

GU/Acad –PG/BoS -NEP/2025-26/295

Date: 06.08.2025

CIRCULAR

The Academic Council & Executive Council of the University has approved Ordinance OA-35A relating to PG Programmes offered at the University campus and its affiliated Colleges based on UGC 'Curriculum and Credit Framework for Postgraduate Programmes'. Accordingly, the University has proposed introduction of Ordinance OA-35A from the Academic year 2025-2026 onwards.

The Programme structure and syllabus of Semester I and II of the **Master of Science in Biotechnology** Programme approved by the Standing Committee of the Academic Council in its meeting held on 24th & 25th June 2025 is 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)
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:

1. Chairperson, BoS in Biotechnology, Goa University.
2. Programme Director, M.Sc. Biotechnology, Goa University.
3. Controller of Examinations, Goa University.
4. Assistant Registrar Examinations (PG), Goa University.
5. Director, 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.

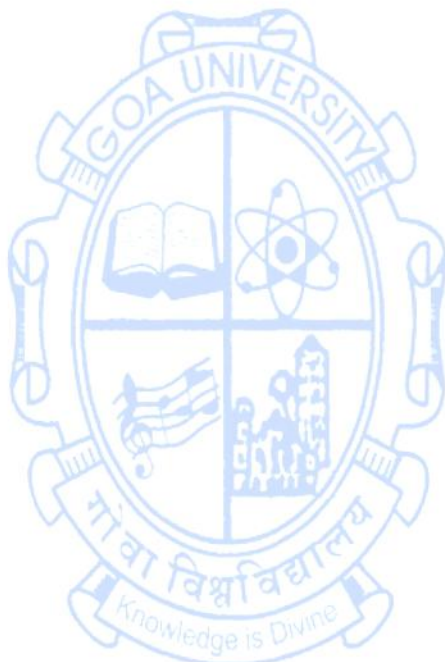


PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO 1.	Core Disciplinary Knowledge: Demonstrate comprehensive understanding of genetic engineering, molecular biology, cell biology, developmental and bioprocess technology, forming the foundation for advanced biotechnology applications.
PSO 2.	Application of Modern 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

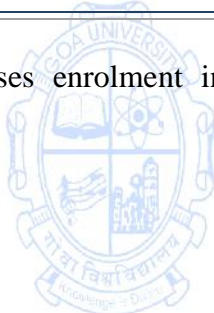
Bridge Courses*			
Sr. No.	Course Code	Title of the Course	Credits
1	GBT-1000	Concepts in Microbiology	2
2	GBT-1001	Fundamentals in Biochemistry	2
3	GBT-1002	Basics of Cell Biology	2

*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	LabV: 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

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: <ul style="list-style-type: none"> • 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:	<p>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.</p> <p>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, Archaeobacterial 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</p> <p>c) Modern /contemporary microbiology in the 21st century: - An overview of the Scope of Microbiology</p>	15	CO1, CO2	K1, K2
Module 2:	<p>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.</p> <p>Bacterial growth kinetics: i) growth curve, the mathematical expression of growth & measurement of growth ii) synchronous growth iii) factors affecting growth.</p> <p>Microbial taxonomy: i) nomenclature ii) polyphasic identification, traditional &</p>	15	CO3, CO4	K1, K2

	<p>molecular, iii) Bergey's manual.</p> <p>General characteristics and functions of: -Algae, Fungi, Cyanobacteria, Bacteria, Viruses, Viroids & prions.; Specialized microorganisms: - Extremophiles, Anaerobes.</p>			
Pedagogy:	Lectures, tutorials, assignments			
Texts:	<ol style="list-style-type: none"> 1. Atlas, R. M. (1997). <i>Principles of Microbiology</i> (latest edition). Wm. C. Brown Publishers. 2. Black, J. G. (2008). <i>Microbiology: Principles and Explorations</i> (7th ed.). Prentice Hall. 3. Madigan, M. T., Aiyer, J., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2024). <i>Brock Biology of Microorganisms</i> (16th ed.). Pearson. 4. Pelczar Jr., M. J., Chan, E. C. S., & Krieg, N. R. (2023). <i>Microbiology</i> (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). <i>General Microbiology</i> (5th ed.). Macmillan. 7. Tortora, G. J., Funke, B. R., Case, C. L., Weber, D., & Bair, W. (2024). <i>Microbiology: An Introduction</i> (14th ed.). Pearson Education. 8. Willey, J. M., Sherwood, L. M., & Woolverton, C. J. (2016). <i>Prescott's Microbiology</i> (10th ed.). McGraw-Hill Education. 9. Reed, G. (1987). <i>Prescott & Dunn's Industrial Microbiology</i>. CBS Publishers. 			
References/ Readings:	<ol style="list-style-type: none"> 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:	<ul style="list-style-type: none"> • 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

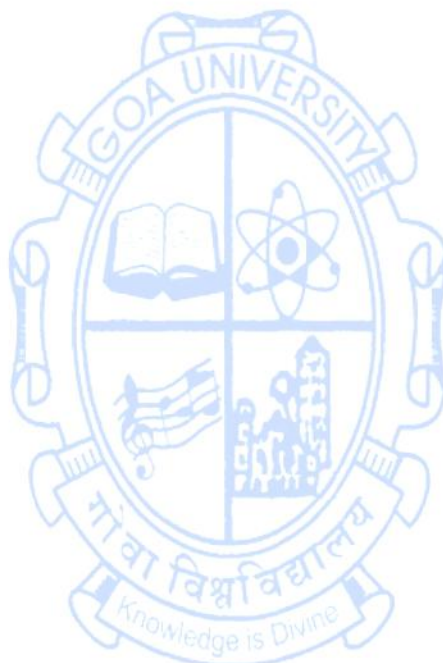
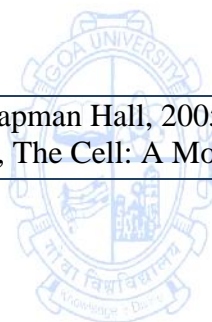
	CO 3. Understand the role of hormones in regulating various physiological processes, including metabolism and reproduction.		PSO1, PSO2, PSO3	
	CO 4. Understand key metabolic pathways, including carbohydrate, lipid, and protein metabolism, and understand how they are regulated.		PSO2, PSO3, PSO4	
Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	<ul style="list-style-type: none"> 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:	<ul style="list-style-type: none"> 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

	<ul style="list-style-type: none"> • Amino acid metabolism; nucleotide metabolism • Photosynthesis and photorespiration 			
Pedagogy:	Lectures, tutorials, assignments			
Texts:	<ol style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 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 Illustrated Biochemistry McGraw Hill publisher, 2022. 			
Web Resources:	<ol style="list-style-type: none"> 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:	<ul style="list-style-type: none"> 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.			

- | | |
|--|---|
| | <ol style="list-style-type: none">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. |
|--|---|



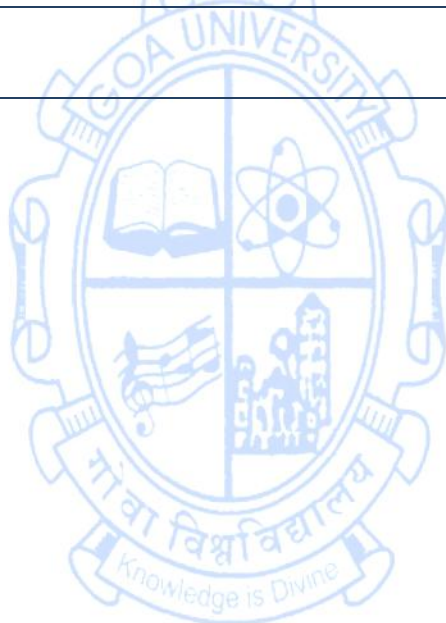
SEMESTER I

Discipline Specific Core 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.			

	<ol style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 1. https://dnalc.cshl.edu/ 2. https://csh.com.sg/



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:	<ul style="list-style-type: none"> 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., <i>Drosophila</i> , <i>Xenopus</i> , <i>C. elegans</i> , 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:	<p>1.1. Organelle dynamics and intracellular trafficking: Nucleus, Mitochondria, Ribosome, Endoplasmic reticulum, Golgi apparatus, lysosome, Peroxisome, vacuoles, plastids.</p> <p>1.2. Organelleopathy</p> <ul style="list-style-type: none"> ● 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 <p>1.3. Cytoskeletal Architecture and Cell Motility.</p> <p>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.</p>	15	CO1, CO2	K1, K2, K3

	<p>1.5. Cell signalling and Signal transduction mechanisms.</p> <p>1.6. Programmed cell Death, Aging and Senescence.</p>			
Module 2:	<p>2.1. Cancer Biology</p> <p>2.2. Introduction to Developmental Biology: Significance of developmental Biology, Model organisms and plants used in developmental Biology: <i>Xenopus</i>, <i>Drosophila</i>, <i>C. elegans</i>, Sea Urchin, Chick, Mouse, Zebra fish, <i>Arabidopsis Thaliana</i>, Rice; Basic concepts and overview of Developmental Biology in animals and plants.</p> <p>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.</p> <p>2.4. Morphogenesis and organogenesis in animals: Cell aggregation and differentiation in <i>Dictyostelium</i>; axes and pattern formation in <i>Drosophila</i>, amphibia and chick; organogenesis – vulva formation in <i>Caenorhabditis elegans</i>, 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.</p>	15	CO3, CO4	K1, K2, K3
Module 3:	<p>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 <i>Arabidopsis</i> and <i>Antirrhinum</i>. Floral induction and organ identity: floral integrator genes, ABCDE model.</p> <p>3.2. Difference between Plant and Animal Developmental Biology</p> <p>3.3 Developmental Plasticity and environmental modulation : Photomorphogenesis: Circadian rhythms, Phytochromes; Themosensory flowers and Vernalisation</p> <p>3.4. Developmental process-oriented disorders and Teratogens: Environmental influence on development, cancer as a developmental disorder, Teratogens: endocrine</p>	15	CO3, CO4, CO5 & CO6	K1, K2, K3, K4, K5, K6

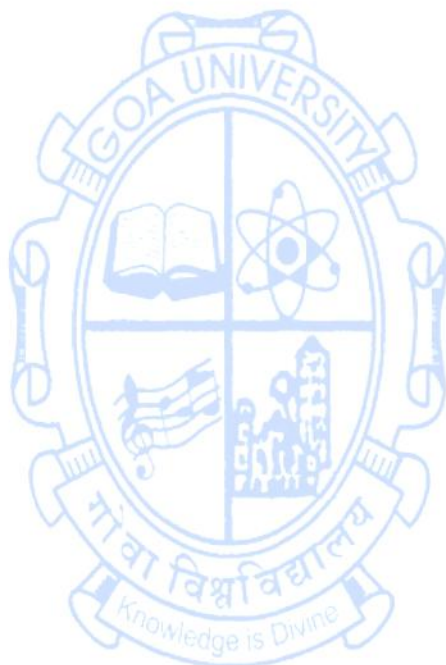
	<p>disrupters, alcohol, Retinoic acid and Congenital abnormalities, genetic disorders in development.</p> <p>3.5. Experimental Techniques in Developmental Biology: Design of CRISPR-Cas9 gene editing strategies, Lineage tracing and fate mapping, Transcriptomics in developmental studies.</p>			
Pedagogy:	Lectures, tutorials, assignments			
Texts: References/ Readings:	<ol style="list-style-type: none"> 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. <i>Plant development</i>. Cold Spring Harbor Laboratory Press. 1997. 16. Leyser, O., & Day, S. <i>Mechanisms in plant development</i>. Blackwell Publishing, 2003. 17. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. <i>Plant physiology and development</i> . Sinauer Associates, 2015. 			

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:	<p>The course is designed to provide a</p> <ul style="list-style-type: none"> • 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:	<ul style="list-style-type: none"> 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:	<ul style="list-style-type: none"> 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

	<ul style="list-style-type: none"> • Spinning-disk microscopy and their applications in biological imaging • Flow Cytometry/FACS 			
Module 3:	<ul style="list-style-type: none"> • 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:	<ol style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 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
--



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:	<ul style="list-style-type: none"> 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:	<p>Introduction to Immunology</p> <ul style="list-style-type: none"> 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. <p>Immune System Architecture</p> <ul style="list-style-type: none"> 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 <p>Antigen Recognition and Presentation</p> <ul style="list-style-type: none"> Nature of antigens, haptens, epitopes, carriers, superantigens, and adjuvants Major Histocompatibility Complex (MHC): <ul style="list-style-type: none"> Discovery, structure (Class I and II), and peptide-binding Role in immune response and restriction Antigen processing and presentation to CD4+ and CD8+ T cells 	15	CO1, CO2	K1, K2

	<ul style="list-style-type: none"> Antigen receptors (BCR, TCR) and accessory molecules of T cells 			
Module 2:	<p>Humoral Immunity</p> <ul style="list-style-type: none"> Immunoglobulins: structure, types, distribution, and functions Antibody production: primary vs. secondary responses Antibody diversity: Somatic recombination, V (D) J recombination, Combinatorial diversity, Junctional diversity. <p>Cell-Mediated Immunity</p> <ul style="list-style-type: none"> T cell subsets (Th1, Th2, Th17, Treg) and their roles Antibody-dependent cell-mediated cytotoxicity (ADCC) <p>Lymphocyte Maturation and Activation</p> <ul style="list-style-type: none"> General features of lymphocyte maturation Gene rearrangements of antigen receptors in B & T cells B and T cell maturation pathways T cell activation: <ul style="list-style-type: none"> Signal transduction pathways (Ras/Rac, Calcineurin, PKC) Activation of transcription factors (NFAT, AP-1, NF-κB) B cell activation: <ul style="list-style-type: none"> BCR signaling and coreceptors Role of CD40 and T-B cooperation Bidirectional molecular interactions 	15	CO3, CO4	K2,K3
Module 3:	<p>Clinical Immunology and Biomedical Diagnostics</p> <ul style="list-style-type: none"> 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

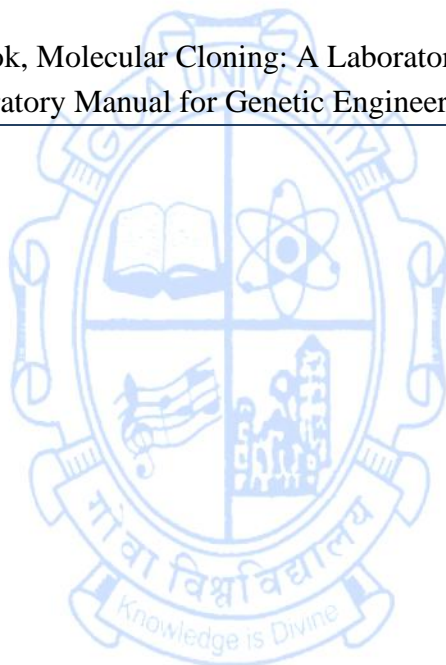
	<ul style="list-style-type: none"> ● Transplantation: Terminology, Auto graft, Isograft, Allograft, Xenograft, Immunological basis of transplantation reactions, GVH reaction. ● Immunosuppression: General mechanisms of immunosuppression, immunosuppression drugs. ● Immune Deficiencies: Introduction, primary and secondary deficiencies. T-cell, B-cell and combined immune deficiencies, Complement 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:	<ol style="list-style-type: none"> 1. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2016). <i>Basic immunology: Functions and disorders of the immune system</i> (5th ed.). Elsevier. ISBN 9780323390828 2. Murray, P. R., Rosenthal, K. S., & Pfaller, M. A. (2016). <i>Medical microbiology</i> (8th ed.). Elsevier. ISBN 9780323299565 3. Murphy, K., & Weaver, C. (2017). <i>Janeway's immunobiology</i> (9th ed.). Garland Science/Taylor & Francis Group. ISBN 9780815345053 4. Burton, D. R., Delves, P. J., Martin, S. J., & Roitt, I. M. (2011). <i>Roitt's essential immunology</i> (Includes desktop edition). Wiley. ISBN 9781405196833 5. Brostoff, J., Male, D. K., & Roitt, I. M. (2001). <i>Immunology</i>. Mosby. ISBN 9780723431893 6. Luttman, M., Bratke, K., Kupper, M., & Myrtek, D. (2006). <i>Immunology</i>. Academic Press. ISBN 9780120885442 7. Owen, J.A., Punt, J., Stranford, S. A., & Jones, P.(2013) <i>Kuby immunology</i> (7th ed.). W. H. Freeman. ISBN-10: 1-4641-3784-6 8. Kimball, J. W. (1990). <i>Introduction to immunology</i>. Macmillan. ISBN 9780023646119 9. Weir, D. M. (Ed.). (1996). <i>Weir's handbook of experimental immunology</i> (Vols. 1– 4).Wiley. ISBN 9780865427984 			

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:	<ul style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). <i>Molecular Biology of the Cell</i> (6th ed.). Garland Science. 2. Bozzola, J. J., & Russell, L. D. (1999). <i>Electron Microscopy: Principles and Techniques for Biologists</i> (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. <i>Cytometry Part A</i>, 61(2), 162–169. https://doi.org/10.1002/cyto.a.20033 4. Kapuscinski, J. (1995). DAPI: A DNA-specific fluorescent probe. <i>Biotech Histochemistry</i>, 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. <i>The Journal of Cell Biology</i>, 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. <i>Current Protocols in Cell Biology</i>, 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. <i>Journal of Immunological Methods</i>, 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. <i>Current Protocols in Immunology</i>, Appendix 3B. https://doi.org/10.1002/0471142735.ima03bs21 9. Wyllie, A. H. (1980). Glucocorticoid-induced thymocyte apoptosis is associated with endogenous endonuclease activation. <i>Nature</i>, 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. <i>Blood</i>, 84(5), 1415–1420. https://doi.org/10.1182/blood.V84.5.1415.bloodjournal8451415 11. Robinson, J. P. (Ed.). (2018). <i>Current Protocols in Cytometry</i>. Wiley. 12. Shapiro, H. M. (2003). <i>Practical Flow Cytometry</i> (4th ed.). Wiley-Liss. 13. Rooney, D. E. (2001). <i>Human Cytogenetics: Constitutional Analysis</i> (Vol. 1, 3rd ed.). Oxford University Press. 			

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



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:	<p>The objective of this laboratory course is to</p> <ul style="list-style-type: none"> • 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:	Immunodiagnosics 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:	<ol style="list-style-type: none"> 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.

Discipline Specific Elective Courses

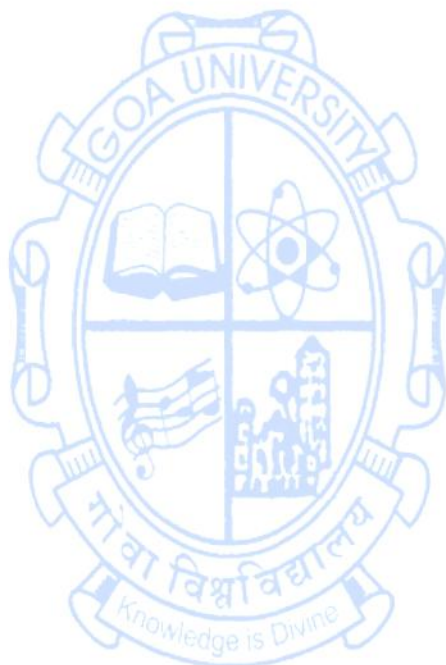
Title of the Course	Computational Biology and Data Analysis	
Course Code	GBT-5201	
Number of Credits	3	
Theory/Practical	Theory	
Level	400	
Effective from AY	2025-26	
New Course	Yes	
Bridge Course/ Value added Course	No	
Course for advanced learners	Yes	
Pre-requisites for the Course:	Nil	
Course Objectives:	<ul style="list-style-type: none"> 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:	<p>Introduction to Biological Databases: Classification of databases—primary, secondary, and specialized (NCBI, ENSEMBL, RefSeq, UniProt, Expression Atlas, HMDB or KEGG, PDB).</p> <p>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.</p> <p>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.</p> <p>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.</p>	15	CO1, CO5	(K1, K2, K3, K4)

Module 2:	<p>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).</p> <p>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.</p> <p>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.</p> <p>Computational Design Applications: In silico design of proteins, enzymes, and synthetic promoters.</p> <p>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).</p>	15	CO2, CO3	(K2, K3, K4, K5, K6)
Module 3:	<p>Next-Generation Sequencing (NGS) Data Handling: Overview of sequencing platforms; file formats including FASTQ, BAM, SAM, and VCF; data preprocessing and quality control.</p> <p>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).</p> <p>Transcriptome Data Analysis: Quality assessment using FastQC, read alignment</p>	15	CO4, CO5, CO6	(K3, K4, K5, K6)

	<p>using HISAT2 or STAR, transcript quantification, and differential gene expression analysis.</p> <p>Functional Enrichment and Pathway Analysis: Gene Ontology annotation; KEGG and Reactome-based biological pathway analysis for interpretation of gene expression changes.</p> <p>Omics Data Integration: Brief overview of analytical workflows in metagenomics, proteomics, and metabolomics for comprehensive biological insights.</p> <p>Network Biology: Introduction to gene and protein interaction networks; network visualization and basic analysis for understanding system-level organization.</p> <p>Exploratory Data Analysis: Techniques such as boxplots, principal component analysis, and correlation matrices for pattern discovery and data quality assessment.</p> <p>Machine Learning: Supervised, semi-supervised, and unsupervised learning approaches, Clustering methods and dimensionality reduction techniques for high-dimensional biological data.</p>			
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion			
Texts: References/ Readings:	<ol style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 1. https://pubchem.ncbi.nlm.nih.gov 2. https://usegalaxy.org 3. https://www.coursera.org/specializations/genomic-data-science 			

- | | |
|--|--|
| | <ol style="list-style-type: none">4. https://www.ebi.ac.uk/training/online/5. https://www.ensembl.org6. https://www.genome.jp/kegg |
|--|--|



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:	<ul style="list-style-type: none"> 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	PSO3, PSO4, PSO6

	relevance, particularly in drug discovery contexts.			
	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:	<ol style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 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. 			

	<p>3. N.C. Jones, and P.A. Pevzner; Introduction to Bioinformatics Algorithms; Ane Books, India, 2004.</p> <p>4. D.W. Mount, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press, 2001.</p> <p>5. Zhumur Ghosh & Bibekanand Mallick, <i>Bioinformatics: A Practical Guide in the Post-Genomic Era</i> (2nd ed.). Oxford University Press. 2022</p>
Web Resources:	<p>https://info-ee.surrey.ac.uk/Teaching/Unix/</p> <p>https://www.genome.jp/kegg</p> <p>https://www.ebi.ac.uk/training/online/</p> <p>https://www.ncbi.nlm.nih.gov/home/tutorials/</p> <p>https://www.coursera.org/specializations/bioinformatics</p>

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:	<ul style="list-style-type: none"> 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:	<ul style="list-style-type: none"> 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:	<ul style="list-style-type: none"> 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:	<ul style="list-style-type: none"> ● 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:	<ol style="list-style-type: none"> 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. Chatterjee, 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:	<ol style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 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:	<ul style="list-style-type: none"> 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/-			

SEMESTER II

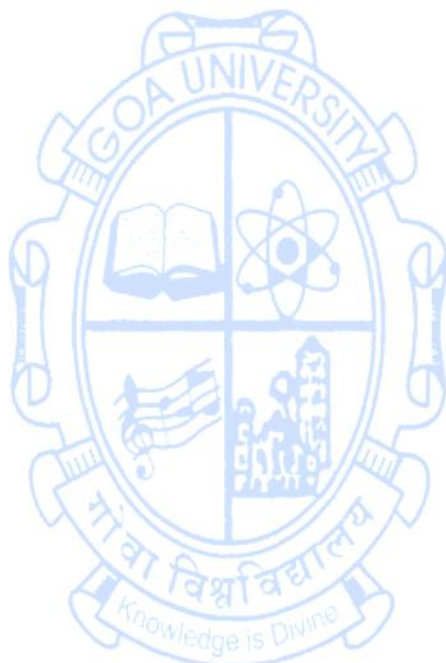
Discipline Specific Core Courses

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: <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • 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

	<ul style="list-style-type: none"> ● Bioprocess for the production of biomass: yeast and mushrooms 			
Module 3:	<p>Downstream Processing:</p> <ul style="list-style-type: none"> ● 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:	<ol style="list-style-type: none"> 1. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2016). <i>Principles of fermentation technology</i> (3rd ed.). Butterworth-Heinemann. 2. Peppler, H. J., & Perlman, D. (Eds.). (1979). <i>Microbial technology: Fermentation technology</i> (2nd ed.). Academic Press. 3. El-Mansi, E. M. T., Bryce, C. F. A., Demain, A. L., & Allman, A. R. (Eds.). (2006). <i>Fermentation microbiology and biotechnology</i> (2nd ed.). CRC Press. 4. Chen, H. (2013). <i>Modern solid state fermentation: Theory and practice</i>. Springer. 5. Smith, J. E. (2009). <i>Biotechnology</i> (5th ed.). Cambridge University Press. 6. Todaro, C. M., & Vogel, H. C. (2014). <i>Fermentation and biochemical engineering handbook</i> (3rd ed.). William Andrew Publishing. 7. Lancini, G., & Lorenzetti, R. (2013). <i>Biotechnology of antibiotics and other bioactive microbial metabolites</i>. Springer. 8. Palmer, T., Bonner, P., (2008) <i>Enzymes Biochemistry, Biotechnology, Clinical chemistry</i>, Wood Head Publishing, 2nd Edition 			
References/ Readings:	<ol style="list-style-type: none"> 1. Pauline M. Doran, Bioprocess Engineering Principles. Academic Press, 1995 2. Rao D.G., Introduction to Biochemical Engineering. Tata McGraw-Hill, 2005 			
Web Resources:	<ol style="list-style-type: none"> 1. https://www.openaccessjournals.com/journals/pharmaceutical-bioprocessing-citations-report.html 			

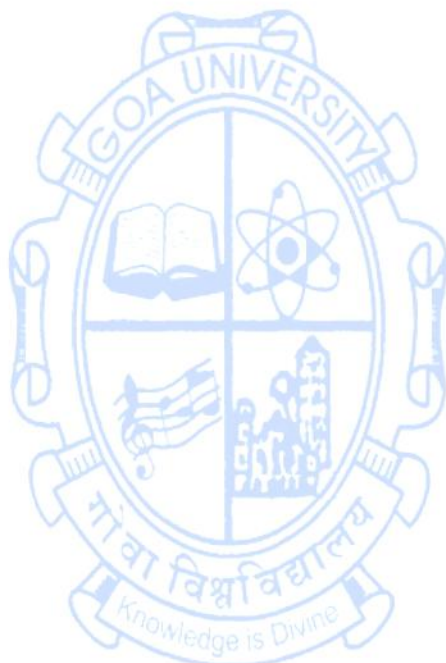
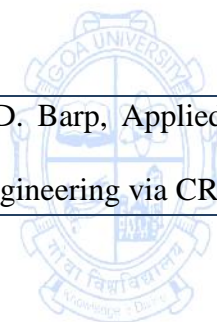
- | | |
|--|--|
| | <ol style="list-style-type: none">2. www.wildfermentation.com/JohnSchollarandBenedikteWatmore,PracticalFermentation-atechnicalguide3. web.mit.edu/professional/short.../fermentation_technology.html4. https://4lfonsina.wordpress.com/wp-content/uploads/2012/11/industrial-microbiology-an-introduction-0632053070-wiley.pdf |
|--|--|



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:	<p>To understand:</p> <ul style="list-style-type: none"> • 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.			

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



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:	<p>The aim of the course is</p> <ul style="list-style-type: none"> • 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:	<ul style="list-style-type: none"> • 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:	<ul style="list-style-type: none"> • 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:	<ul style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 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 			

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:	<ul style="list-style-type: none"> 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:	<p>Plant Biotechnology</p> <p>Principles and tools of plant genetic transformation: Agrobacterium-mediated, biolistic, electroporation.</p> <p>Development of transgenic plants: Selection markers, gene stacking, tissue-specific promoters.</p> <p>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.</p> <p>Metabolic engineering: Modification of seed storage proteins, production of vitamins and nutraceuticals (Golden Rice), engineering of secondary metabolites.</p> <p>Biofactories and synthetic biology: Production of industrial enzymes, pharmaceuticals, and biofuels using transgenic plants and plant cell cultures.</p>	15	CO1, CO2, CO4, CO6	K1, K2, K4, K5
Module 2:	<p>Animal Biotechnology</p> <p>Gene transfer methods: Microinjection, retroviral vectors, electroporation, liposome-mediated delivery, transposons.</p> <p>Transgenic animal models: Mice, poultry, fish; their applications in disease research, functional genomics, and toxicity testing.</p> <p>Cloning and gene editing: SCNT (Somatic Cell Nuclear Transfer), CRISPR/Cas systems in livestock.</p> <p>Biopharming and therapeutic protein production in animals: Recombinant proteins in milk, eggs.</p>	15	CO1, CO2, CO3, CO5, CO6	K1, K2, K3, K4

	<p>Gene targeting, positive and negative selection, and knockouts for functional genomics.</p> <p>Xenotransplantation and ethical considerations.</p> <p>Animal biotechnology in agriculture: Milk enhancement, disease resistance, growth traits.</p>			
Module 3:	<p>Applications of plant and animal biotechnology</p> <p>Section A:</p> <ul style="list-style-type: none"> • 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. <p>Section B:</p> <ul style="list-style-type: none"> • 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:	<ol style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 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/



Title of the Course	LabV: 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:	<p>The students will</p> <ul style="list-style-type: none"> • 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

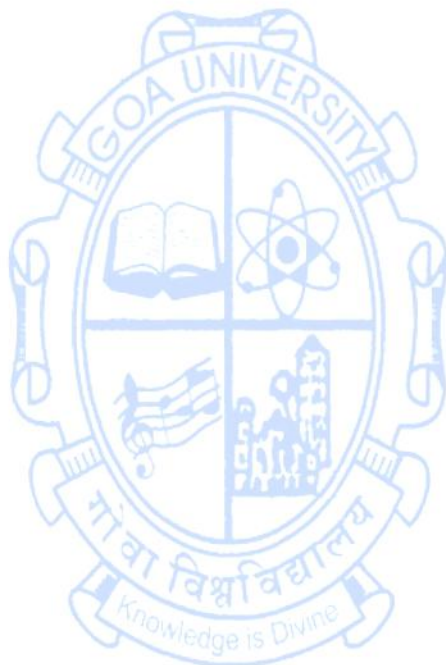
	applications.			
	CO 4. Describing the designs and operational principles of a bioreactor and demonstrating the ability to monitor the bioprocess data.		PSO1, PSO2, PSO3	
	CO 5. Executing fermentation protocols for the production of industrially important bioproducts using submerged and solid substrate 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:	<ol style="list-style-type: none"> 1. S. Carson, <i>Manipulation and expression of recombinant, DNA a laboratory manual</i> Elsevier Academic Press, 2006. 2. M.R Green and J. Sambrook, <i>Molecular Cloning: A Laboratory Manual</i> Three-volume CSH Press, 2012. 3. J.S. Vennison, <i>Laboratory Manual for GENETIC ENGINEERING</i>, PHI Learning, 2009. 4. Stanbury, P. F., Whitaker, A., & Hall, S. J. <i>Principles of Fermentation Technology</i>. Elsevier (2017). 5. Shuler, M. L., & Kargi, F. <i>Bioprocess Engineering: Basic Concepts</i>. Pearson, 2017. 6. Doran, P. M. <i>Bioprocess Engineering Principles</i>. Academic Press, 2013. 7. Crueger, W., & Crueger, A. <i>Biotechnology: A Textbook of Industrial Microbiology</i>, Panima Publishing, 2017. 8. Waites, M. J., Morgan, N. L., Rockey, J. S., & Higton, G. <i>Industrial Microbiology: An Introduction</i>, Wiley-Blackwell, 2009. 9. Demain, A. L., & Sanchez, S. <i>Manual of Industrial Microbiology and Biotechnology</i> (3rd ed.). ASM Press, 2009. 			

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:	<ul style="list-style-type: none"> To gain a comprehensive understanding of the growth and development of plants <i>in vitro</i>. 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:	<ul style="list-style-type: none"> 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:	<ul style="list-style-type: none"> 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:	<p>Specialized Applications, Wiley Blackwell Publisher, 2021.</p> <ol style="list-style-type: none"> 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



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:	<ul style="list-style-type: none"> 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:	<ul style="list-style-type: none"> 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

	<ul style="list-style-type: none"> • 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:	<ul style="list-style-type: none"> • 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:	<ul style="list-style-type: none"> • 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:	<ol style="list-style-type: none"> 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. 			

	<ol style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 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

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:	<ul style="list-style-type: none"> • 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			

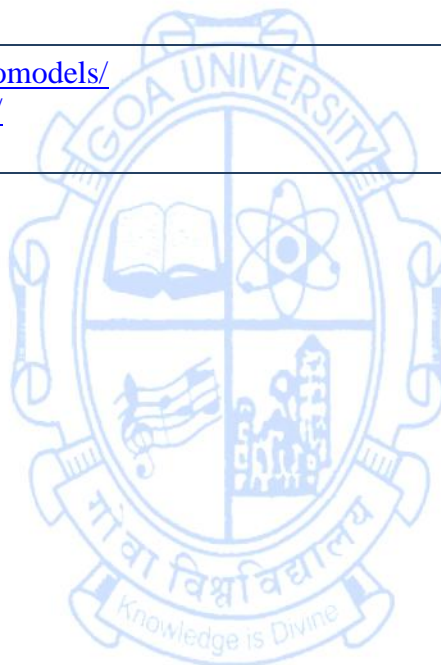
Title of the Course	Systems Biology
Course Code	GBT-5207
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	GBT-5000, GBT-5201	
Course Objectives:	<ul style="list-style-type: none"> 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:	<p>Introduction to Systems Biology: Systems-level understanding vs. reductionism, Historical context and paradigm shift, Applications in medicine, agriculture, and synthetic biology.</p> <p>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.</p> <p>Network Dynamics and Emergent Properties: Feedback loops, noise, robustness, bistability, modularity, oscillations, Time-scale separation and adaptation.</p> <p>Modeling Frameworks: Deterministic vs. stochastic modelling, Boolean and logic-based models, ODE-based models (basics), Constraint-based modeling: flux balance analysis (FBA).</p> <p>Tools and Databases for Network Analysis: Databases: STRING, BioGRID, IntAct, Reactome, Visualization: Cytoscape, Gephi, Network reconstruction from transcriptome/proteome data.</p>	15	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5
Module 2:	<p>High-throughput Omics Overview: Genomics, transcriptomics, proteomics, metabolomics, epigenomics, interactomics, Platforms: NGS, MS, LC-MS, NMR, ATAC-seq, ChIP-seq.</p> <p>Data Processing Pipelines: Genomics: sequencing (Sanger, NGS, PacBio/Nanopore), assembly, annotation, variant calling, Transcriptomics: RNA-Seq</p>	15	CO4, CO5, CO6	K1, K2, K3, K4, K5, K6

	<p>(HISAT2, STAR, DESeq2), Proteomics: MS workflows, quantification, PTM analysis, Metabolomics: GC-MS/LC-MS, preprocessing, interpretation, Epigenomics: bisulfite seq, ChIP-Seq, ATAC-seq basics.</p> <p>Network Construction from Omics Data: Co-expression and interaction networks, Graph measures: centrality, modularity, motifs, Specialized networks (e.g., primary vs. secondary metabolism).</p> <p>Multi-Omics Integration: Challenges: scale, heterogeneity, normalization, Tools: OmicsNet, MixOmics, PaintOmics, Standards: FAIR principles, Case studies in multi-omics integration.</p>			
Module 3:	<p>Biological Pathways and Simulation: Pathway types: metabolic, regulatory, signaling, Databases: KEGG, Reactome, WikiPathways, Modeling dynamics: ODEs, stochastic models (Gillespie), Simulation tools: COPASI, CellDesigner.</p> <p>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.</p> <p>Metabolic Modeling and Engineering: Primary vs. secondary metabolism, Constraint-based modeling: COBRA toolbox, Pathway Tools, Applications in metabolic engineering and synthetic biology.</p> <p>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: <i>E. coli</i> metabolism, yeast cell cycle, immune signaling dynamics.</p>	15	CO2, CO3, CO5, CO6	K3, K4, K5, K6
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion			
Texts: References/ Readings:	<ol style="list-style-type: none"> Alon, U. (2019). <i>An Introduction to Systems Biology: Design Principles of Biological Circuits</i> (2nd ed.). Chapman and Hall/CRC. Kitano, H. (Ed.). (2001). <i>Foundations of Systems Biology</i>. MIT Press. 			

	<ol style="list-style-type: none"> 3. Klipp, E., Liebermeister, W., Wierling, C., Kowald, A., & Herwig, R. (2016). <i>Systems Biology: A Textbook</i> (2nd ed.). Wiley-VCH. 4. Palsson, B. Ø. (2015). <i>Systems Biology: Constraint-based Reconstruction and Analysis</i> (2nd ed.). Cambridge University Press. 5. Zhang, W., & Shmulevich, I. (2009). <i>Computational Systems Biology</i>. Academic Press.
Supplementary Reading	Scientific journals: BMC Systems Biology, Frontiers in Systems Biology.
Web Resources:	<ol style="list-style-type: none"> 1. https://www.ebi.ac.uk/biomodels/ 2. https://www.omicsnet.ca/ 3. https://string-db.org/



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

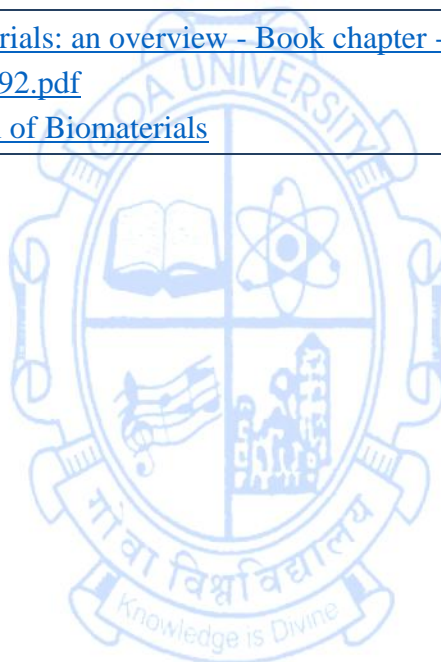
	CO 4. Create pathway enrichment visualizations and simulate ligand-receptor binding to explore functional implications in systems-level contexts.		PSO3, PSO4, PSO6	
Content:		No of hours	Mapped to CO	Cognitive Level
Module:	<ol style="list-style-type: none"> 1. Environmental perturbation and stress-response 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:	<ol style="list-style-type: none"> 1. Kitano, H. (Ed.). (2001). <i>Foundations of Systems Biology</i>. MIT Press. 2. Klipp, E., Liebermeister, W., Wierling, C., Kowald, A., & Herwig, R. (2016). <i>Systems Biology: A Textbook</i> (2nd ed.). Wiley-VCH. 3. Alon, U. (2006). <i>An Introduction to Systems Biology: Design Principles of Biological Circuits</i>. Chapman & Hall/CRC. 4. Palsson, B. (2015). <i>Systems Biology: Constraint-Based Reconstruction and Analysis</i> (2nd ed.). Cambridge University Press. 5. Jiang, X. & Kim, S. (2022). <i>Network Biology: Methods and Applications</i>. Springer. 			
Web Resources:	<p>BioModels Database – https://www.ebi.ac.uk/biomodels/</p> <p>Cytoscape – https://cytoscape.org/</p> <p>COPASI (COMplex PATHway SIMulator) – https://copasi.org/</p> <p>MetaboAnalyst – https://www.metaboanalyst.ca/</p> <p>Gene Expression Omnibus (GEO) – https://www.ncbi.nlm.nih.gov/geo/</p>			

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:	<ul style="list-style-type: none"> 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:	<ul style="list-style-type: none"> • 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:	<ul style="list-style-type: none"> • 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

	<ul style="list-style-type: none"> 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:	<ul style="list-style-type: none"> 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 mediated 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:	<ol style="list-style-type: none"> Young-Chul Lee , Ju-Young Moon, Introduction to Bionanotechnology, Springer Nature, 2020 Nadrin C. Seeman, Structural DNA Nanotechnology, Cambridge University Press, 2016 			

	<ol style="list-style-type: none"> 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:	<p>Introduction to bionanomaterials: an overview - Book chapter - IOPscience</p> <p>L-G-0000584024-0002360992.pdf</p> <p>Bionanotechnology Journal of Biomaterials</p>



Title of the Course	Lab in 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:	<ol style="list-style-type: none"> 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:	<ol style="list-style-type: none"> 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 			