garland Science, 2012. 6. N.H. Malsch, Biomedical Nanotechnology, CRC Press, 2019. 7. Luis E. F. Foa Torres, Stephan Roche, Jean-Christophe Charlier, Introduction to Graphene-Based Nanomaterials, 2020
Web Resources:	Introduction to bionanomaterials: an overview - Book chapter - IOPscience L-G-0000584024-0002360992.pdf Bionanotechnology | Journal of Biomaterials

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Title of the Course	Lab IX: Bionanotechnology
Course Code	GBT-5210
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	GBT-5208	
Course Objectives:	To provide hands-on experience in nanomaterial bio-synthesis including metal nanoparticles, metal oxides etc. and their biological application on bacterial, fungal and animal cells.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Creating metallic and polymeric nanomaterial synthesis	PSO5, PSO7
	CO 2. Use instrumentation studied in bio nanotechnology research	PSO5, PSO7
	CO 3. Develop and explore green synthesis methods for nanomaterial synthesis	PSO4, PSO5, PSO7
	CO 4. Understand nanomaterial handling, characterization and proper disposal of nanomaterial waste	PSO4, PSO5, PSO7

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Synthesis of metallic/bimetallic nanoparticles 2. Synthesis of carbon and polymeric nanomaterial 3. Biosynthesis of metallic and non-metallic nanomaterial 4. Antifungal and antibacterial assay of nanomaterial 5. Nanomaterial cytotoxicity assay (MTT, ROS) 6. Genotoxicity of nanomaterial study on bacterial, animal cells 7. Characterization of nanomaterial with UV-Vis spectroscopy, SEM, FTIR, XRD. 8. Liposome, Micelle and other polymeric nanomaterial synthesis 9. Biosensing application of nanoparticles	**30**	CO1, CO2, CO3, CO4,	K3, K4, K5, K6
Pedagogy:	Laboratory Hands-on training, Demonstration			
Texts:	1. Guozhong, Cao. Nanostructures and nanomaterials: synthesis, properties and applications. World scientific, 2004. 2. Naito, M. et al (Eds.). Nanoparticle Technology Handbook - 3rd Edition – Elsevier, 2018. 3. Greg Hermenson, Bioconjugate Techniques, Academic press, 2013			

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SEMESTER III

Research Specific Elective (RSE) Courses

Title of the Course	Biostatistics in Biological Sciences
Course Code	GBT-6000
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	• To introduce the fundamental concepts and applications of biostatistics in biological research. • To develop an understanding of data collection, organisation, and descriptive statistical analysis in biological contexts. • To apply probability, statistical inference, and hypothesis testing for interpreting biological data. • To train students in using statistical tools and experimental design for scientific data analysis and decision-making.

Course Outcomes:			**Mapped to PSO**	
	CO 1. Define and explain the basic concepts, role, and scope of biostatistics in biological sciences.		PSO1, PSO3, PSO8	
	CO 2. Classify types of data, explain probability concepts, and describe data collection and sampling techniques.		PSO1, PSO3	
	CO 3. Apply descriptive and inferential statistical tools (t-test, ANOVA, chi-square, etc.) to analyse biological data.		PSO2, PSO3, PSO6	
	CO 4. Analyse biological datasets using correlation, regression, and multivariate methods such as PCA and cluster analysis.		PSO2, PSO3, PSO4	
	CO 5. Evaluate hypotheses, interpret statistical results, and select appropriate statistical approaches for experimental data.		PSO3, PSO4, PSO5	
	CO 6. Design and statistically analyse biological experiments using computational and interpret omics data		PSO2, PSO3, PSO5, PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Fundamentals of Biostatistics** • Basic concepts, role and scope of Biostatistics, • Measurement scales, • Types of data and data collection, sampling and statistical inference, • Concepts of probability and probability distribution and its application in biological sciences, • Scientific method and designing of experiments.	**15**	CO1 to CO6	K1, K2, K3, K4, K5, K6

	Descriptive statistics • Frequency distribution of grouped data • Measures of central tendency and dispersion • Hypothesis Testing: Concept of null and alternative hypotheses, Type I and Type II errors, power of the test. **Parametric tests** • t-test (one-sample, independent, paired), • ANOVA (one-way, two-way, repeated measures), • Post hoc tests (Tukey's, Dunnett's, Bonferroni), • Confidence intervals and effect size.			
Module 2:	**Non-parametric tests** • Chi-square test, Mann–Whitney U, Kruskal–Wallis, Wilcoxon signed-rank • Correlation and regression (simple and multiple) • Multivariate methods: Principal Component Analysis (PCA), Cluster Analysis, Discriminant Analysis, Canonical Correspondence Analysis (CCA). • Advanced Statistical Techniques: Introduction to Excel and software for statistical analysis • Statistical approaches in genomics, transcriptomics, and proteomics. • Design and statistical analysis of a biological experiment	**15**	CO3, CO4, CO5, CO6	K3, K4, K5, K6
Pedagogy:	Lectures, tutorials, assignments			
Reference Texts/Reading:	1. Bruce, P., Bruce, A., & Gedeck, P. (2020). *Practical Statistics for Data Scientists* (2nd ed.). O'Reilly Media. 2. Daniel, W. W., & Cross, C. L. (2018). *Biostatistics: A Foundation for Analysis in the Health Sciences* (11th ed.). Wiley. 3. Le, C. T. (2003). *Introductory Biostatistics.* Wiley-Interscience.			

	4. Mahajan, B. K. (2018). *Methods in Biostatistics: For Medical Students and Research Workers.* Jaypee Brothers Medical Publishers. 5. Montgomery, D. C. (2019). *Design and Analysis of Experiments* (10th ed.). Wiley. 6. Pagano, M., & Gauvreau, K. (2018). *Principles of Biostatistics* (2nd ed.). CRC Press. 7. Rastogi, V. B. (2009). *Fundamentals of Biostatistics.* Ane Books Pvt. Ltd. 8. Rosner, B. (2015). *Fundamentals of Biostatistics* (8th ed.). Cengage Learning. 9. Shahbaba, B. (2012). *Biostatistics with R: An Introduction to Statistics Through Biological Data.* Springer. 10. Thompson, J., & Mount, D. W. (2016). *Statistics for Bioinformatics.* Springer. 11. Zar, J. H. (2010). *Biostatistical Analysis* (5th ed.). Pearson Education.

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Title of the Course	Bioentrepreneurship
Course Code	GBT-6001
Number of Credits	02
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	The course aims: • To introduce the fundamentals of bioentrepreneurship and the qualities of a successful biotech entrepreneur. • To develop skills for innovation, startup creation, and navigating legal and regulatory frameworks in biotech ventures. • To equip students with the ability to prepare business plans, manage finances, and explore funding options for bio ventures. • To build competency in marketing, team management, and strategic leadership within the biosciences industry.

Course Outcomes:	By the end of the course, students will be able to:		**Mapped to PSO**	
	CO 1. Demonstrate understanding of bioentrepreneurship concepts and identify opportunities in the life sciences sector.		PSO1, PSO7, PSO8	
	CO 2. Apply innovation tools and legal knowledge to design and initiate a biotech startup.		PSO5, PSO7, PSO8	
	CO 3. Prepare and evaluate business plans with financial forecasting and funding strategies.		PSO5, PSO6, PSO8	
	CO 4. Design marketing strategies and apply leadership skills for managing teams in biotech startups.		PSO6, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Foundations of Entrepreneurship in Biosciences** ● Definition and scope of bioentrepreneurship ● Mission, vision, and qualities of a bioentrepreneur ● Dos and Don'ts of entrepreneurship **Innovation and Start-up Creation in Biotech** ● Design Thinking and Design-Driven Innovation ● Systems thinking and Open Innovation ● How to start a biotech startup? ● Legal and statutory requirements (IPR, GST, Labor law, E-business setup and management) **Business Plan Development for Bioventures** ● Preparing a business proposal for financial institutions ● Approaching banks and funding sources ● Budgeting, cash flow management, and financial forecasting	**15**	CO1, CO2, CO3	K1, K2, K3, K4, K5, K6

	Financing Bio-Startups ● Bootstrapping, crowdfunding, angel investors, venture capital, debt financing ● Incubation and acceleration ● Government schemes and incentives for biotech entrepreneurs and startup **Financial Planning and Analysis** ● Negotiations with financiers and banks ● Understanding financial statements: Profit & Loss, Balance Sheet, Cash Flow ● Cost-volume-profit & Break-even analysis ● Capital budgeting			
Module 2:	**Marketing Management in Biotech Startups** ● Assessing market demand for biotech products ● Market segmentation and trend prediction ● Customer needs and market gaps ● Packaging, branding, and market linkages ● Developing distribution channels ● Pricing strategies and competition analysis ● Advertising and promotion ● Services marketing and dispute resolution **Team Building and Leadership in Bioventures** ● Building interdisciplinary teams ● Role of scientists, business experts, and legal advisors ● Leadership and managerial skills for scientists and entrepreneurs ● Organizational structures: pros and cons	**15**	CO4	K2, K3, K4, K5, K6

	• Team building and teamwork in startups • Performance appraisal and reward systems • Navigating external environmental changes • Crisis management and global strategic thinking			
Pedagogy:	Lectures/tutorials/assignments/ online			
Text references:	1. Adams, D. J., & Sparrow, J. C. (2008). *Enterprise for life scientists: Developing innovation and entrepreneurship in the biosciences*. Scion. 2. Byrne, A. J. (2011). *World changers: 25 entrepreneurs who changed business as we knew it*. Penguin. 3. Desai, V. (2009). *The dynamics of entrepreneurial development and management*. Himalaya Publishing House. 4. Jordan, J. F. (2014). *Innovation, commercialization, and start-ups in life sciences: Companies creating value and competitive advantage with the milestone bridge*. CRC Press. 5. Lynn, J. (2007). *The entrepreneur's almanac: Fascinating figures, fundamentals and facts at your fingertips*. Entrepreneur Media Inc. 6. Ramsey, D. (2011). *EntreLeadership: 20 years of practical business wisdom from the trenches*. Howard Books. 7. Shimasaki, C. D. (2014). *Biotechnology entrepreneurship: Starting, managing, and leading biotech companies*. Academic Press.			
References/ Readings:	1. Juma, C. (2016). *Innovation and its enemies: Why people resist new technologies*. Oxford University Press. 2. Kotler, P., & Keller, K. L. (2016). *Marketing management* (15th ed.). Pearson. 3. Moors, P. A. A. (Ed.). (Year). *Business planning for biotechnology startups*. [Publisher]. 4. Prins, H. H. T., & Breugelmans, C. (Year). *Biotechnology business: Planning, finance, and management*. [Publisher]. 5. Ries, E. (2011). *The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses*. Crown Business. 6. Shimasaki, C. D. (2014). *Biotechnology entrepreneurship: Starting, managing, and leading biotech companies* (2nd ed.). Academic Press.			

Web Resources:	1. https://www.nature.com/bioent/ 2. https://www.bio.org/ 3. https://www.startupindia.gov.in/ 4. https://www.standupmitra.in/

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Title of the Course	Integrated Genomics & Proteomics
Course Code	GBT-6002
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	GBT-5000, GBT-5007	
Course Objectives:	• To understand the structural and functional organization of prokaryotic and eukaryotic genomes. • To develop competence in the methodologies and analytical tools of genomics and proteomics. • To apply genomic and proteomic knowledge to biological, agricultural, and biomedical contexts.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the structural organization and dynamics of prokaryotic, eukaryotic, and organellar genomes, including principles of DNA packaging and chromosomal territories.	PSO 1, PSO 3, PSO 4

	CO 2. Apply genetic, physical, and cytogenetic mapping techniques to locate and characterize genes using molecular markers and FISH-based approaches.		PSO 1, PSO 2, PSO 3	
	CO 3. Retrieve and interpret genome sequence data from major online databases to analyze synteny, gene annotation, and evolutionary relationships.		PSO 3, PSO 4	
	CO 4. Demonstrate understanding of proteomic principles, including protein extraction, separation, identification, and quantification using gel-based and mass spectrometry-based methods.		PSO 1, PSO 2, PSO 6	
	CO 5. Analyse protein–protein, protein–DNA, and protein–RNA interactions, and evaluate post-translational modifications to infer functional and regulatory relationships.		PSO 3, PSO 4, PSO 5	
	CO 6. Assess and integrate genomic and proteomic data for applications in agriculture, health, and biotechnology, including biomarker discovery and drug target identification.		PSO 4, PSO 5, PSO 6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Genome Organization** • Overview of prokaryotic and eukaryotic genome organization • Mitochondrial and chloroplast genomes, • DNA packaging, topological domains, Genome compartment and chromosomal territories. **Genome Mapping and Techniques**: • Principles and applications genetic and physical maps, • Molecular markers for genetic mapping, Gene mapping approaches: Linkage analysis, Physical mapping, Cytogenetic techniques, DNA-FISH and RNA-FISH techniques, Synteny analysis across species **Genome Sequencing and Databases**	**15**	CO 1, CO 2, CO 3, CO 4	K2, K3, K4, K5

	• Human Genome Project and major genome sequencing projects in microbes, plants, and animals. • Accessing and retrieving genome project information from online databases. **Analysis and Applications of Genomics** • Molecular markers in identification and classification of organisms • Genomic approaches to study evolution of eukaryotes. • Determining gene location in genome sequences. • Application of genomics in health and agriculture. Tracking emerging diseases and drug design using genomic data.			
Module 2:	**Introduction and Fundamentals** • Definition, scope, and significance of proteomics. • Relationship between genome and proteome; concept of the dynamic proteome. • Sample preparation: protein extraction from different biological sources, protein solubilization, and fractionation. **Proteomics Approach** • Gel-based proteomics (1D and 2D-PAGE, • isoelectric focusing, differential gel electrophoresis). • Mass spectrometry-based proteomics, principles, instrumentation, MALDI-TOF, ESI-MS, LC-MS. • Quantitative proteomics approaches (iTRAQ, SILAC, TMT, label-free quantification). **Functional and Interaction Proteomics** • Protein–protein interactions: co-immunoprecipitation, pull-down assays, Microscopy based approaches.	**15**	CO 4, CO 5, CO 6	K1, K2, K3, K4, K5

	• Protein–DNA and protein–RNA interactions: EMSA, ChIP, RIP. Post-translational modifications (PTMs) analysis. **Proteome databases and applications** • Different type of proteome databases, tools for protein identification, quantification analysis. • Current challenges in proteomics: complexity, dynamic range, reproducibility, and technical limitations. • Clinical and biomedical applications: biomarker discovery, drug target identification, disease diagnostics.			
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion/ICT			
Texts, References/ Readings:	1. Brown, T. A. (2023). *Genomes 5.* United States: CRC Press. 2. Liebler, D. (2013). *Introduction to Proteomics: Tools for the New Biology.* United States: Humana Press. 3. Mount, D. W. (2004). *Bioinformatics: Sequence and Genome Analysis.* Thailand: Cold Spring Harbor Laboratory Press. 4. Primrose, S. B., & Twyman, R. (2009). *Principles of Genome Analysis and Genomics.* Germany: Wiley. 5. Speicher, D. W. (2004). *Proteome Analysis: Interpreting the Genome.* Netherlands: Elsevier Science. 6. Suhai, S. (2013). *Genomics and Proteomics: Functional and Computational Aspects.* United States: Springer US. 7. Twyman, R. M. (2014). *Principles of Proteomics.* United Kingdom: Garland Science. 8. Watson, J. D. (2014). *Molecular Biology of the Gene.* Germany: Pearson.			
Web Resources:	1. https://www.genome.gov/27530225/free-online-tutorials-teach-anyone-how-to-use-genome-databases 2. https://www.ebi.ac.uk/pride/ 3. http://www.peptideatlas.org 4. https://www.proteomicsdb.org 5. https://iptgxdb.expasy.org 6. https://www.hsls.pitt.edu/obrc/index.php?page=proteomics			

Title of the Course	Lab in Omics
Course Code	GBT-6003
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2026-27
New Course: Yes/No	Yes
Bridge Course/ Value added Course: Yes/No	No
Course for advanced learners: Yes/No	Yes

Pre-requisites for the Course:	GBT-5201, GBT-5202	
Course Objectives:	• To develop hands-on proficiency in computational analysis of high-throughput omics datasets • To enhance data interpretation and communication skills through visualization and network-based analyses, facilitating biological insight extraction from complex omics datasets.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Perform transcriptome data analysis, including expression quantification, differential gene expression, and gene ontology–based functional enrichment to interpret biological significance.	PSO 3, PSO 4, PSO 5

	CO 2. Identify and analyze regulatory motifs and transcription factor binding sites to infer gene regulatory mechanisms using computational tools.		PSO 3, PSO 4, PSO 5	
	CO 3. Conduct taxonomic and functional profiling of microbial communities through metagenomic data analysis and interpretation.		PSO 3, PSO 4, PSO 6	
	CO 4. Process and interpret metabolomics, proteomics, and lipidomics datasets for the detection, quantification, and functional mapping of biomolecules across experimental conditions.		PSO 3, PSO 4, PSO 6	
	CO 5. Integrate and visualize multi-omics datasets using heatmaps, enrichment plots, and network visualization tools such as Cytoscape to reveal system-level biological insights.		PSO 3, PSO 4, PSO 5	
	CO 6. Apply multi-omics data analysis pipelines to address real biological questions related to gene regulation, metabolism, and microbial community dynamics.		PSO 3, PSO 4, PSO 5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Transcriptome** • Perform expression quantification of RNA-seq transcriptome datasets and identify differentially expressed genes between experimental conditions. • Gene Ontology (GO) Annotation and Functional Enrichment Analysis. **Functional Genomics** • Motif Enrichment Analysis for Regulatory Sequence Discovery. • Identification and Analysis of Transcription Factor Binding Sites (TFBS) in nucleotide sequences. **Metagenomics** • Taxonomic Profiling of Microbial Communities using metagenomic data.	**30**	CO 1, CO 2, CO 3	K3, K4 and K5

Module 2:	**Metabolomics** • To process and analyze metabolomics data using computational tools in order to detect, quantify, and interpret significant metabolic changes between experimental groups. • Pathway Mapping of Metabolites using KEGG/MetaboAnalyst **MS-proteomics** • Proteomic data analysis: peptide identification and quantification from MS demo dataset. **Lipidomic** • Computational Analysis of Lipidomics Data: Profiling, Differential Expression, Enrichment, and Network Mapping (LipidSig). **Omics Data visualization** • Heatmap Analysis for Visualization of Omics Data. • Network Visualization and Analysis using Cytoscape	**30**	CO 4, CO 5, CO 6	K3, K4, K5 and K6
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion/ICT/Hands on-training			
Texts, References/ Readings:	1. Arivaradarajan, P., & Misra, G. (2019). *Omics Approaches, Technologies and Applications: Integrative Approaches for Understanding Omics Data.* Germany: Springer Nature Singapore. 2. Azad, R. K. (2024). *Transcriptome Data Analysis.* United States: Springer-Verlag New York. 3. Buffalo, V. (2015). *Bioinformatics Data Skills.* Japan: O'Reilly. 4. Imai, K., & Fong-Yau, S. L. (2013). *Quantitative Proteome Analysis: Methods and Applications.* Singapore: Jenny Stanford Publishing. 5. Ning, K. (2023). *Methodologies of Multi-Omics Data Integration and Data Mining: Techniques and Applications.* Germany: Springer Nature Singapore. 6. Wehrens, R., & Salek, R. (2019). *Metabolomics: Practical Guide to Design and Analysis.* United States: CRC Press.			

	7. Winkler, R. (2022). *Processing Metabolomics and Proteomics Data with Open Software: A Practical Guide.* United Kingdom: RSC.
Web Resources:	1. https://melbournebioinformatics.github.io/MelBioInf_docs/tutorials/rna_seq_dge_basic/rna_seq_basic_tuxedo/ 2. http://geneontology.org 3. https://meme-suite.org 4. https://www.metaboanalyst.ca 5. https://www.genome.jp/kegg/tool/map_pathway2.html 6. https://www.ebi.ac.uk/pride/ 7. https://www.r-graph-gallery.com/heatmap.html 8. https://cytoscape.org

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Title of the Course	Stem Cell Biology and Regenerative Medicine
Course Code	GBT-6004
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	GBT-5001, GBT-5008	
Course Objectives:	The aim of the course is • To bring together cellular, biochemical, histological, physiological and evolutionary medical views of stem cells • To obtain a coherent picture of stem cell and their use in experimental and clinical context • To introduce recent development of stem cells applications for treatment and prevention of disease and medical complications • To introduce ethical and geographical limitation in the field of stem cell technology	
Course Outcomes:		**Mapped to PSO**

	CO 1. Explain the history, principles, origin, and types of stem cells.		PSO1, PSO2	
	CO 2. Describe the maintenance and culture techniques; such as 3D cultures, co-cultures, and transfection techniques.		PSO2, PSO3, PSO5	
	CO 3. Describe the characterization and differentiation methods and stock preparation of various types of cell lineages.		PSO1, PSO2, PSO3	
	CO 4. Application of stem cells in regenerative medicine and ethical consideration in medical science		PSO2, PSO3, PSO5, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• Definition, stem cell origins and plasticity, • Journey from embryo to foetus, the role of cytoplasm in stemness. Nuclear transfer and its significance in stem cell evolution. • classification and source of stem cells • Isolation of stem cells • Identification and characterization of pluripotent stem cells in animal and humans; • Overview of embryonic and adult stem cells for therapy • Stem cell markers. Types of stem cells its advantages and disadvantages. • Proliferation and differentiation control of stem cells by signaling mechanisms. The role of various stimuli and cytokines. • Stem cell differentiation • Stem cells cryopreservation, • Evolution of induced pluripotent stem cells. • Generation of iPSC's. iPSC technology;	**15**	CO1, CO2, CO3, CO4	K1, K2, K3, K4

Module 2:	• Regenerative medicine: scope, applications, advancements and limitation. • Stem cells and Gene Therapy: Signalling pathway involved in self-renewal and differentiation of stem cells (cardiomyocyte and Neuronal). • Clinical use of stem cells. • Stem cell therapy for various diseases (neurodegenerative, retinal, leukemia, heart). • Cancer stem cells: isolation and characterization of cancer stem cells. • Endothelial mesenchymal transition (EMT). • EMT in fibrotic diseases and cancer. • Lab models for stem cell technology. • Human stem cells research. Stem cell in cardiac disease. Stem cells in neurodegenerative disease: • Ethical considerations; Regulatory and ethical issues in the stem cell research. • Stem cell based therapies: Pre-clinical regulatory consideration and patient advocacy.	**15**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5
Pedagogy:	Lectures/tutorials/assignments/models			
Texts, References/ Readings:	1. Collins, J. (2017). *Stem cells: From basic to advanced principles.* Hayle Medical. 2. Hoffman, A. D. (2006). *Stem Cell Transplantation: Biology, Process, Therapy.* Wiley-VCH. 3. Lanza, R. (2006). *Essentials of Stem Cell Biology.* Academic Press. 4. Lanza, R. (2009). *Essential Stem Cell Methods.* Elsevier. 5. Lanza, R. (2011). *Principles of Tissue Engineering.* AP Publisher. 6. Lanza, R. (2013). *Essentials of Stem Cell Biology*. Elsevier.			
Web Resources:	1. 23.Stem Cells 2. Animal Cell Culture: Types, Cell Lines, Procedure, Uses 3. Animal Cell Culture Guide | ATCC			

	4. Preparation of a universally usable, animal product free, defined medium for 2D and 3D culturing of normal and cancer cells - PMC 5. The Cell Image Library

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Title of the Course	Biology of Extremophilic Microorganism
Course Code	GBT-6005
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	• To study types of extreme environments and extremophilic diversity. • To understand physiological and molecular adaptations to stress. • To examine metabolic and survival mechanisms under extreme conditions. • To explore biotechnological applications of extremophiles.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Identify various types of extreme environments and classify major groups of extremophiles.	PSO1, PSO3
	CO 2. Describe the physiological and biochemical mechanisms that enable survival under extreme conditions.	PSO1, PSO3
	CO 3. Explain molecular adaptations such as heat-shock proteins, antifreeze proteins, and membrane modifications in extremophiles.	PSO1, PSO2, PSO4

	CO 4. Analyze the metabolic pathways and energy mechanisms involved in adaptation to high temperature, salinity, pressure, and radiation.		PSO1, PSO3, PSO4	
	CO 5. Evaluate ecological and evolutionary significance of extremophiles in natural and artificial ecosystems.		PSO3, PSO7	
	CO 6. Propose potential biotechnological applications of extremophiles in industry, environment, and medicine.		PSO2, PSO5, PSO6, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• Thermophiles: Tree of life • Types of Extreme habitats based on environmental variables/sources: • Low Temperatures: Polar regions (Antarctica and Arctic). • High temperatures: Deserts, Hot springs, hydrothermal vents, Deserts. • Pressure: Deep-sea environments, Subsurface rocks, Mariana Trench. • Vacuum: Space station, space habitation. • Desiccation: extreme hypersaline environments, deserts. • Hypersaline: coastal lagoons, salt and soda lakes, salterns, deep-sea brine pools, brine channels in sea ice, and fermented foods and pickling brines. • pH: Acidic [Solfataric fields (sulfuric volcanic fields), geysers, sulfuric acid pools, acid minedrainages from coal and metal mining waste] or Alkaline (Soda lakes and soda deserts). • Low oxygen: Low or depleted oxygen level in water bodies (anthropogenic activities, pollution, eutrophication, algal growth) • Methane: Natural wetlands, freshwater lakes, streams, rivers, estuarine and coastal areas, termite, and wild ruminant guts, terrestrial and marine seeps, volcanoes, geothermal vents, gas hydrates, and methane produced from biomass combustion (i.e., wildfires). Anthropogenic sources agriculture, with cattle and rice cultivation as the largest contributors, fossil fuels, waste (ex. landfills, sewage), and biomass/biofuel burning.	**15**	CO1, CO2, CO4	K1-K4

	• Categories of extremophiles: Thermophile, Halophile, Psychrophile, Alkaliphile, Acidophile, Piezophile or barophile, Xerophiles, Anaerobic, methanogenic, metal resistant, radiation resistant, endoliths.			
Module 2:	• Homeostasis, enantiosis (physiological/biochemical) • Thermogenesis, exothermic, endothermy molecular mechanisms (stability of proteins, catalytic rates) Stress proteins: heat shock, chaperonins, SAPKs • Freeze avoidance/tolerance: antifreeze proteins, ice nucleation, frost (cold) hardiness, Membrane structures, and temperature. • Life under pressure: barophilic bacteria, metazoan, Deep diving penguins, mammals • Energy metabolism – the role of oxygen (normoxia, hypoxia, anoxia) physiological adaptations (hibernation, torpor, estivation) • Photosynthesis - physiological and biochemical adaptations to extreme light and temperature • Ionizing radiation - mechanism of radiation resistance • Life with limited water - arthropods, reptiles • Hot, dry environments - mammalian physiological adaptations • Mechanisms to avoid osmotic stress acid and alkaline environments • Overcoming heavy metal and toxin tolerances, • Biotechnological application of extremophiles	15	CO2, CO3, CO4, CO6	K3-K6
Pedagogy:	Lectures, tutorials, assignments			
Texts, References/ Readings:	1. Anitori, R. P. (2012). *Extremophiles: Microbiology and Biotechnology.* Caister Academic Press. 2. Durvasula, R. V., & Subba Rao, D. V. (2018). *Extremophiles: From Biology to Biotechnology.* CRC Press. 3. Elster, J., Prisco, G., Huiskes, A. H. L., & Edwards, H. G. M. (2020). *Life in Extreme Environments: Insights in Biological Capability*. Cambridge University Press. 4. Gunde-Cimerman, N., Oren, A., & Plemenitaš, A. (Eds.). (2005). *Adaptation to Life at High Salt Concentrations in Archaea, Bacteria, and Eukarya.* Springer. 5. Richa, S., & Vivek, S. (2020). *Physiological and Biotechnological Aspects of Extremophiles.* Academic Press. 6. Singh, V. O. (2012). *Extremophiles: Sustainable Biotechnology.* Blackwell Publishing. 7. Wharton, D. A. (2002). *Life at the Limits: Organisms in Extreme Environments.* Cambridge University Press.			

Title of the Course	Internship
Course Code	GBT-6006
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To understand the agency as a system, and to develop an understanding and skills in working with specialized organization. • To impart student with "hands-on" experiences at a qualified place of employment (non-profit or governmental agency or private organizations) • To provide a potential impact to students' cognitive skills, knowledge, interests, and future career.	
Course Outcomes:	By the end of the Internship course, students will be able to:	**Mapped to PSO**
	CO 1. Demonstrate hands-on experience by engaging in daily work practices and responsibilities at a qualified organization (industry, research institution, non-profit, or government agency).	PSO1, PSO2, PSO6
	CO 2. Apply discipline-specific skills and knowledge under professional supervision, thereby enhancing readiness for employment in similar professional environments.	PSO1, PSO2, PSO5, PSO6

	CO 3. Gain exposure to diverse workforces and develop a broader understanding of career opportunities and professional pathways.		PSO6, PSO7, PSO8	
	CO 4. Establish constructive mentor–mentee relationships with supervisors/employers, fostering professional networking and personal growth		PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
	Application of Knowledge and Skills ○ Integration of theoretical knowledge from the classroom with practical exposure in industrial or academic environments. ○ Observation and participation in job-related activities under the supervision of the host organization. **Professional Work Practices** ○ Adherence to organizational policies, work schedules, and professional ethics of the host agency. ○ Active involvement in daily operations, projects, and assigned responsibilities. **Documentation and Reporting** ○ Preparation of a structured internship report detailing tasks performed, skills acquired, and key learnings. ○ Certification of the report by the supervisor/Head of the host organization. ○ Submission of the report to the Program Director/Coordinator for evaluation.	**60**	CO1, CO2, CO3, CO4	K3, K4, K5
Pedagogy:	Theory, practical demonstrations, documentation/ tutorials/assignments			
Texts, References/ Readings:	1. Kothari, C. R. (2004). Research Methodology: Methods and Techniques (2nd ed.). Foundational text for research planning, data collection, and analysis. *New Age International.* 2. Kothari, C. R. (2008). Research methodology: Methods and techniques (2nd rev ed.). New Delhi: New Age International.			

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Title of the Course	Field Trip
Course Code	GBT-6007
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	The primary objectives of the group learning course are as follows: • To provide firsthand experience, • To stimulate interest and motivation in science, • To add relevance to learning and inter-relationships, • To provide a potential impact to students' cognitive skills, knowledge, interests, and future career.	
Course Outcomes:	At the end of this course, the students will be able to:	**Mapped to PSO**
	CO 1. Connect between the field trip learning with prior experiences and knowledge from the classroom.	PSO1, PSO3, PSO7, PSO8
	CO 2. Sharpen their skills of observation and perception.	PSO2, PSO3, PSO8
	CO 3. Understand experiential learning discussed during field trips.	PSO1, PSO2, PSO3,

			PSO4	
	CO 4. At the end of this course, the students will be able to:		PSO5, PSO6, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• Visit to any central science research and development institute or science laboratory (ICAR, NIO, NCPOR) • Visit to a pharmaceutical industry to learn about industrial manufacturing processes.	**30**	CO1, CO2, CO3	K2, K3, K4
Module 2:	• Visit to any Biotechnology industrial unit such as beverage production unit. • Visit to dairy industry, fish processing unit, food processing unit. • Visit to waste processing unit.	**30**	CO3, CO4	K4, K5
Pedagogy:	Field Visit			

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Title of the Course	Research Methodology
Course Code	GBT-6008
Number of credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	The course aims to • Equip students with the conceptual and practical foundations of scientific research. It provides insights into identifying and formulating research problems, developing hypotheses, and designing effective experimental frameworks. • Students will gain competence in applying statistical and analytical tools for data collection, interpretation, and validation. • Emphasis is placed on scientific writing, manuscript preparation, and ethical practices in research, ensuring academic integrity and responsible conduct. • The course aims to develop the critical, analytical, and creative thinking skills necessary for conducting independent research and communicating scientific findings in professional formats.

			Mapped to PSO	
Course Outcomes:	CO 1. Define and remember fundamental concepts of research methodology, scientific method, and research ethics.		PSO1, PSO7	
	CO 2. Explain research problem identification, hypothesis formulation, and the principles of good research design.		PSO1, PSO5	
	CO 3. Apply appropriate sampling methods, measurement tools, and data collection techniques to research studies.		PSO2, PSO3	
	CO 4. Analyze and interpret quantitative and qualitative research data using suitable statistical and computational tools.		PSO2, PSO3	
	CO 5. Evaluate the validity, reliability, and ethical integrity of scientific studies, avoiding plagiarism and research misconduct.		PSO3, PSO4	
	CO 6. Design and construct research proposals, manuscripts, and reports adhering to scientific and ethical standards.		PSO7, PSO8	
Content		**No. of Hours**	**Mapped to CO**	**Cognitive Level**
Module I	**Introduction to Research**: Meaning, Objectives, Motivation in Research. Concept of theory, empiricism, deductive, and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition. Research Process. • Good Laboratory Practices, Ethics in research • Research problem: Selecting and analyzing the research problem – problem statement formulation – formulation of hypothesis. Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance. • Research Design: Concept and Importance in Research – Components and Features of a good research design; Types of research design: concept, and uses of Exploratory, Descriptive, and Experimental Design: Concept of Independent & Dependent variables.	**15**	CO1, CO2	K1, K2, K3

	• Defining the Aims and Objectives, Work Plan – Time-bound Frame.			
Module II	**Measurement, Data Collection, and Sampling Methods**. • Variables in Research – Measurement and scaling – Different scales – Construction of instrument – Validity and Reliability of instrument. • Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non-Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. • Determining the size of the sample-Practical considerations in sampling and sample size. • Data collection, Analysis, and Interpretation: Types of data: Primary and secondary data, Qualitative vs Quantitative data analyses – Univariate(frequency tables, bar charts, pie charts, percentages), Bivariate Cross tabulations.	**15**	CO3, CO4	K1, K2, K3, K4
Module III	**Types of Scientific Writing and Reference Management** • Importance of communicating research; Research manuscript writing: reports, short communication, manuscript/original articles, review articles, thesis writing, editorials, books, book chapters. • Fundamentals of scientific paper: Drafting titles and framing abstracts, Authorship, Keywords, Introduction, Materials and Methods, Results and Discussion, Conclusion, Acknowledgement, Conflicts of Interest, Scientific Objectivity, and Bibliography. • Research proposal writing: Components of research proposal (funding-based and non-funding/PhD-based). • Selection of journals for publication: Tools for suggesting journals for publishing research, Open access and predatory journals, and cloned journals. • Publication/Research metrics - Impact factor, citation count, cite score, h-Index, g-Index. • Research evaluation: Peer review, Viva Voce.	**15**	CO5	K2, K3, K4, K5, K6

	• Reference Styles and Formatting: Overview of different reference styles (APA, MLA, Chicago); Formatting in-text citations and reference lists; Creating bibliographies and webliographies. • Reference Management Systems: Introduction to reference management software (EndNote, Zotero, Mendeley); Building and organizing a reference library; Importing references from databases.			
Module IV	**Ethical aspects in academic writing** ● Ethical issues in research: Code of Ethics in Research ● Human and Animal Ethics ● Scientific conduct and misconduct; Authorship issues ● Plagiarism: Definition and types of plagiarism; Consequences of plagiarism in academia; Strategies to avoid plagiarism; Strategies to prevent scientific misconduct, Falsification, fabrication, misinterpretation of data. Salami, imalas and duplicate publication. ● The investigation and punishment of scientific misconduct. ● Introduction to plagiarism detection software (Turnitin, Grammarly, Dilbrit); Interpreting similarity reports; ● Best practices for maintaining academic integrity. Government guidelines/Official Gazette (UGC Regulations 2018).	**15**	CO5, CO6	K1, K2, K3
Pedagogy	Lecture, Tutorial, Assignments, Presentations, Discussions			
Reference Texts	1. Kothari, C. R. (2008). *Research methodology: Methods and techniques* (2nd rev. ed.). New Age International. 2. Kumar, R. (2018). *Research methodology: A step-by-step guide for beginners*. SAGE Publications.			
References/ Readings	1. Olsen, B. R., Benestad, H. B., & Laake, P. (Eds.). (2007). *Methodology in the medical and biological sciences*. Academic Press. 2. Cooray, P. G. (1992). *Guide to scientific and technical writing*. P. G. Cooray. 3. Marczyk, G. R., DeMatteo, D., & Festinger, D. (2010). *Essentials of research design and methodology*. Wiley. 4. Shamoo, A. E., & Resnik, D. B. (2003). *Responsible conduct of research*. Oxford University Press. 5. University Grants Commission. (2018). *University Grants Commission (Promotion of academic integrity and prevention of plagiarism in higher educational institutions) regulations, 2018* (Gazette of India No. F.1-18/2010 (CPP-II))			

Discipline Specific Vocational Elective (DSVE) Courses

Title of the Course	Enzymes: Chemistry and Engineering
Course Code	GBT-6401
Number of Credits	4
Theory/Practical	Theory + Practical
Level	500
Effective from AY	2026 - 27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	This course will provide a comprehensive view of enzyme with respect to • Develop a fundamental understanding of enzyme structure, function, and catalysis, and how these properties can be modified. • Provide theoretical and practical knowledge of enzyme production, extraction, assay, and purification techniques. • Familiarize students with modern enzyme engineering methods including rational design, directed evolution, and site-directed mutagenesis. • Explore advanced enzyme modifications, emerging technologies, and their applications in industrial, clinical, and diagnostic fields.

	• Develop practical skills in enzyme extraction, purification, and assay techniques. • Apply biochemical methods to analyze enzyme kinetics. • Utilize analytical tools to characterize enzyme properties and activity. • Interpret experimental data to understand enzyme behaviour under various conditions.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Explain the principles of enzyme catalysis and analyze how enzyme properties such as activity, specificity, and stability can be modified through amino acid sequence manipulation.		PSO1, PSO3, PSO5	
	CO 2. Apply knowledge of enzyme production systems, extraction methods, quantitative assays, and purification techniques to isolate and characterize enzymes.		PSO1, PSO2, PSO6	
	CO 3. Demonstrate understanding of enzyme engineering techniques such as directed evolution, rational design, and site-directed mutagenesis to modify enzyme functions.		PSO2, PSO3, PSO5	
	CO 4. Evaluate the role of advanced enzyme modifications and discuss their applications in clinical diagnostics, industrial processes, and biosensor development.		PSO4, PSO6, PSO7, PSO8	
	CO 5. Isolate, purify, and characterize enzymes from biological sources, including performing activity assays and determining kinetic parameters (Km, Vmax).		PSO1, PSO2, PSO3, PSO6	
	CO 6. Analyze factors affecting enzyme activity and stability (pH, temperature, inhibitors) and effectively interpret, document, and present experimental data.		PSO1, PSO3, PSO4, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Principles of Enzyme Engineering** ● Understanding enzyme catalysis	**15**	CO1, CO2	K1, K2,

	• Modifying enzyme properties (activity, specificity, stability) • Amino acid sequence manipulation and structure-function relationships **Enzyme Engineering Approaches** • Directed evolution and Rational design • Site-directed mutagenesis techniques **Enzyme Production and Extraction** • Enzyme extraction strategies • Choice of systems for enzyme production (microbial, plant, or mammalian systems for biotechnological applications) **Enzyme Activity Assay** • General methods for quantitative assay of enzymes • Units of activity, specific activity, and assay optimization **Enzyme Purification and Analysis** • Principles and techniques of enzyme purification: o Salting in and out o Molecular sieving (gel filtration) o Ion exchange chromatography o Affinity chromatography • Electrophoretic techniques: o Gel electrophoresis o Isoelectric focusing o 2-D electrophoresis • Fold purification and enzyme recovery			K3, K4, K5, K6

	• Setting up and interpreting a purification table			
Module 2:	**Enzyme Engineering and Modification** • Role and methods of covalent modification in enzymatic activity • Use of chemical modifiers (e.g., PEGylation) and its applications • Enzyme fusion and its biotechnological relevance **Enzyme Applications** • Pharmaceutical & Clinical applications of enzymes in diagnostics, therapeutics (e.g., penicillinase, glucose oxidase), • Industrial applications of hydrolytic enzymes (e.g., in food, detergent, textile industries) • Development and application of enzyme-based biosensors **Special Enzyme Systems** • Catalytic antibodies (abzymes): concept and applications. • Artificial enzymes (synzymes)	**15**	CO3, CO4	K2, K4, K5, K6
Module 3:	**Enzyme Isolation, Purification & Characterization** 1. Preparation of crude enzyme extract from a biological source (e.g., plant tissue, microbial culture). 2. Ammonium sulfate precipitation for partial purification. 3. Dialysis for desalting and concentration. 4. Ion exchange/Affinity/Gel filtration Chromatography for preparation of a purification table to determine the steps in purity 5. Protein quantification (e.g., Bradford or Lowry method). 6. Determination of specific activity at each purification step, fold purification, percentage yield of enzyme 7. SDS-PAGE analysis of enzyme purity.	**30**	CO1, CO4,	K3, K4, K5

Module 4:	**Enzyme Activity and Kinetics** 1. Assay of enzyme activity (e.g., amylase) using spectrophotometry. 2. Effect of substrate concentration on reaction rate. 3. Determination of Km and Vmax using Michaelis-Menten and Lineweaver-Burk plots. 4. Effect of pH and temperature on enzyme activity and stability. 5. Enzyme immobilization	**30**	CO2, CO3, CO4	K3, K4, K5, K6
Pedagogy:	Lectures/tutorials/assignments/Hands-on Experiments/Demonstrations/online/self-study			
Texts/ References/ Readings:	1. **Boyer, R.** (2000). *Modern Experimental Biochemistry.* Pearson Education India. 2. C**opeland, R. A.** (2000). *Enzymes: A practical introduction to structure, mechanism, and data analysis.* Wiley-VCH. 3. **de Paula, J., & Atkins, P.** (2011). *Physical Chemistry for the Life Sciences* (2nd & 3rd eds.). W. H. Freeman. 4. **Dixon, M., & Webb, E. C.** (1979). *Enzymes.* Longman Group Ltd. 5. **Gray, N., et al.** (2010). *Enzyme biotechnology.* Scientific Publishers. 6. **James, J. F.** (2017). *An Introduction to Practical Laboratory Optics.* Cambridge University Press. 7. **Jayaraman, J.** (2011). *Laboratory Manual in Biochemistry.* New Age International Publishers. 8. **John, G.** (2020). *Biological Centrifugation.* CRC Press. 9. **Lewin, B.** (2000). *Genes VII.* Oxford University Press. 10. **Mahler, H. R., & Cordes, E. H.** (1986). *Biological chemistry.* Harper & Row. 11. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry* (7th ed.). W. H. Freeman and Company. **ISBN:** 9781464126116 12. **Palmer, T.** (2004). *Enzymes: Biochemistry, biotechnology, and clinical chemistry.* Horwood Publishing. 13. **Plummer, D. T.** (2001). *Introduction to Practical Biochemistry.* Tata McGraw-Hill Education. 14. **Prakash, B. S., & Bisen, P. S.** (2014). *Laboratory Protocols in Applied Life Sciences.* Taylor & Francis.			

	15. **Riedel, L., & Engels, J. W.** (2018). *Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology*. Wiley-VCH. 16. **Sivasankar, B.** (2005). *Bioseparations: Principles and techniques.* Prentice-Hall of India. 17. **Van Holde, K. E., Johnson, C., & Ho, P. S.** (2005). *Principles of Physical Biochemistry* (2nd ed.). Prentice Hall. 18. **Voet, D., Voet, J. G., & Pratt, C. W.** (2016). *Fundamentals of Biochemistry* (5th ed.). John Wiley & Sons.
Web Resources:	1. https://www.ncbi.nlm.nih.gov/books/NBK22430/ 2. https://www.brenda-enzymes.org 3. https://www.rcsb.org 4. https://www.nature.com/scitable/topicpage/enzyme-technology-14112516 5. https://www.addgene.org/protocols/mutagenesis/ 6. https://www.khanacademy.org/ 7. https://www.protocol-online.org/ 8. https://gchem.cm.utexas.edu/kinetics/

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Title of the Course	Algal Biotechnology and Bioeconomy
Course Code	GBT-6402
Number of Credits	4
Theory/Practical	4 (2T + 2P)
Level	500
Effective from AY	2026 - 27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	• To understand the physiological, biochemical, and ecological roles of microalgae and macroalgae in global carbon cycling, productivity, and the blue bioeconomy. • To develop knowledge of microalgal cultivation systems, strain selection, and downstream processing for biofuel and high-value biomolecule production. • To examine the biochemical composition, cultivation, and molecular biology of seaweeds for biotechnological and industrial applications. • To evaluate the sustainability, environmental impact, and biorefinery approaches integrating algal biotechnology within the blue economy framework. • To develop practical skills in culturing, maintaining, isolating, and identifying microalgal and macroalgal species using standard laboratory and taxonomic techniques. • To train students in biomass estimation, growth analysis, and extraction of pigments and bioactive compounds for

	biotechnological applications.			
Course Outcomes:	At the end of the course students will be able to			**Mapped to PSO**
	CO 1. Explain the physiological, biochemical, and ecological roles of microalgae and macroalgae in global carbon cycling and productivity.			PSO1, PSO3, PSO7
	CO 2. Demonstrate understanding of algal cultivation systems, strain selection, and downstream processing for biofuel and biomolecule production.			PSO1, PSO5, PSO6
	CO 3. Analyze the biochemical composition and molecular biology of seaweeds for industrial and biotechnological applications.			PSO1, PSO3, PSO6
	CO 4. Evaluate sustainability and biorefinery approaches integrating algal biotechnology within the blue economy framework.			PSO4, PSO6, PSO7
	CO 5. Perform isolation, culturing, maintenance and identification of microalgal and macroalgal species using standard laboratory techniques.			PSO1, PSO2, PSO8
	CO 6. Estimate algal biomass and extract pigments and bioactive compounds for biotechnological evaluation.			PSO2, PSO5, PSO6
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Microalgal Biotechnology and Bioeconomy** **Introduction & Scope** • Importance of microalgae in global primary productivity and carbon cycling • CO_2 sequestration potential • Overview of role in the bioeconomy: feed, food, fuel, pharmaceuticals, pigments, aquaculture applications **Diversity, Physiology & Strain Selection** • Major industrially relevant groups: o Chlorophyta (e.g., *Chlorella*, *Scenedesmus*): lipid accumulation, biofuels, nutraceuticals	**15**	CO1, CO2, CO3, CO4	K2, K4, K6

	○ Bacillariophyta (diatoms, e.g., *Phaeodactylum*, *Navicula*): silica frustules, PUFA production ○ Cyanobacteria (e.g., *Arthrospira/Spirulina*): protein-rich biomass, pigments (phycocyanin) • Strain selection criteria: productivity, product profile, stress tolerance, GRAS status **Cultivation Systems & Scale-up** • Growth requirements: light, nutrients, CO_2, and temperature • Open systems (raceway ponds): design, advantages, and limitations • Closed photobioreactors (PBRs): basic types and operational considerations • Brief overview of hybrid systems and scale-up challenges **Harvesting & Downstream Processing** • Overview of harvesting methods: flocculation, sedimentation, centrifugation, membrane filtration. • Cell disruption techniques: mechanical and non-mechanical methods • Extraction approaches: solvent extraction, supercritical CO_2 • Purification strategies: chromatography, crystallisation **Products and Applications** • **Biofuels**: Triacylglycerol induction via nutrient stress (N starvation), Biodiesel production pipeline and limitations in commercial feasibility • **High-value metabolites**: Pigments , phycobiliproteins, Polyunsaturated fatty acids, Antioxidants • **Proteins & Polysaccharides**: Single-cell protein; Exopolysaccharides with immunomodulatory activity • **Bioactive molecules**: antimicrobial, antiviral, anticancer compounds • **Biorefinery approach**: Concept of cascade utilization: fuels + pigments + proteins + co-products, Example flowsheets integrating multiple product streams			

	Applications in Phytoremediation • Nutrient removal (nitrogen, phosphorus) • Heavy metal sequestration • Integration with aquaculture wastewater treatment			
Module 2:	**Macroalgal Biotechnology and Bioeconomy** **Introduction to Seaweed Biology** • Classification and taxonomy of seaweeds (Rhodophyta, Phaeophyceae, Chlorophyta) • Morphology and anatomy of macroalgae • Life cycles and reproduction **Seaweed Cultivation and Harvesting** • Methods of seaweed farming (offshore, onshore) • Environmental factors affecting growth • Seed production and nursery techniques • Seaweed-Microbe Interactions: Role of microbial communities in seaweed health, growth, nutrient cycling, and disease resistance • Harvesting and post-harvest handling **Seaweed Biochemistry and Molecular Biology** • Primary and secondary metabolites in seaweeds • Biochemical composition: polysaccharides (agar, carrageenan, alginate), proteins, lipids, pigments • Molecular tools in seaweed biotechnology (DNA barcoding, genetic markers) **Biotechnological Applications of Seaweeds** • Seaweed Biorefinery • Production of food, feed, and bioactive compounds • Industrial applications: pharmaceuticals, nutraceuticals, cosmetics, Biofuel, and bioplastics from macroalgae	**15**	CO1, CO2, CO3, CO4	K2, K5, K6

	• Seaweed in wastewater treatment and carbon sequestration **Genetic Engineering and Molecular Breeding** • Genetic modification approaches in seaweeds • Breeding strategies for enhanced traits • Challenges and ethical considerations **Sustainable Seaweed Industry** • Blue Bioeconomy and role of seaweeds • Market trends and economic potential • Environmental impact and sustainability of seaweed farming • Policy and regulatory aspects			
Module 3:	**Microalgal Technology** • Preparation of Culture Media for Marine and Freshwater Phytoplankton. • Isolation and identification of microalgae using standard identification keys. • Cell enumeration and growth curve analysis • Methods for harvesting Microalgal biomass • Pigment Extraction and Characterization • Extraction of primary and secondary metabolites from microalgae	**30**	CO5, CO6	K2, K3, K4
Module 4:	**Macroalgal Biotechnology and Bioeconomy** • Seaweed collection from coastal habitat • Seaweed preservation techniques (herbarium preparation) • Morphological identification using dissecting and compound microscopes • Media preparation, cultivation of Ulva culture • Seaweed biomass estimation: Calculation of productivity & biomass yield • Extraction of Bioactive Compound from seaweed.	**30**	CO5, CO6	K2, K3, K4
Pedagogy:	Lectures/tutorials/assignments/Hands-on experiments in the laboratory/Field training/Demonstration/online/self-study			

Texts, References/ Readings:	1. Andersen, R. A., & Kawachi, M. (2005). *Microalgae isolation techniques. Algal Culturing Techniques*, 83, 92. 2. Cameselle, C., Maceiras, R., & Rodríguez, M. (2025). *Optimization of ultrasound-assisted extraction of bioactive compounds and biopolymers from Ulva* spp. *Journal of Applied Phycology*. https://doi.org/10.1007/s10811-025-03492-2 3. Chapman, A. R. O., & Chapman, D. J. (1980). *Seaweed Ecology and Physiology.* Cambridge University Press. 4. Ganesan, P., Kumar, C. S., & Bhaskar, N. (2019). *Seaweed extracts as a modern bio-stimulant: An emerging trend in agriculture and forestry. Journal of Applied Phycology*, 31(1), 123–136. https://doi.org/10.1007/s10811-018-1602-x 5. Gopinathan, C. P., Rajagopalan, M., Kaladharan, P., & Prema, D. (2007). *Training manual on phytoplankton identification/taxonomy*. 6. Holdt, S. L., & Kraan, S. (2011). *Bioactive compounds in seaweed: Functional food applications and legislation. Journal of Applied Phycology*, 23(3), 543–597. https://doi.org/10.1007/s10811-010-9632-5 7. Karlson, B., Cusack, C., & Bresnan, E. (2010). *Microscopic and molecular methods for quantitative phytoplankton analysis.* 8. Kim, S.-K., & Bhatnagar, I. (Eds.). (2011). *Seaweed Biology: Novel Insights into Ecophysiology, Ecology and Utilization.* CRC Press. 9. Moncheva, S., Parr, B., Sarayi, D., & Hareket, I. I. (2010). *Manual for phytoplankton sampling and analysis in the Black Sea. Phytoplankton Manual, UP-GRADE Black Sea Scene Project, FP7, 226592.* 10. Pappou, S., Tziveleka, L.-A., Ioannou, E., & Roussis, V. (2022). *Extraction of bioactive compounds from the green seaweed Ulva lactuca*: *Optimization and evaluation of antioxidant activity. Applied Sciences*, 12(4), 2117. https://doi.org/10.3390/app12042117 11. Reynolds, C. S. (2006). *The ecology of phytoplankton.* Cambridge University Press. 12. Robles-Carnero, M., García-Balboa, C., Morales-Amador, A., Sánchez-Rodríguez, I., & López-Figueroa, F. (2024). *Biomass productivity and photosynthetic activity in Ulva rigida (Chlorophyta) cultured under different conditions of light and nutrients. Plants*, 13(12), 1612. https://doi.org/10.3390/plants13121612 13. Royal Botanic Garden Edinburgh. (2017). *Preparation and care of herbarium specimens* (Revised 6 November 2017). Edinburgh, UK: RBGE. Retrieved from https://www.rbge.org.uk/media/4584/preparation-care-and-art-of-herbarium-specimens-revised-6-nov-2017.pdf 14. Singh, R. P., & Reddy, C. R. K. (2014). *Seaweed–microbial interactions: Key functions of seaweed-associated bacteria. FEMS Microbiology Ecology*, 88(2), 213–230. https://doi.org/10.1111/1574-6941.12228 15. Sluiman, H. (2009). *Phycology. Edinburgh Journal of Botany*, 66(3), 483–484. 16. Smithsonian National Museum of Natural History. (n.d.). *Algae preservation techniques.* Washington, DC:

	Smithsonian Institution. Retrieved from https://naturalhistory.si.edu/research/botany/research/algae/algae-preservation-techniques 17. Tomas, C. R. (Ed.). (1997). *Identifying marine phytoplankton.* Elsevier. 18. Venkatesan, J., Anil, S., & Kim, S.-K. (Eds.). (2017). *Seaweed polysaccharides: Isolation, biological and biomedical applications* (1st ed.). Elsevier. ISBN: 978-0-12-8098165 (print), 978-0-12-8098172 (eBook).
Web Resources:	1. https://roscoff-culture-collection.org/ 2. https://seaweedhub.extension.uconn.edu/

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Title of the Course	Biopharmaceutical Technology and Pharmacology
Course Code	GBT-6403
Number of Credits	4 (2T + 2P)
Theory/Practical	Theory + Practical
Effective from AY	2026 - 27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	• Introduce students to the principles, scope, and industrial importance of biopharmaceuticals. • Provide knowledge on production and purification of recombinant therapeutic proteins, monoclonal antibodies, vaccines, downstream processing. • Discuss preclinical and clinical development, formulation, and regulatory aspects of biopharmaceuticals. • Develop understanding of modern trends such as biosimilars, personalized medicine, and biopharma entrepreneurship. • Perform laboratory techniques to assess drug stability, dissolution, and diverse biological activities such as antimicrobial, antioxidant, enzyme inhibition, and cytotoxic effects. • Assess pharmacological safety and biocompatibility through experimental and computational approaches, including hemolysis, hemocompatibility, model organism assays, and prediction of adverse drug reactions.

Course Outcomes:	At the end of the course students will be able to:		**Mapped to PSO**	
	CO 1. Explain the basic concepts, types, and significance of biopharmaceuticals.		PSO1, PSO3, PSO4	
	CO 2. Describe recombinant DNA-based production of therapeutic proteins and monoclonal antibodies.		PSO1, PSO2, PSO3	
	CO 3. Analyse formulations, delivery, and pharmacokinetics of pharmaceuticals.		PSO4, PSO5, PSO6, PSO8	
	CO 4. Evaluate regulatory, ethical, and business perspectives in biopharmaceutical development.		PSO7, PSO4, PSO8	
	CO 5. Demonstrate and analyse drug dissolution, stability, and biological activities such as antioxidant, enzyme inhibitory, and antimicrobial properties using suitable laboratory techniques.		PSO1, PSO2, PSO3	
	CO 6. Assess pharmacological safety and cytotoxicity through experimental and computational approaches, integrating results to evaluate overall drug efficacy and safety.		PSO3, PSO4, PSO6, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	***Introduction to Biopharmaceuticals*** • Historical development of biopharmaceuticals - traditional pharmaceuticals vs biopharmaceuticals. • Overview of the global biopharmaceutical industry and major products. • Classification of biopharmaceutical products (therapeutic proteins, hormones, enzymes, monoclonal antibodies, vaccines, nucleic acid drugs, cell therapies) ***Expression Systems and Production Technology*** • Expression hosts: *E. coli*, yeast, mammalian cells, transgenic plants/animals.	**15**	CO1, CO2, CO3	K1, K2, K3, K4

	• Case studies: recombinant insulin, erythropoietin, interferon. • Process optimization, validation, stability and potency testing. • Hybridoma technology and Antibody engineering. • Biosimilars: development and approval. • Quality by Design (QbD) and Good Manufacturing Practices (GMP).			
Module 2:	***Principles of Pharmacology*** • Scope and significance in Biotechnology. • Sources of drugs: natural, synthetic, recombinant. • Drug–receptor interactions, dose-response relationships, therapeutic index. • Pharmacodynamics - molecular targets and biological pathways. • Pharmacokinetics - absorption, distribution, metabolism, and excretion (ADME). ***Major Pharmacological classes and mechanisms of Action*** • Case studies of biopharma drugs: antibiotics, anticancer agents, anti-inflammatory, analgesic, antipyretic agents, biologics, nervous system drugs (cholinergic, adrenergic). • Mechanisms: Enzyme inhibitors, receptor antagonists, ion channel inhibitors, kinases, transcription factors. ***Pharmacogenomics, Toxicology, and Ethics*** • Genetic basis of variable drug response (Cytochrome P450 polymorphisms). • Types of toxicity (acute, chronic, reproductive, genotoxicity). • Pre-clinical testing (animal models, LD_{50}). • Phases of drug development, Post market safety. • GLP, and CPCSEA guidelines. • Emerging Areas in Pharmacology: Immuno-pharmacology, Personalized medicine, AI in drug development.	**15**	CO3, CO4	K3, K4, K5, K6
Module 3:	**Biopharmaceutical Technology** 1. Model drug dissolution study (eg. ascorbic acid).	**30**	CO5	K2, K3, K4

	2. Stability Testing of a Model Formulation (Thermal stress / GI simulation / Photostability/ Oxidative stress/ Storage stability) 3. Determination of Minimum Inhibitory Concentration (MIC) for an antimicrobial compound. 4. DPPH antioxidant activity assay. 5. α-Amylase enzyme inhibition assay. 6. Nitroblue tetrazolium (NBT) assay for superoxide scavenging.			
Module 4:	**Pharmacology** 1. Hemolysis, hemocompatibility test. 2. MTT assay for cytotoxicity evaluation (yeast model). 3. Dose–response curve and LD_{50} determination using *Artemia salina* lethality bioassay. 4. Comparative statistical analysis for predicting adverse drug reactions. 5. QSAR, ADMET & Predictive Toxicology	**30**	CO6	K4, K5, K6
Pedagogy:	Lectures/tutorials/assignments/Hands-on experiments in the laboratory/Field training/Demonstration.			
Texts, References/ Readings:	1. Blunt, J. W., & Munro, M. H. G. (2017). *Marine natural products: Practical approaches to isolation, structure elucidation, and bioactivity evaluation.* Springer. 2. Brunton, L. L., Hilal-Dandan, R., & Knollmann, B. C. (Eds.). (2023). *Goodman & Gilman's: The pharmacological basis of therapeutics* (14th ed.). McGraw-Hill Education. 3. Chaurasia, H., & Pathak, A. (Eds.). (2021). *Experimental pharmacology for pharmacy and allied health sciences: Laboratory manual.* Springer. 4. Katzung, B. G., Vanderah, T. W., & Trevor, A. J. (2021). *Basic and clinical pharmacology* (15th ed.). McGraw-Hill Education. 5. Kiyota, H. (Ed.). (2021). *Marine natural products* (Vol. 58, *Topics in Heterocyclic Chemistry*). Springer. 6. Kulkarni, S. K. (2019). *Handbook of experimental pharmacology* (5th ed.). Vallabh Prakashan.			

	7. McLaughlin, J. L., Rogers, L. L., & Anderson, J. E. (1998). *The brine shrimp lethality bioassay.* In K. Hostettmann (Ed.), *Methods in plant biochemistry: Assays for bioactivity* (Vol. 6, pp. 1–37). Academic Press. 8. Rang, H. P., Dale, M. M., Ritter, J. M., Flower, R. J., & Henderson, G. (2016). *Rang & Dale's pharmacology* (8th ed.). Elsevier. 9. Verma, A. S., & Singh, A. (Eds.). (2020). *Animal Biotechnology: Models in Discovery and Translation* (2nd ed.). Academic Press. 10. Whitesides, G. M., & Deutch, J. M. (Eds.). (2020). *Principles of drug discovery and development.* Springer. 11. Willmann, S., & Lippert, J. (Eds.). (2019). *Pharmacokinetic and pharmacodynamic data analysis: Concepts and applications.* Springer.

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SEMESTER IV

Generic Elective (GE) courses

Title of the Course	Synthetic Biology
Course Code	GBT-6201
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	• To introduce the fundamental principles, history, and conceptual frameworks of synthetic biology**.** • To provide an understanding of DNA synthesis, genetic circuit design, and genome engineering technologies**.** • To cultivate awareness of ethical, biosafety, and societal implications associated with synthetic biology research and its translational potential.

Course Outcomes:			**Mapped to PSO**	
	CO 1. Explain the fundamental principles, history, and conceptual frameworks of synthetic biology, including top-down and bottom-up approaches for system design.		PSO 1, PSO 4	
	CO 2. Apply molecular cloning, DNA synthesis, and genome editing techniques to construct and modify synthetic biological systems.		PSO 1, PSO 2, PSO 5	
	CO 3. Design and model synthetic genetic circuits using computational and mathematical tools to simulate regulatory behaviors such as switches, oscillators, and logic gates.		PSO 3, PSO 4, PSO 5	
	CO 4. Analyze strategies for protein, pathway, and minimal genome engineering to create artificial and functional biological systems.		PSO 2, PSO 3, PSO 5	
	CO 5. Evaluate the applications of synthetic biology in biotechnology, health, agriculture, environment, and bio-manufacturing sectors.		PSO 4, PSO 5, PSO 6	
	CO 6. Assess the ethical, biosafety, and societal implications of synthetic biology research and its emerging frontiers.		PSO 7, PSO 8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Principles and Foundations** • Introduction, history, and scope of synthetic biology. • Top-down and bottom-up approaches to building synthetic systems. **DNA technologies** • Artificial DNA synthesis, synthetic genomics, genome modularity. • Standard biological parts and design frameworks (Biobricks, Gibson Assembly, Golden Gate cloning). **Synthetic genetic circuits** • Oscillators, switches, logic gates, and analog tuners. Circuit design and modeling: basic computational and mathematical approaches.	**15**	CO 1, CO 2, CO 3, CO 4	K2, K3, K4 and K6

	• Introduction to enabling technologies: microfluidics, synthetic transcription factors. **Case studies** • Simple circuit design and minimal genome projects.			
Module 2:	**Techniques** • Genome editing technologies: CRISPR and related systems in synthetic biology. • Protein and pathway engineering: principles and computational approaches. • Artificial and minimal cells: protocells, Mycoplasma laboratorium, synthetic genomes. **Applications of synthetic biology** • Biosensors and diagnostics, Therapeutics and gene therapy, Bioenergy and sustainable production, Agriculture and food biotechnology, Biomaterials and bio-manufacturing. **Emerging frontiers** • Organoids, bio-printed organs, synthetic immunology, and biological computation. • Bioinformatics resources for synthetic biology: databases, registries of standard parts, and design tools. **Ethical, safety, and societal considerations:** • Biosafety, biosecurity, dual-use concerns, and public perception.	**15**	CO 2, CO 4, CO 5, CO 6	K3, K4, K5, K6
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion/ICT			
Texts, References/ Readings	1. Baldwin, G. (2016). *Synthetic biology: A primer*. Imperial College Press. 2. Myers, C. J. (2016). *Engineering genetic circuits*. CRC Press. 3. Meyers, R. A. (2015). *Synthetic biology* (2 vols.). Wiley. 4. Smolke, C. (2018). *Synthetic biology: Parts, devices and applications*. Wiley. 5. Zhao, H. (2013). *Synthetic biology: Tools and applications*. Elsevier Science. 6. Zhao, H., & Zeng, A. (2018). *Synthetic biology: Metabolic engineering*. Springer International Publishing.			

Web Resources:	1. https://igem.org 2. https://www.addgene.org/synthetic-biology/ 3. https://academic.oup.com/synbio 4. https://www.frontiersin.org/journals/synthetic-biology 5. https://pubs.acs.org/journal/asbcd6

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Title of the Course	Vaccine Technology
Course Code	GBT-6202
Number of credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Basic knowledge of immune system function	
Course Objectives:	• To provide an advanced understanding of the principles, design, and development of modern vaccines. • To focus on immune mechanisms underlying vaccination. • To explore the evolution of vaccine technologies from conventional to next-generation platforms. • To introduce various adjuvant systems and delivery vehicles used in vaccine development. • To explain clinical evaluation processes involved in vaccine testing and approval. • To equip students with conceptual and practical insights into vaccine formulation and safety assessment. • To familiarize students with regulatory aspects relevant to public health and biotechnology industries.	
Course Outcomes:		**Mapped to PSO**
	CO1: Explain immune responses and mechanisms underlying vaccination.	PSO1, PSO2, PSO3, PSO4

	CO2: Differentiate types of vaccines and their design principles.		PSO1, PSO2, PSO3, PSO4, PSO6	
	CO3: Describe the role and formulation of adjuvants and delivery systems.		PSO1, PSO2, PSO3, PSO4, PSO6	
	CO4: Evaluate vaccine development stages, from preclinical design to clinical trials.		PSO1, PSO2, PSO4, PSO5, PSO6	
	CO5: Assess regulatory, ethical, and quality control aspects in vaccine production.		PSO1, PSO2, PSO4, PSO5, PSO6	
	CO6: Apply knowledge of emerging vaccine technologies to global health challenges.		PSO1, PSO2, PSO3, PSO4, PSO5, PSO6	
Content		**No. of Hours**	**Mapped to CO**	**Cognitive Level**
Module I	**Fundamentals of Immunization and Vaccine Development** • Overview of immune system and principles of immunization. • Types of immune responses: humoral and cellular. • Primary and Secondary immune responses during infection. • Antigen presentation and Role of Antigen-presenting cells: Dendritic cells in immune response • History of vaccines- conventional vaccines- types of vaccines based on preparation- live Attenuated- Inactivated Vaccines- Toxoids- Subunit Vaccines- Peptide Vaccines. • Herd immunity and global vaccination programs (WHO, GAVI). • Epitopes, linear and conformational epitopes, characterization and location of APC, MHC, and immunogenicity. • Different types of Vaccines: Inactivated Vaccine, Attenuated Vaccine, Toxoid Vaccine, Subunit Vaccine, Conjugate Vaccine, Valence Vaccine, Heterotypic Vaccine, mRNA vaccine with Examples	**15**	CO1, CO2	K1, K2, K4

	• Vaccines based on routes of administration: oral, intranasal, intramuscular. Subcutaneous, intravenous. Case examples of injectable vaccines, and combination vaccines. • Physical method of gene delivery: tattooing, gene gun, electroporation, ultrasound, and laser • Maternal Immunization			
Module II	**Vaccine Adjuvants, Delivery Systems, and Formulations** • Vaccines with and without adjuvants. Different types of adjuvants: oil-based adjuvants such as Freunds, aluminum hydroxide, aluminum phosphate, [AS04] aluminum potassium sulfate monophosphoryl lipid A (MPL) + aluminum salt, [MF59] Oil in water emulsion composed of squalene. [AS01] Monophosphoryl lipid A (MPL) and QS-21, a natural compound extracted from the Chilean soapbark tree, combined in a liposomal formulation, [cpG1018] Cytosine phosphoguanine (CpG), a synthetic form of DNA that mimics bacterial and viral genetic material. • Vaccine delivery systems (e.g., emulsion (water- in- oil-in-water multiple emulsions, microemulsions, or nanoemulsions) microparticles, immune-stimulating complexes ISCOMs liposomes, nanoparticles, dendrimer and micellar) with examples such as PLGA, Chitosans, polyphosphazene, polyanyhydrides, polymethacrylic acid, liposomes, and their derivatives, virosomes, polymeric nanoparticle delivery system. **Clinical Evaluation, Quality Control, and Regulations** • quality control and regulations in vaccine research, animal testing, rational design to clinical trials. • large-scale production, commercialization, vaccine safety, ethics, and legal issues. • New emerging diseases and vaccine needs (Ebola, Zika).	**15**	CO3, CO4, CO5, CO6	K2, K3, K4, K5, K6
Pedagogy	Lecture, Tutorial, Assignments, Presentations			

Texts	Punt, J., Stranford, S. A., Jones, P. P., & Owen, J. A. (2018). *Kuby immunology*. W. H. Freeman.
References/Readings	1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). *Immunobiology: The immune system in health and disease*. Garland Science. 2. Barton, C. (2009). *Advances in vaccine technology and delivery*. Espicom Business Intelligence. 3. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). *Kuby immunology*. W. H. Freeman. 4. Thiel, K., & Ulmer, J. (2021). *Modern vaccine development: Technologies and challenges*. Wiley-VCH. 5. Wen, E. P., Pujar, N. S., & Ellis, R. (Eds.). (2014). *Vaccine development and manufacturing*. Wiley. 6. Ashfield, R., Oli, A. M., Esimone, C., & Anagu, L. (Eds.). (2022). *Vaccinology and methods in vaccine research*. Academic Press.

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Title of the Course	Model Organisms for Genomic Research
Course Code	GBT-6203
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To introduce the concept, selection criteria, and historical significance of model organisms in advancing genomic research. • To provide comprehensive knowledge of prokaryotic, fungal, plant, invertebrate, vertebrate, and human model systems. • To train students to access and utilize specialized genomic databases and resources associated with diverse model organisms. • To highlight the applications of model organism research in diverse area, and biotechnology, while addressing ethical, legal, and societal considerations.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the conceptual foundations and historical development of model organisms, describing the criteria for their selection and significance in genomic research.	PSO1, PSO3, PSO4

	CO 2. Compare and interpret the genetic, molecular, and physiological features of key prokaryotic and fungal models to understand conserved biological mechanisms.		PSO1, PSO3, PSO5	
	CO 3. Analyze plant and agricultural model systems to elucidate the molecular basis of development, stress responses, and traits relevant to sustainability and food security.		PSO3, PSO5, PSO6	
	CO 4. Evaluate the use of invertebrate and vertebrate models in developmental, genetic, and disease research, integrating data from dedicated genomic databases.		PSO3, PSO4, PSO6	
	CO 5. Assess the contributions of human genomic studies—including variation, evolution, and disease genomics—to biomedical and translational research.		PSO1, PSO4, PSO6	
	CO 6. Integrate genomic information across multiple model systems to draw comparative and evolutionary inferences, while critically appraising the ethical, legal, and social implications (ELSI) of genomic research.		PSO3, PSO4, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to model organisms** • Concept, criteria for selection, advantages, and limitations significance in genomics, historical milestones. **Prokaryotic models** • *Escherichia coli* (*E. coli* K-12): molecular genetics, recombinant DNA technology, metabolic pathways. • *Bacillus subtilis*: differentiation, sporulation, gram-positive model. • Prokaryotic genomic database (proGenomes, ProPan) **Yeast and fungal models** • *Saccharomyces cerevisiae*: eukaryotic gene regulation, cell cycle, proteomics. • Schizosaccharomyces pombe: mitosis, epigenetics, genome stability. • Neurospora crassa: circadian rhythms, fungal genetics, gene silencing. • Databases resource for fungi (Fungidb, SGD).	**15**	CO 1 CO 2	K2, K4
Module 2:	**Plant and Agricultural Models**	**15**	CO 3	K2, K4

	• *Arabidopsis thaliana*: development, stress genomics, epigenetics. • *Oryza sativa* (Rice): crop genomics, food security, comparative genomics. • Medicago truncatula nodulation, plant–microbe interactions, legume genomics. • *Brachypodium distachyon*: grass genomics, bioenergy crops. • Plant databases: TAIR, Rice Genome Annotation Project, Ensembl Plant, Legume Information System. • Applications in sustainable agriculture, food security, and climate resilience.			
Module 3:	**Invertebrate models:** • *Caenorhabditis elegans* (Nematode): cell lineage mapping, RNAi, developmental biology. • *Drosophila melanogaster* (Fruit fly): genetics of development, signaling pathways, disease models. • Databases resources for invertebrate (Ensemble metazoa, FlyBase, WormBase). **Vertebrate models** • Danio rerio (Zebrafish): embryogenesis, organ development, regeneration, live imaging. • Mus musculus (Mouse): mammalian genomics, transgenics, disease models. • Databases resources for vertebrate (Ensemble Vertebrate, ZFIN, MGD and RGD).	**15**	CO 4	K4, K5
Module 4:	**Humans as a system: opportunities and challenges.** • The Human Genome Project: milestones, outcomes, and legacy. • Human genetic variation: SNPs, structural variants, copy number variation. • Evolutionary genomics and human ancestry. • Human genomics in health and disease: cancer, neurological disorders, rare diseases. • Ethical, legal, and social implications (ELSI) of human genomic research. • Human genomic databases and resources (NCBI, Ensemble, ENCODE, HSCDG, , Human Cell Atlas).	**15**	CO 5 CO6	K4, K5, K6
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion/ICT			

Texts, References/ Readings:	1. Davis, R. H. (2000). *Neurospora: Contributions of a model organism*. Oxford University Press. 2. Davis, R. H. (2003). *The microbial models of molecular biology: From genes to genomes*. Oxford University Press. 3. Green, S. (2024). *Animal models of human disease*. Cambridge University Press. 4. Grotewold, E., Chappell, J., & Kellogg, E. A. (2015). *Plant genes, genomes and genetics*. Wiley. 5. Kavanagh, K. (2017). *Fungi: Biology and applications*. Wiley. 6. Robert, L. J., & McCluskey, K. (2021). *The biological resources of model organisms*. Taylor & Francis Group. 7. Striedter, G. F. (2022). *Model systems in biology: History, philosophy, and practical concerns*. MIT Press.
Web Resources:	1. https://progenomes.embl.de 2. https://fungidb.org/fungidb/ 3. https://www.yeastgenome.org 4. https://www.arabidopsis.org 5. http://rice.plantbiology.msu.edu 6. https://flybase.org 7. https://wormbase.org 8. https://zfin.org 9. http://www.informatics.jax.org 10. https://rgd.mcw.edu 11. https://www.ncbi.nlm.nih.gov/ 12. https://www.ensembl.org 13. https://www.encodeproject.org 14. https://www.humancellatlas.org

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Title of the Course	Trends in Sustainable Waste Resource Management
Course Code	GBT-6204
Number of Credits	04
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	GBT-5203 GBT-5204
Course Objectives:	The course is aimed to: • Impart knowledge of global and local water and waste challenges, with a focus on biotechnological solutions for wastewater and solid waste treatment. • Explore biological and microbial approaches for wastewater treatment, nutrient recovery, and sustainable reuse of treated water. • Introduce biotechnological innovations in organic waste treatment, composting, and integrated solid waste biorefineries for energy and material recovery. • Understand advanced bioprocesses and future technologies, including microbial fuel cells, bioleaching, biohydrogen production, and circular bioeconomy principles.

Course Outcomes:			**Mapped to PSO**	
	CO 1. Analyze global and regional water and waste issues and evaluate the role of biotechnology in addressing these challenges.		PSO1, PSO3, PSO7	
	CO 2. Apply microbial and enzymatic processes for wastewater treatment, nutrient recovery, and non-potable water reuse.		PSO1, PSO2, PSO6	
	CO 3. Assess and compare biotechnological methods for solid waste treatment, including composting, anaerobic digestion, and biorefineries.		PSO3, PSO4, PSO6	
	CO 4. Evaluate advanced and emerging biotechnologies (e.g., microbial electrochemical systems, bioleaching, biohydrogen production) for energy and material recovery from waste.		PSO4, PSO5, PSO6, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Biotechnological Approaches to Wastewater Treatment and Global Water Challenges** ● Global and India-specific water demand and wastewater challenges ● The role of biotechnological innovations in addressing the water crisis ● Water consumption vs. supply: How biological wastewater treatment contributes to water sustainability ● Microbial and biotechnological solutions to reduce environmental and health impacts of untreated wastewater ● Biotreatment challenges across major sectors (domestic, industrial, agricultural) ● Impacts of complex wastewater composition on microbial treatment efficacy and bio-process design ● Decentralized biotreatment systems: Advantages of bio-based systems in flexible, site-specific treatment ● Biotech perspective on decentralized vs. centralized/on-site systems: Microbial	**15**	CO1, CO2	K2, K3, K4, K5

	community management, scalability, and adaptability.			
Module 2:	**Resource Recovery from Wastewater through Biotechnological Innovations** ● Biological reuse systems: Microbial treatment for non-potable water reuse (e.g., irrigation, cooling, flushing) ● Microbial and enzymatic recovery of resources: Nitrogen, phosphorus, metals, and organic matter ● Energy recovery: Biogas production, microbial fuel cells (MFCs), and microbial electrochemical technologies (MECs) ● Advanced biotech processes: Anaerobic digestion, membrane bioreactors, and bio-electrochemical systems ● Integration of biotechnology into circular water economy: Using engineered microbes for enhanced recovery and treatment ● Future trends: Genetically modified microbes, microbiome engineering. ● Omics-based monitoring in treatment and recovery systems.	**15**	CO2, CO4	K3, K4, K5, K6
Module 3:	**Organic Waste Treatment and Resource Recovery** ● Overview of organic waste treatment technologies with emphasis on recovery ● Sustainable development and environmentally friendly biotech practices ● Recycling and composting techniques: traditional and novel methods (e.g., terra preta, vermicomposting, black soldier fly larvae) ● Anaerobic digestion for energy and nutrient recovery ● Nutrient recycling technologies for soil enhancement ● Biotechnological innovations in composting and nutrient cycling ● Waste utilization in agriculture: recycling crop residues, agri-byproducts into nutrient-rich manure and biomethane ● Bioconversion of solid waste into cattle feed and soil conditioners	**15**	CO3	K2, K3, K4, K5, K6
Module 4:	**Advanced Biotechnologies for Energy and Bioresource Recovery from Solid Waste**	**15**	CO3, CO4	K3, K4, K5, K6

	• Integrated solid waste biorefineries: production of biofuels, biochemicals, and bioenergy • Waste-to-Energy technologies: incineration, thermochemical conversion, microbial electrolysis cells • Clean biological hydrogen production and biofuel generation • Biomass valorization: wood waste, agricultural waste, MSW, sewage sludge as bioenergy sources • Bioleaching, biopolymer production, and carbon capture/sequestration • Technological innovations in biotech-based waste management • Environmental impacts and challenges: effects and mitigation of combustion by-products			
Pedagogy:	Lectures/tutorials/assignments/ online/self-study			
Texts, References/ Readings:	1. Rittmann, B. E., & McCarty, P. L. (2020). *Environmental biotechnology: Principles and applications* (2nd ed.). McGraw-Hill Education. 2. Tchobanoglous, G., Burton, F. L., Stensel, H. D., & Tsuchihashi, R. (2014). *Wastewater engineering: Treatment and resource recovery* (5th ed.). McGraw-Hill Education. 3. Lens, P. N. L., & Pol, L. H. (Eds.). (2000). *Environmental technologies to treat sulfur pollution: Principles and engineering*. IWA Publishing. 4. Kiran, E. U., Trzcinski, A. P., Ng, W. J., & Liu, Y. (2014). Bioconversion of food waste to energy: A review. *Fuel, 134*, 389–399. https://doi.org/10.1016/j.fuel.2014.05.074. 5. Mohan, S. V., Modestra, J. A., Amulya, K., Butti, S. K., & Velvizhi, G. (2016). A circular bioeconomy with biobased products from CO_2 sequestration. *Trends in Biotechnology, 34*(6), 506–519. https://doi.org/10.1016/j.tibtech.2016.02.012. 6. Verstraete, W., & Vlaeminck, S. E. (2011). ZeroWasteWater: Short-cycling of wastewater resources for sustainable cities of the future. *International Journal of Sustainable Development & World Ecology, 18*(3), 253–264. https://doi.org/10.1080/13504509.2011.570804 7. Singh, R. P., Ibrahim, M. H., & Esa, N. (2011). Composting of waste from municipal solid waste. *International Journal of Environmental Sciences, 1*(7), 1520–1530.			

	8. Owamah, H. I., & Dahunsi, S. O. (2021). Biotechnological applications for the treatment and valorization of food waste: A review. *Bioresource Technology*, *337*, 125597. https://doi.org/10.1016/j.biortech.2021.125597 9. Pandey, A., Negi, S., Soccol, C. R., & Larroche, C. (Eds.). (2022). *Biotechnology for sustainable environment*. Elsevier. 10. Logan, B. E., & Rabaey, K. (2012). Conversion of wastes into bioelectricity and chemicals by using microbial electrochemical technologies. *Science*, *337*(6095), 686–690. https://doi.org/10.1126/science.1217412.
Web Resources:	1. https://www.unwater.org 2. https://cpcb.nic.in 3. https://www.iwa-network.org 4. https://www.epa.gov/water-research

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Title of the Course	Modern Agricultural Techniques and Livestock management
Course Code	GBT-6205
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• Understand the principles of modern agriculture, integrated farming systems, and sustainable practices. • Implement modern livestock breeding for high-yielding, disease-resistant animals. • Integrate agricultural biotechnology, precision agriculture, smart farming, and digital tools for crop and livestock productivity. • Comprehend agricultural economics, policies, and technology transfer mechanisms for sustainable farm management.	
Course Outcomes:		**Mapped to PSO**
	CO1: Explain the fundamentals of modern agriculture, integrated farming systems, and sustainable agriculture principles.	PSO1, PSO3, PSO7
	CO2: Analyze precision agriculture strategies, smart farming systems, and use of IoT, GIS, drones, and AI in agriculture.	PSO2, PSO3, PSO4

	CO3: Evaluate livestock breeding, reproductive management, nutrition, and health interventions for high productivity.		PSO1, PSO5, PSO6	
	CO4: Apply veterinary therapeutics, responsible drug usage, molecular diagnostics, and ethical principles in animal care.		PSO2, PSO6, PSO7	
	CO5: Make informed decisions combining crop, livestock, veterinary, and technological strategies for sustainable and productive agriculture.		PSO5, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to Modern Agriculture & its Components** ● Global food security challenges, Green Revolution vs. Sustainable Agriculture ● Integrated Farming Systems (IFS) **Soil Health Management** ● Modern soil testing methods ● Bio-fertilizers and bio-pesticides ● Regenerative agriculture principles **Water Management** ● Modern irrigation techniques (Drip, Sprinkler, Micro-irrigation, Rainwater harvesting) **Integrated Pest and Disease Management** ● Biological control agents ● Pest surveillance and forecasting ● New-generation pesticides ● Biosecurity in crop fields. **Organic and Natural Farming** ● Principles and practices of organic certification	**15**	CO1	K1, K2

	• Zero Budget Natural Farming • Compost and vermicomposting technologies			
Module 2:	**Precision Agriculture (PA) & Smart Farming** • Concept, components (GIS, GPS, Remote Sensing • Sensors and IoT in Agriculture • Real-time data collection and analysis • Automated farm operations and monitoring **Drones and AI in Agriculture** • Aerial surveying, Crop health monitoring • Disease and pest diagnosis using Machine Learning.	**15**	CO2	K3, K4
Module 3:	**Modern Livestock Production and Management** • High-yielding indigenous breeds (Cattle, Buffalo, Sheep, Goat, Pig) • Formulation of balanced and economic rations **Reproductive Management Technologies** • Artificial Insemination (AI) techniques • Embryo Transfer Technology • In Vitro Fertilization **Disease Prevention and Control** • Principles of vaccination • Diagnosis and control of major bacterial, viral, and parasitic diseases (e.g. Brucellosis, Rabies, Parasitism), Zoonotic diseases. • Molecular diagnostic techniques (PCR)	**15**	CO3	K3, K4, K5
Module 4:	**Veterinary Therapeutics** • Responsible use of antimicrobials • Herbal veterinary medicine **Animal Welfare and Ethics**	**15**	CO4, CO5	K3, K5, K6

	● Humane handling and transportation ● Ethical considerations in modern farming **Agricultural Economics** ● Economics of crop and livestock production ● Supply chain and market linkages **Technology Transfer and Policies** ● Government schemes for modern agriculture and livestock ● Regulations on Genetically Modified Organisms			
Pedagogy:	Lectures/tutorials/assignments/models			
Texts, References/ Readings:	1. Balasubramanian, S., Natarajan, G., & Chelliah, P. R. (2024). *Intelligent robots and drones for precision agriculture*. Springer Nature. 2. Banhazi, T. M., Halas, V., & Maroto-Molina, F. (Eds.). (2022). *Practical precision livestock farming*. Wageningen Academic Publishers. 3. Bhattacharyya, P., & Chakraborty, G. (2020). *Organic and natural farming: Concepts and practices*. New India Publishing Agency. 4. Belák, S., & Pestana, E. (Eds.). (2014). *Veterinary infection biology: Molecular diagnostics and high-throughput strategies*. Springer Nature. 5. FAO. (2018). *Precision agriculture: Technologies for sustainable farming systems*. Food and Agriculture Organization of the United Nations. 6. Kaushik, P., & Kumar, S. (Eds.). (2023). *Agricultural policy, technology transfer, and sustainability in the global south*. Springer Nature. 7. Khatri, N., Vyas, A. K., Iwendi, C., & Chatterjee, P. (2024). *Precision agriculture for sustainability: Use of smart sensors, actuators, and intelligent systems*. CRC Press. 8. Krishnan, S., Rose, B. R., Narayanan, R., & Prasanth, B. (Eds.). (2023). *Cloud IoT systems for smart agricultural engineering*. CRC Press. 9. Lal, R. (2020). *Soil health and climate change*. Springer Nature. 10. Mandal, S. C. (2025). *Textbook of veterinary parasitology*. Springer Nature.			

	11. Mukhopadhyay, C. S., Choudhary, S., Panwar, P. S., & Malik, Y. S. (Eds.). (2023). *Biotechnological interventions augmenting livestock health and production*. Springer Nature. 12. Pathak, A., & Sharma, R. (2023). *Advanced molecular techniques in animal disease diagnosis*. New India Publishing Agency. 13. Singh, K., & Sharma, R. (2020). *Agricultural economics and farm management*. Kalyani Publishers. 14. Yata, V. K., Mohanty, S., & Lichtfouse, E. (Eds.). (2021). *Sustainable agriculture reviews: Animal biotechnology for livestock production (Vol. 54)*. Springer Nature. 15. Zhang, Z., Liu, H., & Yang, C. (Eds.). (2023). *Unmanned aerial systems in precision agriculture: Technological progresses and applications*. Springer Nature.

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Title of the Course	Microbiome
Course Code	GBT-6206
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To understand the diversity, structure, and ecological principles governing microbiomes across human, plant, animal, and environmental systems. • To elucidate the roles of microbiomes in health, nutrition, biogeochemical cycling, and ecosystem functioning. • To analyze the mechanisms and consequences of dysbiosis and host-microbe interactions in disease and stress conditions. • To explore advanced tools, engineering strategies, and translational applications of microbiome research for sustainable biotechnology solutions.	
Course Outcomes:	At the end of the course students will be able to:	**Mapped to PSO**
	CO 1. Describe and differentiate the composition and ecological dynamics of human, plant, animal, and environmental microbiomes.	PSO1, PSO3, PSO4

	CO 2. Explain the physiological and functional roles of microbiomes in health, nutrition, and environmental processes.		PSO1, PSO3, PSO6	
	CO 3. Analyze the impact of dysbiosis, environmental perturbations, and anthropogenic factors on microbial community structure and function		PSO3, PSO4, PSO7	
	CO 4. Evaluate microbiome-based technologies, engineering strategies, and emerging trends for therapeutic, agricultural, and industrial applications.		PSO4, PSO5, PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction & Human Microbiome** ***Introduction:*** • Definitions: microbiota vs microbiome, holobiont, metagenome. • Historical milestones (Koch to Human Microbiome Project). • Community ecology concepts: assembly, resilience, core vs variable microbiome. • Taxonomic Components: Bacteria, archaea, fungi (mycobiome), viruses (virome), protists; strain-level variation and significance. ***Human Microbiome Sites & Functions*** • Gut: composition, metabolic functions, SCFAs, vitamin synthesis. • Skin, oral, respiratory, urogenital microbiomes — ecological niches and host interactions. • Microbiome development: birth, infancy, adulthood, aging. ***Dysbiosis & Disease Associations*** • Mechanisms of dysbiosis; links to metabolic disease, IBD, allergies, neuropsychiatric disorders, oncobiome concepts. • Antibiotics, diet, lifestyle, host genetics. ***Therapeutic Modulation*** • Probiotics, prebiotics, synbiotics, postbiotics, and FMT: principles, evidence,	**15**	CO1, CO2, CO3	K1, K2, K3, K4

	risks. • Microbiome diagnostics and biomarkers.			
Module 2:	**Plant & Animal Microbiomes** ***Plant Microbe functional interactions*:** • Holobiont and phytobiome. Rhizosphere, rhizoplane, endosphere, phyllosphere, seed microbiome. • Community assembly: root exudates, vertical vs horizontal transmission. • Nutrient acquisition: N-fixation, P solubilization, siderophores. • Mycorrhizae (AMF vs ECM), PGPR mechanisms (IAA, ACC deaminase). • Microbiome roles in stress tolerance (drought, salinity, heavy metals) and disease suppression. ***Animal Microbiomes:*** • Comparative gut microbiomes: ruminants, monogastrics, fish, insects. • Rumen microbiology, methanogenesis, fish gut and aquaculture implications. • Host–microbe co-evolution, immunity, nutrition.	**15**	CO1, CO2, CO3	K2, K3, K4
Module 3:	**Environmental Microbiomes** ***Soil Microbiomes:*** • Composition, role in C/N/P/S cycles, rhizosphere versus bulk soil. • Soil health indicators and microbiome responses to agriculture and pollution. • Bioremediation examples and microbial processes for pollutant degradation. ***Freshwater & Marine Microbiomes:*** • Planktonic vs particle-attached microbes; microbial loop; phytoplankton–bacteria interactions. • Coral, sponge, seaweed holobionts; microbial roles in reef resilience and bleaching. ***Built Environment & Airborne Microbiomes:*** • Human-built environment microbiomes (hospitals, homes, ships): exchange	**15**	CO1, CO2, CO3	K2, K3, K4

	with humans and health implications.			
Module 4:	**Tools, Technologies & Applications** ***Key methodologies:*** • Molecular and Sequencing-Based Approaches • Bioinformatics and Data Integration ***Microbiome Engineering & Therapeutics:*** • Synthetic communities, designer consortia, microbiome editing. • Phage therapy, bacteriocins, and targeted modulation strategies. ***Applications & Translation:*** • Precision medicine, diagnostics, agricultural products, bioremediation commercialization, regulatory & ethical issues. ***Emerging Trends & Future Direction:*** • Microbiome-AI integration, microbiome big data, policy and global consortia.	**15**	CO4	K3, K4, K5
Pedagogy:	Lectures/ tutorials/ assignments/group discussion/ self study			
Texts:	1. Adetunji, C. O., Michael, O. S., Esiobu, N., & Aluko, R. E. (Eds.). (2024). *An Introduction to the Microbiome in Health and Diseases*. Academic Press. 2. Dhanasekaran, D., Paul, D., Amaresan, N., Sankaranarayanan, A., & Shouche, Y. S. (Eds.). (2021). *Microbiome-host interactions*. CRC Press. 3. Douglas, A. E. (2018). *Fundamentals of microbiome science: how microbes shape animal biology*. Princeton University Press.			
References/ Readings:	1. Alexandrescu, L., Tofolean, I. T., Condur, L. M., Tofolean, D. E., Nicoara, A. D., Serbanescu, L., ... & Stanigut, A. M. (2025). Smart Microbiomes: How AI Is Revolutionizing Personalized Medicine. *Bioengineering*, *12*(9), 944. 2. Bai, X., Huang, Z., Duraj-Thatte, A. M., Ebert, M. P., Zhang, F., Burgermeister, E., ... & Zuo, T. (2023). Engineering the gut microbiome. *Nature Reviews Bioengineering*, *1*(9), 665-679. 3. Compant, S., Samad, A., Faist, H., & Sessitsch, A. (2019). A review on the plant microbiome: ecology, functions, and emerging trends in microbial application. *Journal of advanced research*, *19*, 29-37. 4. D'Urso, F., & Broccolo, F. (2024). Applications of artificial intelligence in microbiome analysis and probiotic			

interventions—An overview and perspective based on the current state of the art. *Applied Sciences*, *14*(19), 8627.

5. Garn, H., Bahn, S., Baune, B. T., Binder, E. B., Bisgaard, H., Chatila, T. A., ... & Renz, H. (2016). Current concepts in chronic inflammatory diseases: interactions between microbes, cellular metabolism, and inflammation. *Journal of Allergy and Clinical Immunology*, *138*(1), 47-56.
6. Gilbert, J. A., Blaser, M. J., Caporaso, J. G., Jansson, J., Lynch, S. V., & Knight, R. (2018). *Current understanding of the human microbiome. Nature Medicine / NPJ*, retrieved via PMC. PMCID: PMC7043356
7. Ma, Z., Zuo, T., Frey, N., & Rangrez, A. Y. (2024). A systematic framework for understanding the microbiome in human health and disease: from basic principles to clinical translation. *Signal Transduction and Targeted Therapy*, *9*(1), 237.
8. Zhou, T., & Zhao, F. (2025). AI-empowered human microbiome research. *Gut*.

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Title of the Course	Marine Bioremediation and Pollution Monitoring
Course Code	GBT-6207
Number of credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To provide an in-depth understanding of marine pollution, its sources, types, and ecological impacts on aquatic ecosystems. • To introduce the fundamental principles and mechanisms of bioremediation. • To emphasize the roles of marine microorganisms and biotechnological innovations in pollutant degradation. • To develop insight into pollution monitoring approaches, including chemical, biological, and molecular tools. • To explore emerging technologies used in marine pollution assessment and control. • To familiarize students with international and national regulatory frameworks related to marine pollution. • To highlight the significance of these frameworks in sustainable marine management.	
Course Outcomes:		**Mapped to PSO**
	Explain the sources, types, and ecological impacts of marine pollutants on diverse aquatic ecosystems.	PSO1, PSO3, PSO7

	Analyze the mechanisms and microbial pathways involved in the bioremediation of various marine pollutants.		PSO1, PSO2, PSO3, PSO6	
	Evaluate the use of physical, chemical, biological, and molecular tools for marine pollution monitoring.		PSO2, PSO3, PSO4	
	Assess the role of biosensors, molecular assays, and biotechnological innovations in pollution detection and mitigation.		PSO2, PSO4, PSO6	
	Appraise global and national environmental policies and propose sustainable marine bioremediation strategies.		PSO5, PSO6, PSO7	
Content		**No. of Hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Marine Pollution and Its Impact** 1. Marine Pollutants: Sources and Types • Agricultural runoff, industrial discharge, marine litter, Eutrophication and algal blooms; Plastic and microplastic pollution; Oil spills and hydrocarbon pollutants; Heavy metals and metalloids (Hg, Cd, Pb, As) and radioactive materials; Persistent organic pollutants, Ballast water and bio-invasion. 2. Impacts on Marine Ecosystems • Effects on coral reefs, mangroves, and seagrass beds; Bioaccumulation and biomagnification in food webs; biofouling, bioadhesion, anaerobiosis; Changes in species diversity and population dynamics; Synergistic and antagonistic effects of pollutant mixtures on marine life forms.	**15**	CO1, CO2	K1, K2
Module 2:	**Bioremediation Mechanisms** 1. **Fundamentals of Bioremediation** • Principles and stages: biotransformation, mineralization • Intrinsic vs engineered bioremediation • Biostimulation and bioaugmentation 2. **Marine Microbial Players**	**15**	CO2, CO3	K3, K4, K5

	• Hydrocarbon-degrading bacteria (e.g., Alcanivorax, Pseudomonas, Marinobacter) • Fungi and algae in pollutant degradation • Anaerobic vs aerobic degradation pathways 3. **Pollutant-Specific Biodegradation** • Petroleum hydrocarbons • Polycyclic aromatic hydrocarbons (PAHs) • Pesticides and pharmaceuticals (emerging contaminants) • Plastic and microplastic degradation enzymes (PETase, laccases) 4. **Genetic Engineering in Marine Bioremediation** • Use of genetically modified microbes • CRISPR and synthetic biology in enhancing degradation • Biosafety and bioethics concerns 5. **Case Studies** • Deepwater Horizon oil spill • Plastic degrading bacteria in marine environments • Bioremediation of ballast water.			
Module 3:	**Pollution Monitoring Tools and Regulations** 1. Chemical and Physical Monitoring • Sampling techniques (water, sediment, biota) • Physico-chemical parameters (DO, pH, salinity, turbidity) • Detection of metals, hydrocarbons, nitrates, phosphates 2. Biological Monitoring • Use of indicator species (mussels, bivalves, foraminifera) • Biomarkers of exposure (e.g., metallothioneins, cytochrome P450 enzymes) • Bioassays and toxicity tests (e.g., algal growth inhibition test) 3. Molecular and Biotechnological Tools • Environmental DNA (eDNA), qPCR, and metagenomics • Biosensors: microbial, enzymatic, immunosensors • Microarrays and omics-based monitoring approaches	**15**	CO3, CO4	K4, K5

	4. Remote and Real-time Monitoring • Autonomous sensors and underwater robots • GIS-based pollution mapping • Role of AI and data analytics in pollution prediction.			
Module 4:	1. Applied Aspects of Marine Bioremediation • Aquaculture effluent management • Restoration of coral reef and mangrove ecosystems • Management of ballast water and shipyard pollution 2. Environmental and Regulatory Frameworks • MARPOL Convention and UNCLOS • National Coastal Regulation Zone (CRZ) norms • Blue economy and sustainable development goals (SDG 14) • Community-based participatory monitoring 3. Limitations and Prospects of Marine Bioremediation • Environmental variability and microbial survival • Risk of invasive or genetically modified organisms.	**15**	CO5	K5, K6
Pedagogy	Lecture, Tutorial, Assignments, Presentations			
Texts	1. Atlas, R. M., & Bartha, R. (2013). *Microbial Ecology: Fundamentals and Applications.*Pearson Education, USA. 2. Dash, S. P. (2018). *Marine biotechnology: Applications of molecular biology and marine genetics*. Springer Nature. 3. Hester, R. E., & Harrison, R. M. (Eds.). (2017). *Marine pollution and human health*. Royal Society of Chemistry. 4. Munn, C. (2019). Marine Microbiology: Ecology & Applications. United Kingdom: CRC Press.			
References/ Readings	1. Birnie, P., Boyle, A., & Redgwell, C. (2009). *International law and the environment*. Oxford University Press. 2. Churchill, R. R., & Lowe, A. V. (2022). *The law of the sea*. Manchester University Press. 3. Kennish, M. J. (2017). *Practical handbook of estuarine and marine pollution*. CRC Press. 4. Kumar, S. (2020). *Environmental legislation in India: An overview*. S. Chand Publishing. 5. Springer. (2006). *Oceans and health: Pathogens in the marine environment*. Springer. 6. Weis, J. S. (2015). *Marine pollution: What everyone needs to know*. Oxford University Press. 7. Ghosh, A., & Dam, B. (2020). *Bioremediation: Current research and applications*. Nova Science Publishers. 8. Hennion, M. C. (Ed.). (1999). *Monitoring of marine pollution*. Elsevier.			

	9. Willey, J. M., Sherwood, L., & Woolverton, C. J. (2017). *Prescott's microbiology*. McGraw-Hill Education.

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