KURUKSHETRA UNIVERSITY
KURUKSHETRA

("A^{++}" Grade Accredited by NAAC)

Syllabus for

Under-Graduate Programme

(Subject: Biotechnology)

(5th to 8th Semester)

Under Multiple Entry-Exit, Internship and CBCS-LOCF in accordance to NEP-2020 w.e.f. 2024-25 (in phased manner)

CC-5/ MCC-9

Session: 2024-2025			
Part A - Introduction			
Subject	Biotechnology		
Semester	V		
Name of the course	Immunology		
Course Code	B23-BTY-501		
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	CC-5/ MCC- 9		
Level of the course (As per Annexure-I)	300-399		
Pre-requisite for the course (if any)	NA		
Course Learning Outcomes (CLO): (CLOs 1-4 of theory and 5th of practical)	After completing this course, the learner will be able to: 1. Conceptualize how the innate and adaptive immune responses coordinate to fight invading pathogens. 2. Understand and describe antigen, antibodies and their interactions. 3. Know about the basic principles of immune cells responses. 4. Learn about the problems emerging in health sector, diseases related to immune system, hybridoma technology and different types of vaccines. 5. Exhibit skills to isolate lymphocytes and serum from Blood and to perform various immunological assays such as ELISA, DID and blood typing.		
Credits	Theory	Practical	Total
	3	1	4
Contact Hours/ week	3	2	5
Max. Marks: 100 **Internal Assessment Marks: 30** (20 Theory + 10 Practical) **End Term Exam Marks: 70** (50 Theory + 20 Practical)	**Time:** 3h (Theory); 4h (Practical)		

Part B - Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Introduction and overview:** Introduction and overview of immunology, cells and organs of immune system. Primary and secondary responses. Innate immunity: anatomic, physiological, phagocytic and inflammatory barriers. Adaptive immunity: Humoral and cell-mediated. Interrelationship between innate and acquired immunity.	10
II	**Antigens:** Concept of antigenicity and immunogenicity, Antigens, epitopes, haptens and adjuvants. **Antibodies:** basic structure of antibodies, antibody classes and their biological activity, antigenic determinants on immunoglobulins, immunoglobulin super family, antigen-antibody interactions: immunoprecipitation, agglutination.	12
III	**Basic principles of immune system:** Structure and function of B-cell receptor, T-cell receptor. Introduction of self-tolerance and MHC-restriction. Structure and role of Major Histocompatibility Complex, Antigen processing and presentation. Complement system and its activation pathways. Cytokines and their role.	12
IV	**Immune system in health and disease:** Hypersensitivity reactions-their types and mechanism, Autoimmune disorders. Passive and active immunization. Hybridoma technology: production of monoclonal antibodies. Vaccines*:* live attenuated, killed, subunit, conjugate and DNA vaccines.	11
V*	**List of Practicals:** 1. Isolation of Lymphocytes from peripheral blood. 2. Serum preparation and serological reactions-Agglutination and Precipitation 3. To perform Enzyme-linked Immunosorbent assay 4. To perform immunodiffusion by Mancini and Ouchterlony method (single or double) 5. To perform immuno-electrophoresis with a given antigen-antibody system **6.** Assays based on agglutination reactions-Blood typing	30

Suggested Evaluation Methods	
Internal Assessment: ➢ Theory-20 Marks • Class Participation: 5 • Seminar/presentation/assignment/quiz/class test etc.: 5 • Mid-Term Exam: 10 ➢ Practicum - 10 Marks • Class Participation: • Seminar/Demonstration/Viva-voce/Lab records etc.: 10 • Mid-Term Exam: NA	**End Term Examination:** Theory: 50 Marks (Written exam); Practical: 20 Marks (Demonstration/Viva-voce/Lab records etc.)

Part C- Learning Resources

Recommended Books/e-resources/LMS:

1. Benjamin E. Immunology – A short course 4th Edition, John Wiley, NewYork
2. Kuby J. Immunology,8th Edition, W.H. Freeman & Co., NewYork
3. Roitt, I.M. Essential Immunology, 12thEdition, Oxford Black Well Science,London
4. TizardI.R.Immunology–Anintroduction,9th Edition, Philadelphia Saunders College press.
5. Gupta P.K. Biotechnology and Genomics, Rastogi Publications Meerut
6. Ommerville et al. Alcamo's Fundamentals of Microbiology, Jones and Barteett Publishers.

MCC-10

Session: 2024-2025			
Part A - Introduction			
Subject	**Biotechnology**		
Semester	**V**		
Name of the course	**Microbial Genetics**		
Course Code	**B23-BTY- 502**		
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	**MCC-10**		
Level of the course (As per Annexure-I)	**300-399**		
Pre-requisite for the course (if any)	**NA**		
Course Learning Outcomes (CLO): (CLOs 1-4 of theory and 5th of practical)	After completing this course, the learner will be able to: 1. Know about structure of Prokaryotic Genome and DNA Replication 2. Gain the knowledge of Mutation and DNA repair. 3. Explain about Genetic transformation and Mechanism of genetic exchange 4. Stages in the Lytic Life and Lysogenic Life Cycle of a typical phage 5. Exhibit practical skills in preparation of media and preparation of cell culture. Gain the knowledge of Isolation genetic material from E. *coli* and its analysis.		
Credits	Theory	Practical	Total
	3	1	4
Contact Hours/ week	3	2	5
Max. Marks: 100 **Internal Assessment Marks: 30** (20 Theory + 10 Practical) **End Term Exam Marks: 70** (50 Theory + 20 Practical)	**Time:** 3h (Theory), 4h (Practical)		

Part B - Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	**Topics**	**Contact Hours**
I	**Prokaryotic Genomes**: Physical organization of bacterial genomes (Structure of the bacterial nucleoid, Replication and partitioning of the bacterial genome). **DNA replication:** Mechanism of DNA replication-conservative, semi-conservative and dispersive types, experimental evidence for semi-conservative replication, enzymes and accessory proteins, proof reading, inhibitors in prokaryotic replication.	10

II	**Mutations**: Spontaneous and induced (physical and chemical mutagens), DNA repair mechanisms, Direct repair- photolyase and Ada, Mismatch repair- *mutSLH*, Recombinational repair- *recA, recFOR, recBCD*, SOS and translation synthesis- *umuCD*, Mutator genes. Molecular mechanisms of mutations: Point mutations, base substitution-transition and transversion (framshift mutations, deletion, addition).	12
III	**Genetic Transformation:** Griffith's Experiment, Genetic change: transformation, transduction, conjugation, plasmids. **Mechanism of genetic exchange**: Plasmid and bacterial sex, Types of plasmids (F Plasmid : a Conjugate plasmid', Mobilization of Non-conjugative plasmid, R plasmid, Col plasmid Copy number and incompatibility), Episomes. Transposable elements (Insertion sequence and transposons, Integrons and Antibiotic-Resistance cassettes, Multiple Antibiotic Resistant bacteria, Mu–virus).	12
IV	**Bacteriophages:** Stages in the Lytic Life Cycle of a typical phage, Properties of a phage infected bacterial culture, Specificity in phage infection, E. coli PhageT4, E.coli Phage T7, E.coli phage lambda, Immunity to infection, Prophage integration, Induction of prophage, Prophage excision, Repressor, Structure of the operator and binding of the repressor and the Cro product, Decision between the lytic and lysogenic Cycles, Transducing phages, E.coli phage phiX174, filamentous DNA phages, Single stranded RNA phages, The lysogenic Cycle.	11
V*	List of Practical: **1.** Preparation of Nutrient Agar Media **2.** Different Method of Plating and preparation of agar slant. **3.** Preparation of pure culture **4.** Culture of E.coli in Luria Bertani Media and Study of Bacterial Cell Count by using spectrophotometer **5.** Isolation of DNA from E.coli and analysis by agarose gel electrophoresis **6.** Isolation of RNA from E.coli **7.** Isolation of Plasmid from E.coli and analysis by agarose gel electrophoresis	30
Suggested Evaluation Methods		

Internal Assessment:	**End Term Examination:**
➢ Theory-20 Marks •Class Participation: 5 •Seminar/presentation/assignment/quiz/class test etc.:5 •Mid-Term Exam: 10 ➢ Practicum -10 Marks •Class Participation: •Seminar/Demonstration/Viva-voce/Lab records etc.:10 Mid-Term Exam: NA	Theory: 50 Marks (Written exam); Practical: 20 Marks (Demonstration/Viva-voce/Lab records etc.)

Part C- Learning Resources

Suggested Reading

1. Maloy *et al*., 1994, Microbial genetics, Jones & Barlett publishers
2. Dale JW 1994, Molecular Genetics of Bacteria, John Wiley & sons
3. Lewin 2002, Gene IX oxford University Press
4. Hayes W, Bacterial & Viral Genetics
5. General microbiology (Vth edi) Stanier, Ingraham, Wheelis & Painter
6. Dubey & Maheshwari , Text book of Microbiology

DSE-2

Session: 2024-2025			
Part A - Introduction			
Subject	Biotechnology		
Semester	V		
Name of the course	Fundamentals of Enzymology		
Course Code	B23-BTY-503		
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	DSE-2		
Level of the course (As per Annexure-I)	300-399		
Pre-requisite for the course (if any)	NA		
Course Learning Outcomes (CLO): (CLOs 1-4 of theory and 5th of practical)	After completing this course, the learner will be able to: 1. Learn various characteristics of enzymes, classify them and elaborate the role of cofactors in enzyme catalysis. 2. Correlate the structure of enzymes to their functions, mechanism of enzyme catalysis. 3. Exhibit the knowledge of enzyme kinetics of unisubstrate reactions, various kinetics parameters (Km, Vmax etc.) and describe different types of enzyme inhibitions. 4. Discuss techniques of enzyme isolation and purification and analyze the importance of immobilized enzymes and the techniques to prepare them. 5. Knowledge to extract and quantitatively estimate the enzyme activity and protein content of the samples; exhibit skills in studying various characteristics of enzymes like temperature optima, Km, Vmax.		
Credits	Theory	Practical	Total
	3	1	4
Contact Hours/ week	3	2	5
Max. Marks: 100 **Internal Assessment Marks: 30** (20 Theory + 10 Practical) **End Term Exam Marks: 70** (50 Theory + 20 Practical)	**Time:** 3h(Theory), 4h (Practical)		

Part B - Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	History of Enzymology, General characteristics, nomenclature & classification of enzymes. Significance of numbering system. Introduction to terms: holoenzyme, apoenzyme, coenzymes, cofactors, activators, inhibitors, active site, metallo-enzymes, isoenzymes, monomeric	11

	enzymes, oligomeric enzymes, multifunctional enzyme and multi-enzyme complexes. Measurement and expression of enzyme activity: Enzyme assay, enzyme units, enzyme turn over number and specific activity.	
II	**Role of cofactors in enzyme catalysis:** NAD/NADP, FMN/FAD, CoA, biocytin, Vit B12, lipoamide, TPP, PLP, tetrahydrofolate and metal ions. Enzyme catalysis: Reaction co-ordinate diagram, transition state, acid-base catalysis, covalent catalysis, proximity and orientation effects, strain and distortion theory. Mechanism of action of chymotrypsin, carboxypeptidase and ribonuclease.	12
III	**Introduction to Enzyme Kinetics,** Factors affecting enzyme activity **(**enzyme concentration, substrate concentration, pH and temperature**)**. Derivation of Michaelis-Menten equation for uni-substrate reaction. K_m and its significance. Lineweaver-Burk plot. Importance of K_{cat}/K_m**.** Reversible (competitive, non-competitive and uncompetitive inhibitions) and irreversible inhibition. Enzyme regulation**:** Feedback inhibition, Allosteric enzymes. Covalently modulated enzymes. Zymogen activation.	12
IV	**Enzyme purification:** methods of isolation of Enzyme, purification of enzyme- Ammonium sulphate precipitation, molecular sieving, ion-exchange chromatography, affinity chromatography, Criteria of homogeneity of enzyme. **Immobilized enzymes:** methods of immobilization - Adsorption, ionic binding, covalent coupling, cross-linking, entrapment, microencapsulation. Advantages and disadvantages of immobilization. Applications of immobilized enzymes. Enzyme reactors, Enzymes as biosensors. Extremozymes, Abzymes and Ribozymes Clinical aspects of Enzymology and Future prospects.	10
V*	**List of Practicals:** 1. Estimation of protein by Biuret/Lowry method 2. Assay of acid/alkaline phosphatase activity from germinating mungbean seeds and calculation of activity and specific activity of acid/alkaline phosphatase. 3. Effect of enzyme concentration on the rate of enzyme catalysed rection. 4. Effect of substrate concentration on acid/alkaline phosphatase activity and determination of its Km value. 5. Effect of Temperature on Enzyme activity and determination of optimum temperature. 6. Partial purification of enzyme by change of pH, temperature, addition of organic solvents and ammonium sulphate fractionation technique and to determine the specific activity of the enzyme	30

Suggested Evaluation Methods	
Internal Assessment: Theory-20 Marks • Class Participation: 5 • Seminar/presentation/assignment/quiz/class test etc.: 5 • Mid-Term Exam: 10 Practicum – 10 Marks • Class Participation: • Seminar/Demonstration/Viva-voce/Lab records etc.: 10 • Mid-Term Exam: NA	**End Term Examination:** Theory: 50 Marks (Written exam); Practical: 20 Marks (Demonstration/Viva-voce/Lab records etc.)

Part C- Learning Resources

Recommended Books/e-resources/LMS:

1. Structure and mechanism in Protein Science, by Alan Fersht (2017). World Scientific.
2. Fundamentals of Enzymology, 3rd edition, by Nicholas C. Price and Lewis Stevens (2009) Oxford U.
3. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry by Trevor Palmer, Philip Bonner (2008). East West Publishing.
4. The Chemical Kinetics of Enzyme action by K.J. Laidler and P.S. Bunting, Oxford University Press London.
5. An introduction to Practical Biochemistry, 3rd Edition, by David Plummer (2017). Tata Mc-Graw Hill
6. Introductory Practical Biochemistry by S.K. Sawhney& R. Singh (2014). Narosa Publishers
7. Modern Experimental Biochemistry, 3rd edition, by R. Boyer (2002). Addison-Wesley Longman.

DSE-2

Session: 2024-2025			
Part A – Introduction			
Subject	Biotechnology		
Semester	V		
Name of the course	Fermented Foods		
Course Code	B23-BTY-504		
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	DSE-2		
Level of the course (As per Annexure-I)	300-399		
Pre-requisite for the course (if any)	NA		
Course Learning Outcomes (CLO): (CLOs 1-4 of theory and 5th of practical)	After completing this course, the learner will be able to: 1. Understand the principles and processes of fermentation. 2. Identify the microorganisms involved in fermentation and their roles. 3. Examine the biochemical transformations during fermentation. 4. Analyze the nutritional and sensory attributes of fermented foods. 5. Explore the production techniques of different fermented food products.		
Credits	Theory	practical	Total
	3	1	4
Contact Hours/ week	3	2	5
Max. Marks: 100 Internal Assessment Marks: 30 (20 Theory + 10 Practical) End Term Exam Marks:70 (50 Theory + 20 Practical)	Time:3h theory,4h practical		

Part B - Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	**Topics**	**Contact Hours**
I	Introduction to Fermentation: Definition of fermentation Historical significance and cultural aspects of fermented foods, Importance of fermentation in food preservation and flavor development, Microbiology of Fermentation: Microorganisms involved in fermentation (bacteria, yeasts, molds) Role of microorganisms in fermentation processes Factors influencing microbial growth and activity in fermentation.	10

II	Principles of Fermentation: Biochemical pathways involved in fermentation (e.g., lactic acid fermentation, alcoholic fermentation), Fermentation kinetics and factors affecting fermentation rates, Control of fermentation parameters (temperature, pH, oxygen availability	12
III	Fermented Food Products: Dairy products (e.g., yogurt, cheese, kefir); Fermented vegetables (e.g., sauerkraut, kimchi); Fermented beverages (e.g., beer, wine, kombucha); Fermented grains and legumes (e.g., sourdough bread, tempeh); Fermented meats and fish (e.g., salami, fish sauce)	12
IV	Fermentation Techniques and Equipment: Traditional and modern fermentation techniques; Equipment used in fermentation processes (e.g., fermentation tanks, starter cultures); Scaling up fermentation processes for commercial production; Quality Control and Fermentation Monitoring: Methods for monitoring fermentation progress (e.g., pH measurement, microbial analysis); Quality parameters for evaluating fermented foods (e.g., texture, flavor, shelf life)	11
V	List of Practical: Lab demonstrations of fermentation processes 1. Preparation of yoghurt and buttermilk 2. Preparation of pickles 3. Preparation and maintenance of starter culture 4. Analysis of fermented food products for quality and safety parameters	30

Suggested Evaluation Methods

Internal Assessment:	**End Term Examination:**
Theory – 20 Marks Class Participation:5 Seminar/presentation/assignment/quiz/class test etc.: 5 Mid-Term Exam: 10 Practicum – 10 Marks Class Participation: Seminar/demonstration/viva-voce/lab records etc.: 10 Mid-Term Exam: NA	Theory: 50 Marks (Written exam); Practical: 20 Marks (Demonstration/Viva-voce/Lab records etc.)

Part C- Learning Resources

Recommended Books/e-resources/LMS:

1. "Fermented Foods: Principles and Applications" by Jyoti Prakash Tamang
2. Handbook of Fermented Food and Beverage Technology" edited by Y. H. Hui, Lisbeth Meunier-Goddik, et al.
3. The Art of Fermentation: An In-Depth Exploration of Essential Concepts and Processes from Around the World" by Sandor Ellix Katz
4. "Microbiology and Technology of Fermented Foods" by Robert W. Hutkins

DSE-3

Session: 2024-2025			
Part A - Introduction			
Subject	Biotechnology		
Semester	V		
Name of the course	Foundations of Environment and Ecology		
Course Code	B23-BTY- 505		
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	DSE-3		
Level of the course (As per Annexure-I)	300-399		
Pre-requisite for the course (if any)	NA		
Course Learning Outcomes (CLO): (CLOs 1-4 of theory and 5th of practical)	After completing this course, the learner will be able to: 1. Students will be able to describe basic concepts of ecology and ecosystem. 2. Students will be able to describe the various biological interactions and relation between abiotic and biotic factors. 3. Students will able to understand biogeochemical cycles and concept of Biodiversity. 4. Students will able to understand the causes of different types of pollution and their management strategies. 5. Learners will able to measure various physio-chemical parameters of water samples		
Credits	Theory	Practical	Total
	3	1	4
Contact Hours/ week	3	2	5
Max. Marks: 100 **Internal Assessment Marks: 30** (20 Theory + 10 Practical) **End Term Exam Marks: 70** (50 Theory + 20 Practical)	**Time:** 3h (Theory), 4h (Practical)		

Part B - Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	**Topics**	**Contact Hours**
I	Basic concepts of ecology: Definition, significance. Concepts of habitat and ecological Niche. Ecosystem: Concept, components, properties and functions; Ecological energetics and energy flow-food chain, food web, trophic structure; ecological pyramids, concept of productivity.	10
II	Factors affecting environment: Abiotic factors (light-intensity, quality and duration), temperature, humidity, wind, Rainfall, topography; edaphic factors; Biotic factors.	12

	Introduction to major ecosystems of the world.	
III	Biogeochemical cycles: Concept, reservoir pool, gaseous cycles and sedimentary cycles. Population: Growth and regulation. Concept of biodiversity and conservation of natural resources.	12
IV	Population interactions: Competition, predation, parasitism, commensalisms and mutualism. Environmental pollution: Soil, Water, Air, radiation, landscape, noise Detection of Environmental pollutant. Hazardous wastes Environmental cleanup, Bioremediation, Waste disposal.	11
V*	List of Practical: 1. Chemical analysis of pond and soil ecosystem for pH, 2. Chemical analysis of pond and soil ecosystem for dissolved oxygen, BOD 3. Chemical analysis of pond and soil ecosystem for free CO_2 4. Chemical analysis of pond and soil ecosystem for Nitrates, phosphates and chlorides 5. DNA isolation from soil microbial community 6. Isolation of azotobacter species from soil	30

Suggested Evaluation Methods

Internal Assessment:	**End Term Examination:**
➢ Theory-20 Marks •Class Participation: 5 •Seminar/presentation/assignment/quiz/class test etc.:5 •Mid-Term Exam: 10 ➢ Practicum -10 Marks •Class Participation: •Seminar/Demonstration/Viva-voce/Lab records etc.:10 •Mid-Term Exam: NA	Theory: 50 Marks (Written exam); Practical: 20 Marks (Demonstration/Viva-voce/Lab records etc.)

Part C- Learning Resources

Suggested Reading

1. Fundamentals of Ecology; Odum EP.
2. Wastewater Engineering – Treatment, Disposal and Reuse; Metcalf & Eddy, Tata McGrawhill
3. Environmental Pollution Control Engineering, Rao CS, New Age International Publication.

DSE-3

Session: 2024-2025			
Part A - Introduction			
Subject	Biotechnology		
Semester	V		
Name of the course	Foundations of Nano-Biotechnology		
Course Code	B23-BTY-506		
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	DSE-3		
Level of the course (As per Annexure-I)	300-399		
Pre-requisite for the course (if any)	NA		
Course Learning Outcomes (CLO): (CLOs 1-4 of theory and 5th of practical)	After completing this course, the learner will be able to: 1. To understand the fundamentals of nanotechnology and its application in biology. 2. To explore the synthesis and characterization of nano materials used in bio-nanotechnology. 3. To examine the interactions between biological systems and nanoparticles. 4. To investigate the applications of bio-nanotechnology in medicine, biosensing, and biotechnology. 5. To discuss ethical, safety, and societal implications of bio-nanotechnology.		
Credits	Theory	Practical	Total
	3	1	4
Contact Hours / week	3	2	5
Max. Marks: 100 Internal Assessment Marks: 30(20 Theory + 10 Practical) End Term Exam Marks:70 (50 theory + 20 Practicals)	Time: 3h (theory),4h(practical)		

Part B - Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	**Topics**	**Contact Hours**
I	Introduction to Bio-Nanotechnology - Cellular nanostructures, self-assembly of colloidal nanostructures of biological relevance, bioactive nanoparticles (respiratory surfactants, magnetic nanoparticles), Nanoparticles for drug delivery (including solid lipid nanoparticles, synthetic and biopolymeric nanoparticles).	10

II	carbon nanotubes, polymeric nanofibers, Implications in neuroscience, tissue engineering and cancer therapy, and Environmental and safety aspects of bio-nanotechnology.	12
III	Introduction to Nanotechnology (Definitions, history and current practice), Multilayer Thin Film: Polyelectrolyte multilayers, coated colloids, smart capsules, LbL self-assembly, Colloids and Colloid Assemblies for Bio-nanotechnology, Nanoengineered biosensors, Fiber Optic Nano-sensors in medical care.	12
IV	Semiconductor and Metal Nanoparticles: Synthesis and Applications, Nanotechnology in Tissue Engineering, Microemulsions and Drug Delivery in Nanotechnology. Overview of current industry applications; nanoscale science and engineering principles	11
V	1. To study nanotube modeller software. 2. To study ninithi software 3. To synthesize nanoparticles by chemical reduction method 4. To synthesize nanoparticles by plant extract. 5. To study AFM 6. To study X Ray diffraction	30

Suggested Evaluation Methods

Internal Assessment:	**End Term Examination:**
Theory 20 Marks ➢ Class Participation: 5 ➢ Seminar/presentation/assignment/quiz/class test etc.: 5 ➢ Mid-Term Exam: 10 Practicum 10 Marks ➢ Class Participation: ➢ Seminar/Demonstration/viva/Lab records etc.: 10 ➢ Mid-Term Exam: NA	Theory: 50 Marks (Written exam); Practical: 20 Marks (Demonstration/Viva-voce/Lab records etc.)

Part C- Learning Resources

Recommended Books/e-resources/LMS:

1. Multilayer Thin Films; Decher G, Schlenoff JB, Wiley-VCH Verlag GmbH & Co. KGaA.
2. Bio-nanotechnology : Lessons from Nature; Goodsell DS, Wiley-Liss.
3. Nanotechnology - A Gentle Introduction to the Next Big Idea; Ratner and Ratner, Prentice Hall PTR

CC-6/ MCC-11

Session: 2024-2025			
Part A - Introduction			
Subject	Biotechnology		
Semester	VI		
Name of the course	Microbial Technology		
Course Code	B23-BTY-601		
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	CC-6/ MCC- 11		
Level of the course (As per Annexure-I)	300-399		
Pre-requisite for the course (if any)	NA		
Course Learning Outcomes (CLO): (CLOs 1-4 of theory and 5th of practical)	After completing this course, the learner will be able to: 1. Evaluate the role of micro-organisms in specific biotechnological processes. Have insight about industrially important microbes, recent developments in fermentation processes and various types of fermentations. 2. Attain knowledge about designing of industrial strains and various media optimization strategies, strategies for overproduction of industrial important metabolites structure and functioning of fermenter. 3. Understand the basic principles of microbial commercial fermentations 4. Get introduced to various strategies of product recovery from a fermentation broth. knowledge to solve critical problems 5. Develop practical skill to isolate, improve, analyze and preserve industrially important microbes.		
Credits	Theory	Practical	Total
	3	1	4
Contact Hours/ week	3	2	5
Max. Marks: 100 **Internal Assessment Marks: 30** (20 Theory + 10 Practical) **End Term Exam Marks: 70** (50 Theory + 20 Practical)	**Time:** 3h (Theory), 4h (Practical)		

Part B - Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Microbial Biotechnology**: Scopes, application and challenges. Biology of industrial micro- organisms: Industrial microorganisms, growth metabolism regulation, substrate assimilation/ product formation. Isolation and preservation of	11

	industrially important microorganisms. Fermentation system; batch and continuous system, fed batch system, multistage system. Solid state fermentation and its applications.	
II	**Overproduction of primary & secondary metabolites**: Use of mutation selection and recombination techniques. Fermentation raw materials: Media for industrial fermentations; criteria used in media formulation. Fermenter /bioreactor design and operation; types of fermenter, stirred tank reactor, bubble column reactor, airlift reactor, packed bed reactor, fluidized bed reactor and trickle bed reactor, agitation and aeration in a reactor, mass transfer. Foam formation and control.	12
III	Industrial production of alcoholic beverages, antibiotics and vaccines (a brief idea). Microbial production of industrial chemicals: ethanol, citric acid, acetic acid, gluconic acid, glycerol, acetone and butanol. Single cell protein (SCP) production, extracellular polysaccharides and enzymes.	12
IV	Microbial inoculants: Food starter cultures; baker's yeast, starter cultures for the dairy industry, meat starter cultures,; microbial inoculants; Microbial transformation of steroids and sterols. Down-stream processing: separation processes for microbial cells and other solids, cell disruption, centrifugation, solvent recovery, drying and crystallization. Recovery schemes for non-volatile metabolites, biomass.	10
V*	**List of Practical:** 1. Demonstration of working of fermenter. 2. Production of Biomass in sub-merged fermentation and surface fermentation. 3. Optimizing growth conditions: physical and chemical. 4. Isolation of industrially important micro-organisms. 5. Isolation of protease/lipase/amylase producing micro-organisms 6. Production of xylanase/Cellulase/ Pectinase by microbes and activity estimation 7. Preservation of isolated microbial cultures.	30

Suggested Evaluation Methods	
Internal Assessment: ➢ Theory-20 Marks • Class Participation: 5 • Seminar/presentation/assignment/quiz/class test etc.: 5 • Mid-Term Exam: 10 ➢ Practicum - 10 Marks • Class Participation: • Seminar/Demonstration/Viva-voce/Lab records etc.: 10 • Mid-Term Exam: NA	**End Term Examination:** Theory: 50 Marks (Written exam); Practical: 20 Marks (Demonstration/Viva-voce/Lab records etc.)

Part C- Learning Resources

Recommended Books/e-resources/LMS:

1. Stanbury P.F. et al. (1997), Principles of Fermentation Technology, Pergmon Press Oxford.
2. Ward O.P., (1998), Fermentation Biotechnology – Principles, Process and Products. Prentice Hall Publishing, NewJersey.
3. Microbial Biotechnology: Basic Research and Applications (2020). Edit. Singh *et al*. Pub.Springer
4. Modern Industrial Microbiology and Biotechnology (2007) by Nduka Okafor. Science Publishers
5. Arnold I. Demain and Julian E. Davies (1999), Manual of Industrial Microbiology and Biotechnology, 2nd Edition, ASM Press, Washington D.C.
6. Glazer and Nikaido (1998) Microbial Biotechnology by WH Freeman & Company, NewYork.
7. Cruger and Cruger (2002), Biotechnology – A Textbook of Industrial Microbiology, 2nd Edition, Panima Publishing Corporation, New Delhi.

MCC-12

Session:2024-25			
Part A-Introduction			
Subject	**Biotechnology**		
Semester	**VI**		
Name of the Course	**Bio-analytical Techniques**		
Course Code	**B23-BTY-602**		
Course Type: (CC/MCC/MDC/CC-M /DSEC/VOC/DSE/PC/AEC/VAC)	**MCC-12**		
Level of the course(As per Annexure-I	**300-399**		
Pre-requisite for the course (if any)	NA		
Course Learning Outcomes (CLO): (CLOs 1-4 of theory and 5th of practical)	After completing this course, the learner will be able to: 1. Understand various techniques in Biotechnology 2. Gain the knowledge of scope and applications of such techniques 3. Get an insight of scope and applications of bio-analytical techniques 4. Gain knowledge of structure, working, maintenance/calibration and safety measures during handling of biotech lab instruments. Also get insight of maintenance of hygiene/ aseptic conditions. 5. Gain knowledge of various techniques		
Credits	Theory	Practical	Total
	3	1	4
Contact Hours/ week	3	2	5
Max. Marks:100 **InternalAssessmentMarks:30**(20Theory+10Practical) **EndTermExamMarks:70**(50Theory+20Practical)		**Time:**3h(Theory),4h(Practical)	
Part B-Contents of the Course			
Instructions for Paper- Setter Nine questions will be set in all. Question No.1comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Q.No.1 &four others selecting One question from each unit. All questions carry equal marks.			

Unit	Topics	Contact Hours
I	Bio-separation; filtration, centrifugation, sedimentation, flocculation; Cell disruption; Liquid- liquid extraction; Purification by chromatographic techniques, reverse osmosis and ultra- filtration; Drying; Crystallization; Storage and packaging. Principles of Sedimentation, centrifugation techniques and their applications, differential centrifugation, density gradient and ultracentrifugation techniques.	12
II	Light Microscopy – Magnification, resolving power, Numerical aperture, Limit of Resolution, Principles and applications of bright field, phase contrast, fluorescence, scanning and transmission electron microscopy. Concept, Factors affecting electrophoresis, Agarose gel electrophoresis, Pulse field gel electrophoresis, PAGE, SDS-PAGE, Isoelectrofocusing, 2-Dimentional electrophoresis	12
III	Principles and applications of Paper, Thin layer, Gel-filtration, ion-exchange, Affinity chromatography, Gas liquid chromatography, High pressure liquid chromatography (HPLC); Reversed Phase chromatography. Beer-Lambert law, light absorption and its transmittance, extinction coefficient, a brief account of instrumentation and applications of visible and UV spectroscopic techniques (structure elucidation excluded), NMR and ESR spectroscopy.	11
IV	Types of radiations, radioactive decay, units of radioactivity, detection and measurement of radioactivity (methods based on gas ionization and liquid scintillation counting) and Quenching. Autoradiography: overview, nuclear emulsions used in biological studies, isotopes commonly used in biochemical studies (32P, 35S, 14C and 3H). Biological hazards of radiations and safety measures in handling radioisotopes. Biological applications of radioisotopes.	10
V*	List of Practical: 1. Quantitative estimation of DNA and RNA content in the given sample. 2. Paper Chromatography or Thin Layer Chromatography 3. Gel Filtration, Ion-exchange and Affinity Chromatography 4. Agarose gel electrophoresis 5. PAGE 6. Centrifugation 7. Methods for preparation of nano-bioparticles	30

Suggested Evaluation Methods	
Internal Assessment: ➢ Theory-20 Marks • ClassParticipation:5 • Seminar/presentation/assignment/quiz/classtestetc.:5 • Mid-Term Exam: 10 ➢ Practical-10 Marks • Class Participation: • Seminar/Demonstration/Viva-voce/Labrecordsetc.:10 • Mid-Term Exam: NA	**End Term Examination:** Theory: 50 Marks (Written exam); Practical: 20 Marks (Demonstration/Viva-voce/Lab records etc.)

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Molecular Cloning: A Laboratory Manual, J. Sambrook, E.F. Fritsch and T. Maniatis, Cold Spring Harbor Laboratory Press, New York,2000
2. Walker J.and Wilson K (2010),PrinciplesandTechniques-PracticalBiochemistry,7th Edition, Cambridge University Press, London.
3. Sawhney, S.K. and Singh R (2005), Introductory Practical Biochemistry, Alpha Science International.
4. Upadhayaye,A;Upadhyaye,KandNathN.(2002),BiophysicalChemistry:Principles & Techniques, Himalaya Publication House, New Delhi.

DSE-4

Session:2024-25			
Part A-Introduction			
Subject	**Biotechnology**		
Semester	**VI**		
Name of the Course	**Medical Microbiology**		
Course Code	**B23-BTY-603**		
Course Type: (CC/MCC/MDC/CC-M /DSEC/VOC/DSE/PC/AEC/VAC)	**DSE-4**		
Level of the course(As per Annexure-I	**300-399**		
Pre-requisite for the course (if any)	NA		
Course Learning Outcomes (CLO): (CLOs 1-4 of theory and 5th of practical)	After completing this course, the learner will be able to: 1. Describe basic principles of medical microbiology, infectious diseases and mechanisms of disease transmission 2. Understand the importance of pathogenic microorganisms in human disease 3. Understand the morphology, pathogenesis, symptoms, laboratory diagnosis, preventive measures and chemotherapy of gram positive and gram negative bacteria. 4. Learn about modes of infections, their prevention and cure. 5. Learn about culturing techniques.		
Credits	Theory	Practical	Total
	3	1	4
Contact Hours/ week	3	2	5
Max. Marks:100 **InternalAssessmentMarks:30**(20Theory+10Practical) **EndTermExamMarks:70**(50Theory+20Practical)		**Time:**3h(theory),4h(practical)	
Part B-Contents of the Course			
Instructions for Paper- Setter Nine questions will be set in all. Question No.1comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Q.No.1 &four others selecting One question from each unit. All questions carry equal marks.			

Unit	Topics	Contact Hours
I	Introduction and history & developments of microbiology, scope of microbiology, general characteristics of prokaryotes and eukaryotes, introduction to bacteriology, mycology, virology and parasitology. Definition, Importance, Principle, Operation and Applications of microscopy. Sterilization and Disinfection: Introduction and its types, principle, procedure and its application, biosafety in microbiology lab.	12
II	Introduction, types of chemotherapeutic agents, mode of action and clinical importance of different chemotherapeutic agents, antibiotic sensitivity tests and its medical importance, multiple drugs resistance and mechanism of drug resistance. Normal microbial flora of the human body, collection and transport of specimens, processing of clinical specimens for microbiological examination.	12
III	Growth kinetics, different types of culture medium, continuous culture and synchronous growth cultures, aerobic & anaerobic cultures, Introduction and its types, various factors affecting the microbial growth Introduction: Normal microflora of human body, nosocomial infections, carriers, septic shock, septicemia, pathogenicity, virulence factors, toxins, biosafety levels.	11
IV	Morphology, pathogenesis, symptoms, laboratory diagnosis, preventive measures and chemotherapy of gram positive bacteria: *S.aureus, B.anthracis, C.tetani, C.botulinum, C.diphtheriae, M.tuberculosis*. Morphology, pathogeneis, symptoms, laboratory diagnosis, preventive measures and chemotherapy caused by gram negative bacteria: *E.coli, N. meningitidis, S. typhi, H. influenzae, V. cholerae, M. pneumoniae.*	10
V*	List of Practical: 1. Introduction, working and sample preparations for light microscopy. 2. Measurement of growth of microbial culture 3. Different biosafety techniques and precautions to be taken in laboratory. 4. Antibiotic sensitivity tests. 5. Isolation of pure culture from given sample.	30

Suggested Evaluation Methods	
Internal Assessment: ➢ Theory-20 Marks • ClassParticipation:5 • Seminar/presentation/assignment/quiz/classtestetc.:5 • Mid-Term Exam: 10 ➢ Practical-10 Marks • Class Participation: • Seminar/Demonstration/Viva-voce/Labrecordsetc.:10 • Mid-Term Exam: NA	**End Term Examination:** Theory: 50 Marks (Written exam); Practical: 20 Marks (Demonstration/Viva-voce/Lab records etc.)

Part C-Learning Resources

Recommended Books/e-resources/LMS:

- Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication.
- Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology. 4th edition. Elsevier.
- Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

DSE-4

Session:2024-25			
Part A-Introduction			
Subject	**Biotechnology**		
Semester	**VI**		
Name of the Course	**Molecular medicine and Gene therapy**		
Course Code	**B23-BTY-604**		
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/ VAC)	**DSE -4**		
Level of the course (As per Annexure-I	**300-399**		
Pre-requisite for the course (if any)	NA		
Course Learning Outcomes(CLO): (CLOs1-4of theory and 5th of practical)	After completing this course, the learner will be able to: 1. Acquire a broad understanding of current molecular medicine and gene therapy including current areas of research. 2. Understand how normal cellular processes change, fail or are destroyed by disease development. 3. Understand the role of stem cells and small molecules used in molecular medicine. 4. Understand the role of gene therapy in particular for genetic diseases and role of modern therapeutics. 5. Understand the online/offline/wet lab protocols involved in molecular medicine and gene therapy related to animal/human cells for use of animals/humans etc.		
Credits	Theory	Practical	Total
	3	1	4
Contact Hours/ week	3	2	5
Max.Marks:100 **InternalAssessmentMarks:30** (20Theory+10 Practical) **EndTermExamMarks:70** (50Theory+20Practical)		**Time:**3h(theory),4h (practical)	

Part B-Contents of the Course		
Instructions for Paper-Setter Nine questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting one question from each unit. All questions carry equal marks.		
Unit	**Topic**	**Contact Hours**
I	**Introduction to Molecular Medicine**: Definition, scope, and historical perspective, Concept of Molecular Medicine? Need, Significance and Limits of Molecular Medicine, Development of Molecular Medicine, Applications of Molecular Medicine for curing human diseases.	10
II	**Molecular Basis of Diseases:** Genetic vs. acquired diseases, Molecular mechanisms underlying common diseases (e.g., cancer and neurodegenerative diseases).Diagnostic Techniques in Molecular Medicine:Polymerase chain reaction (PCR), DNA sequencing, and microarray analysis, Molecular imaging techniques (e.g., PET, MRI).	11
III	**Stems cells and small molecules in Molecular Medicine:** Brief description about stem cells, types of stem cells, Regenerative potential of different stem cell types, Stem cell therapy for neurodegenerative diseases, Cardiac regeneration using stem cells. Small molecules: Importance of small molecules in molecular medicine and drug discovery, role of small molecules in disease treatment.	12
IV	**Gene Therapy: Principles and Applications:** Concept and history of gene therapy. Types of gene therapy: somatic vs. germline, ex vivo vs. in vivo. Vectors for Gene Delivery: Viral vectors (retrovirus, adenovirus, adeno-associated virus). Non-viral vectors (liposomes, nanoparticles). Applications in correcting genetic disorders.Challenges and ethical considerations in gene therapy.	12

V*	**List of practical:** 1. Use online tools or software to simulate Polymerase Chain Reaction (PCR) experiments. 2. Design primers, set PCR conditions, and analyze the results virtually. 3. Perform PCR amplification of a known DNA fragment using genomic DNA as a template. 4. Verify the success of amplification by agarose gel electrophoresis. 5. Transfect cultured cells with a plasmid containing a reporter gene 6. Utilize online bioinformatics tools to analyze DNA or protein sequences. 7. Perform sequence alignment, homology searches, and phylogenetic analysis. 8. Access databases such as NCBI GEO or EMBL-EBI for gene expression data. 9. Use online platforms that simulate molecular cloning techniques. 10. Practice designing cloning experiments, selecting restriction enzymes, and analyzing plasmid maps.	30

Suggested Evaluation Methods

Internal Assessment: ➢ Theory-20 Marks • Class Participation:5 • Seminar/presentation/assignment/quiz/classtestetc.:5 • Mid-TermExam:10 ➢ Practicum-10 Marks • Class Participation: • Seminar/Demonstration/Viva-voce/Labrecordsetc.:10 • Mid-Term Exam: NA	**End Term Examination:** Theory: 50 Marks (Written exam); Practical: 20 Marks (Demonstration/Viva-voce/Lab records etc.)

Part C-Learning Resources

Recommended Books/e-resources/LMS:

1. Jameson, J. L., & Fauci, A. S. (2006). *Principles of Molecular Medicine.* Humana Press.
2. Giacca, M. (2010). *Gene Therapy.* Springer.
3. Trent, R. J. (2005). *Molecular Medicine: An Introductory Text.* Academic Press.
4. Wolfe, T. M., & Lipinski, D. J. (2017). *Gene Therapy: Principles and Applications.* Wiley.
5. Singh, B., Gautam, S.K., Mukesh, M. (2019). *Advances in Animal Biotechnology*. Springer International Publishing
6. Arora, R., & Gupta, P. (2013). *Molecular Medicine: Genomics to Personalized Healthcare.* Elsevier.
7. Lanza, R., Atala, A., & Thomson, J. A. (2009). *Essentials of Stem Cell Biology and Gene Therapy*. Academic Press.
8. Press, O. W. (2002). *Gene Therapy: A Handbook for Physicians.* CRC Press.
9. Cook, R. E. (2008). *Molecular Medicine: An Introduction.* Wiley-Liss.
10. O'Carroll, C. D. (2016). *Gene Therapy: Therapeutic Mechanisms and Strategies.* Academic Press.

DSE-5

<table>
<tr><th colspan="4">Session: 2024-2025</th></tr>
<tr><th colspan="4">Part A - Introduction</th></tr>
<tr><td>Subject</td><td colspan="3">Biotechnology</td></tr>
<tr><td>Semester</td><td colspan="3">VI</td></tr>
<tr><td>Name of the course</td><td colspan="3">Biostatistics</td></tr>
<tr><td>Course Code</td><td colspan="3">B23-BTY-605</td></tr>
<tr><td>Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)</td><td colspan="3">DSE-5</td></tr>
<tr><td>Level of the course (As per Annexure-I)</td><td colspan="3">300-399</td></tr>
<tr><td>Pre-requisite for the course (if any)</td><td colspan="3">NA</td></tr>
<tr><td>Course Learning Outcomes (CLO): (CLOs 1-4 of theory and 5th of practical)</td><td colspan="3">After completing this course, the learner will be able to:
1. To understand basic principles of probability and statistics.
2. To apply statistical methods for analyzing biological data.
3. To interpret and communicate statistical results effectively.
4. To critically evaluate statistical methods used in biological research.
5. To design experiments and studies using appropriate statistical techniques.</td></tr>
<tr><td rowspan="2">Credits</td><td>Theory</td><td>Practical</td><td>Total</td></tr>
<tr><td>3</td><td>1</td><td>4</td></tr>
<tr><td>Contact Hours/ week</td><td>3</td><td>2</td><td>5</td></tr>
<tr><td>Max. Marks: 100
Internal Assessment Marks: 30 (20 Theory + 10 Practical)
End Term Exam Marks:70 (50 theory + 20 Practical)</td><td colspan="3">Time: 3h (theory), 4h (practical)</td></tr>
<tr><th colspan="4">Part B - Contents of the Course</th></tr>
</table>

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Statistics, its meaning and objectives. Population samples, frequency tables and their graphs, measures of central tendency (mean, mode, median) and their dispersion.	10
II	Concepts of moments, Skewness and kurtosis, Intuitive definition of random variables, probability mass function and probability density function, expectation and variance. Standard distribution ; binomial , Poisson and normal distribution with their important properties and significance.	12
III	Fitting of main distributions and testing of goodness –of – the –fit with special reference to $\chi 2$- test, t –test, Z-test. Fitting of trends; linear and quadratic with least square method	12
IV	Lines of regression, coefficient of correlation, coefficient of variation and their significance. Analysis of variance; one way and two way classification. Learn applications of statistics in the field of biology	11
V	**List of Practicals :** 1: Measurement and Sampling 2: Frequency Distributions 3: Summary Statistics 4: Probability 5: Introduction to Estimation 6: Introduction to Hypothesis Testing 7: Paired Samples 8: Independent Samples	30

Suggested Evaluation Methods

Internal Assessment:	**End Term Examination:**
Theory 20 Marks ➢ Class Participation: 5 ➢ Seminar/presentation/assignment/quiz/class test etc.: 5 ➢ Mid-Term Exam: 10 Practicum 10 Marks ➢ Class Participation: ➢ Seminar/ Demonstration/ viva/ Lab records etc.: 10 ➢ Mid-Term Exam: NA	Theory: 50 Marks (Written exam); Practical: 20 Marks (Demonstration/Viva-voce/Lab records etc.)

Part C- Learning Resources

Recommended Books/ e-resources/ LMS:

1. Biostatistics; Arora PN, Malhotra PK, Himalaya Publishing House.
2. Introduction to Biostatistics; Sokal S & Rohit S, Toppan Publication.

DSE-5

Session: 2024-2025			
Part A - Introduction			
Subject	**Biotechnology**		
Semester	**VI**		
Name of the course	**Bio-entrepreneurship**		
Course Code	**B23-BTY- 606**		
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	**DSE-5**		
Level of the course (As per Annexure-I)	**300-399**		
Pre-requisite for the course (if any)	NA		
Course Learning Outcomes (CLO): (CLOs 1-4 of theory and 5th of practical)	After completing this course, the learner will be able to: 1. Exhibit the knowledge of structure, management and role of innovations in an organization 2. Discuss the government schemes for commercialization of biotechnology 3. Describe various elements of operational research and management, Compare and analyse the characteristics of biotech enterprises 4. Various parameters of quality control and government regulations. 5. Analyse personality and ability as an entrepreneur by different type of assessment tests. Plan and analyse the requirement and status of Biotech industry		
Credits	Theory	Practical	Total
	3	1	4
Contact Hours/ week	3	2	5
Max. Marks: 100 **Internal Assessment Marks: 30** (20 Theory + 10 Practical) **End Term Exam Marks: 70** (50 Theory + 20 Practical)	**Time:** 3h (Theory), 4h (practical)		

Part B - Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Creativity & Entrepreneurial personality and Entrepreneurship in Biotechnology Organizational structure & Management. Capital Management. Product innovation and management. Government schemes for commercialization of technology (Eg. Biotech Consortium)	10
II	Basics of production management: Methods of manufacturing-Project/Jobbing, Batch. Production, Flow/Continuous production, process production-Characteristics of each method. Plant location-Importance, Factors affecting location, factory Building, Plant layout-Installation of Facilities.	12
III	Operational Research: Linear Programming, PERT and CPM; Production Planning and Control-Scheduling- Gantt Charts-Documentation-Production Work Order. Kaizen (Continuous improvement in product & management) Biotech enterprises: Small, Medium and Large.	12
IV	Quality control in Biotech industries. Govt. regulations for biotech products Public policy, regulatory and ethical challenges facing the biotechnology Entrepreneurship. Business development for medical products	11

V*	List of Practical: 1. To analyze your entrepreneurial personality and creativity 2. To analyze your entrepreneurial potential by performing online Bill Wager's self assessment test. 3. To analyze your personality type by performing online Jung & Myer Brigg's assessment test. 4. To analyze personality type by performing online DISC self assessment test. 5. To make a business plan. 6. To study Biotech Enterprises	30

Suggested Evaluation Methods

Internal Assessment:	**End Term Examination:**
➢ Theory-20 Marks •Class Participation: 5 •Seminar/presentation/ assignment/ quiz/ class test etc.:5 •Mid-Term Exam: 10 ➢ Practicum -10 Marks •Class Participation: •Seminar/ Demonstration/ Viva-voce/ Lab records etc.:10 •Mid-Term Exam: NA	Theory: 50 Marks (Written exam); Practical: 20 Marks (Demonstration/Viva-voce/Lab records etc.)

Part C- Learning Resources

Suggested Reading

1. Holt DH. Entrepreneurship: New Venture Creation.
2. Kaplan JM Patterns of Entrepreneurship.
3. Gupta CB, Khanka SS. Entrepreneurship and Small Business Management, Sultan Chand &Sons. Innovation and Entrepreneurship in Biotechnology: Concepts, Theories &Cases;
4. Hyne D and Kapeleris J. Entrepreneurship in Biotechnology: Managing for growth from start-up; Martin Gross Mann.
5. Best Practices in Biotechnology Education; Friedman Y, Logos Press.

CC-H1

Session: 2025-26	
Part A-Introduction	
Subject	**Biotechnology**
Semester	**VII**
Name of the Course	**Recombinant DNA Technology-II**
Course Code	**B23-BTY-701**
Course Type: (CC/MCC/MDC/CC-M /DSEC/VOC/DSE/PC/AEC/VAC)	**CC-H1**
Level of the course (As per Annexure-I	**400-499**
Pre-requisite for the course(if any)	NA
Course Learning Outcomes(CLO):	After completing this course, the learner will be able to: 1. Understand about gene library and their types along with diverse procedures required for selection of rDNA clones and their expression products. 2. Understand the concept of mutagenesis, types and their impact on gene modification 3. Learn about different approaches to be used for studying gene expression, its regulation. 4. Know applications of rDNA technology including in medical care and food industry
Credits	4
Contact Hours/ week	4

Max. Marks: 100 Internal Assessment Marks: 30 End Term Exam Marks: 70	Time: 3h

Part B-Contents of the Course		
Instructions for Paper- Setter Nine questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting one question from each unit. All questions carry equal marks.		
Unit	**Topics**	**Contact Hours**
I	**Genomic and cDNA library**: Gene library, types and Applications, Making genomic and cDNA libraries in plasmids and phages. PCR product cloning (TA cloning), cDNA synthesis strategies – Linkers – Adapters – Homopolymer tailing; Properties of cDNA, mRNA enrichment **Site Directed Mutagenesis:** Oligonucleotide directed mutagenesis, PCR amplified oligonucleotide directed mutagenesis, Random mutagenesis with degenerate oligonucleotide primers / nucleotide analogs. Deletion mutagenesis, Applications.	16
II	**Selection of rDNA clones and their expression products**: Direct and indirect methods. Drug resistance, gene inactivation, DNA hybridization, Colony and Plaque hybridization, In-situ hybridization (Southern, Northern and Dot blots and immunological techniques Western blotting), Subtractive hybridization; Protein-Protein interactions - Phage display, Yeast two hybrid system. **Gene expression and Regulation studies:** Primer extension, S1 mapping, RNase protection assay, Gel retardation assay, Deletion analysis, Reporter genes, DNA foot printing.	15

III	**Manipulation of recombinant gene expression in Prokaryotes:** Problems with production of recombinant proteins in *E coli*, Optimizing expression of foreign genes in *E.coli*- Strong and regulatory promoters, Codon usage, Fusion proteins, Increasing protein stability and secretion, Translation expression vectors, Protease deficient host strains.	14
IV	**Heterologous protein production in Eukaryotes:** *Saccharomyces cerevisiae* and *Pistia pastoris* expression systems, Baculovirus Insect cell expression systems, Mammalian cell expression system, CRE LOX system and CRISPR/Cas9 **Applications of rDNA technology**: Diagnostics; Pathogenesis; Genetic diversity; Therapeutic proteins-Vaccines. Molecular probes (Production, labeling and uses)	15

Suggested Evaluation Methods

Internal Assessment: 30 Marks • Class Participation:5 • Seminar/presentation/ assignment/ quiz/ class test etc.: 10 • Mid-Term Exam: 15	**End Term Examination:** 70 Marks

Part C- Learning Resources

Recommended Books/ e-resources/ LMS:

1. Gene cloning and DNA analysis – An Introduction (2006) 5th edition, T. A Brown, Blackwell publisher.
2. Essential genes (2006), Benzamin Lewin, Pearson education international.
3. Genome-3 (2007) T. A Brown. Garland science, Taylor & Francis, NewYork.
4. Principles of gene manipulation and Genomics (2006) 7th edition, S.B Primose and R.M Twyman, Blackwell publishing.

CC-H2

Session: 2025-26	
Part A- Introduction	
Subject	**Biotechnology**
Semester	**VII**
Name of the Course	**Pharmaceutical Biotechnology**
Course Code	**B23- BTY- 702**
Course Type:(CC/MCC/ MDC/CC-M /DSEC/VOC/DSE/PC/AEC/ VAC)	**CC-H2**
Level of the course (As per Annexure-I	**400-499**
Pre-requisite for the course (if any)	NA
Course Learning Outcomes (CLO):	After completing this course, the learner will be able to: 1. Learn the fundamental biotechnological techniques used in pharmaceutical research and development. 2. Apply biotechnological tools to design and produce novel pharmaceutical products. 3. Understand the regulatory requirements and ethical considerations in pharmaceutical biotechnology. 4. Proficient in critically analyzing current trends and challenges in the field of pharmaceutical biotechnology.
Credits	4
Contact Hours/ week	4
Max. Marks: 100 **Internal Assessment Marks: 30**	**Time:3h**

End Term Exam Marks: 70	

Part B- Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No.1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting one question from each unit. All questions carry equal marks.

Unit	Topic	Contact Hours
I	**Introduction to Pharmaceutical Biotechnology: O**verview of the principles and applications of biotechnology in the pharmaceutical industry. Fundamentals of biopharmaceutical production processes. Biotechnology in drug discovery, development, and production. Regulatory frameworks governing the biopharmaceutical sector.	15
II	**Biopharmaceutical Product Development:** Development of biopharmaceutical products, including monoclonal antibodies, therapeutic proteins, and gene therapies. Design and engineering of biologics, as well as the optimization of production processes for large-scale manufacturing. Quality control, validation, and regulatory requirements for biopharmaceutical development.	15
III	**Bioprocessing and Manufacturing:** Bioprocessing techniques and manufacturing strategies used in the production of biopharmaceuticals. Cell culture methods, downstream processing, purification techniques, and formulation considerations.	15

IV	**Advanced Topics in Pharmaceutical Biotechnology:** Emerging trends in pharmaceutical biotechnology. Recent developments in areas such as personalized medicine, gene editing technologies, and the development of biosimilars. Ethical considerations, regulatory challenges, and future directions in Pharmaceutical Biotechnology.	15

Suggested Evaluation Methods

Internal Assessment: 30 Marks • Class Participation:5 • Seminar/ presentation/ assignment/ quiz/ class test etc.: 10 • Mid-TermExam:15	**End Term Examination:** 70 Marks

Part C-Learning Resources

Recommended Books/ e-resources/ LMS:

1. Glick, B. R., & Pasternick, J. J. (2010). *Molecular Biotechnology.* ASM Press.
2. Dey, G., & Chatterjee, J. (Eds.). (2022). *Pharmaceutical Biotechnology: Principles and Applications.* CRC Press.
3. Singh, S. (Ed.). (2021). *Advances in Pharmaceutical Biotechnology.* Academic Press.
4. Ratledge, C., & Kristiansen, B. (Eds.). (2021). *Pharmaceutical Biotechnology: Concepts and Applications.* Wiley.
5. Gupta, P. K., & Sharma, G. (Eds.). (2020). *Recent Advances in Pharmaceutical Biotechnology.* Springer.
6. Singh, B., Gautam, S.K., Mukesh, M. (2019). *Advances in Animal Biotechnology*. Springer International Publishing
7. Gad, S. C. (Ed.). (2020). *Handbook of Pharmaceutical Biotechnology.* Wiley.
8. Gaur, R., & Sharma, A. K. (Eds.). (2019). *Pharmaceutical Biotechnology: Fundamentals and Applications.* Springer.
9. Jain, K. K. (2020). *Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs.* Wiley.
10. Singh, R. S., & Upadhyay, S. K. (Eds.). (2021). *Biotechnology for Pharmaceutical Industries: Perspectives and Challenges.* Elsevier.

CC-H3

Session: 2025-26	
Part A-Introduction	
Subject	**Biotechnology**
Semester	**VII**
Name of the Course	**Molecular Cell Biology**
Course Code	**B23-BTY-703**
Course Type: (CC/MCC/MDC/CC-M /DSEC/VOC/DSE/PC/AEC/VAC)	**CC-H3**
Level of the course (As per Annexure-I	**400-499**
Pre-requisite for the course (if any)	NA
Course Learning Outcomes (CLO):	After completing this course, the learner will be able to: 1. Acquire the knowledge and understanding of the fundamentals of molecular process of life. 2. Analyse architecture of the genomes, genes, and the flow of genetic information through replication, transcription, translation. 3. Correlate between signal molecules and their role in various cellular activities. 4. Understand the genetic basis & causes of cancer and application of molecular biology to cancer prevention and treatment.
Credits	4
Contact Hours/ week	4

Max. Marks:100 **Internal Assessment Marks:30** **End Term Exam Marks: 70**	**Time: 3h**

Part B-Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting one question from each unit. All questions carry equal marks.

Unit	**Topics**	**Contact**

		Hours
I	Origin and evolution of cells, Cells as experimental models, tools of cell biology. Heredity, Genes, and DNA, Expression of Genetic Information, Recombinant DNA, Detection of Nucleic Acids and Proteins	15
II	Nuclear envelope and traffic between the nucleus and cytoplasm, internal organization of the nucleus, nucleolus, nucleus during mitosis. Protein Sorting and Transport: Endoplasmic reticulum, Golgi apparatus, and Lysosomes, mechanism of vesicular transport. DNA polymerases, replication fork, fidelity of replication, origins and initiation of replication, replication at the ends of chromosomes.	15
III	Nonsense, missense, frameshift and point mutations; intragenic and intergenic suppression. Direct reversal of DNA damage, excision repair, error-prone repair, recombinational repair. Prokaryotic transcription, Eukaryotic transcription: RNA polymerases and transcription factors, model systems of transcriptional control: lac operon, trp operon lambda phage; promoters, enhancers, repressors.	15
IV	Signaling molecules and their receptors, functions of cell surface receptors, pathways of intracellular signal transduction, signal transduction and cytoskeleton, Developmental abnormalities due to defective signaling pathways, Signal transducing machinery as targets for potential drugs. Development and causes of cancer, tumour viruses, oncogenes, tumour suppressor genes, application of molecular biology to cancer prevention and treatment.	15

Suggested Evaluation Methods

Internal Assessment: 30 Marks • Class Participation:5 • Seminar/ presentation/ assignment/ quiz/ class test etc.: 10 • Mid-Term Exam: 15	**End Term Examination:** 70 Marks

Part C- Learning Resources

Recommended Books/ e-resources/ LMS:

1. Molecular Biology of the Cell, Alberts, B., Johnson, A., Lewis J., Raff, M., Roberts, K., and Walter, P., Garland Science Publishing (2008).
2. The world of the Cell, Becker, W.M., Klein smith, L.J. and Hal din, J., Seventh Edition, Pearson Education (2008).
3. The Cell - A Molecular Approach (sixth edition) Cooper, Geoffrey M. Sunderland (MA): Sinauer Associates, Inc.;c2013
4. Cell and Molecular Biology: Concepts and Experiments, 5th Edition, Gerald Karp: Wiley 2007

DSE-H1

Session: 2025-2026	
Part A - Introduction	
Subject	Biotechnology
Semester	VII
Name of the course	**Molecular diagnostics**
Course Code	**B23-BTY- 704**
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	**DSE-H1**
Level of the course (As per Annexure-I)	**400-499**
Pre-requisite for the course (if any)	NA
Course Learning Outcomes (CLO):	After completing this course, the learner will be able to: 1. Know about uses of enzymes and antibodies (monoclonal & polyclonal) for diverse immunoassays and their applications in medical diagnostic purpose 2. Gain the knowledge of various molecular approaches (PCR, RFLP etc) and chemotherapy tests which can be used in clinical testing. 3. Explain about automation in microbial diagnosis and other rapid diagnostic approaches. 4. Concept of idiotypes. Describe various diagnostic tools which can help to study in details about cell biology such as RIA, immunoflorescence, chromatrography, microscopy etc and associated with medical science.
Credits	4
Contact Hours/ week	4
Max. Marks: 100 **Internal Assessment Marks: 30** **End Term Exam Marks: 70**	**Time: 3h**

Part B - Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Enzyme Immunoassays**: Comparison of enzymes available for enzyme immunoassays, conjugation of enzymes. Solid phases used in enzyme immunoassays. Homogeneous and heterogeneous enzyme immunoassays. Enzyme immunoassays after immuno blotting. **Enzyme immuno histochemical techniques**: Use of polyclonal or monoclonal antibodies in enzymes immuno assays. Applications of enzyme immunoassays in diagnostic microbiology.	16
II	**Molecular methods in clinical microbiology:** Applications of PCR, RFLP, Nuclear hybridization methods, Single nucleotide polymorphism and plasmid finger printing in clinical microbiology	14
III	**Laboratory tests in chemotherapy**: Susceptibility tests: Micro-dilution and macro-dilution broth procedures. Susceptibility tests: Diffusion test procedures. Susceptibility tests: Tests for bactericidal activity. Automated procedures for antimicrobial susceptibility tests. **Automation and rapid diagnostic approach**: Automation in microbial diagnosis, rapid diagnostic approach including technical purification and standardization of antigen and specific antibodies.	16
IV	**Idiotypes and immunodiagnostic:** Concepts and methods in idiotypes. Anti-idiotypes and molecular mimicry and receptors. Epitope design and applications. Immunodiagnostic tests-Immuno florescence. Radioimmunoassay.	14

	Diagnostic tools: GLC, HPLC, Electron microscopy, flow cytometry and cell sorting.	

Suggested Evaluation Methods

Internal Assessment: 30 Marks • Class Participation:5 • Seminar/ presentation/ assignment/ quiz/ class test etc.: 10 • Mid-Term Exam: 15	**End Term Examination:** 70 Marks

Part C- Learning Resources

Suggested Reading

1. Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker
2. Bioinstrumentation, Webster
3. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van Impe, Kluwer Academic
4. Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ).University Press Publication.
5. Brooks GF, Carroll KC, Butel JS and Morse SA.(2007). Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication.
6. Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology. 4th edition. Elsevier.
7. Joklik WK, Willett HP and Amos DB (1995). Zinsser Microbiology. 19th edition. Appleton Centuary-Crofts publication.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.
9. Microscopic Techniques in Biotechnology, Michael Hoppert

DSE-H1

Session: 2025-2026	
Part A - Introduction	
Subject	Biotechnology
Semester	VII
Name of the course	Biotechnology in Environment Protection
Course Code	**B23-BTY- 705**
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	**DSE-H1**
Level of the course (As per Annexure-I)	**400-499**
Pre-requisite for the course (if any)	NA
Course Learning Outcomes (CLO):	After completing this course, the learner will be able to: 1. Have an overview of the developments in the field of environmental biotechnology with special emphasis on the role of microbes in mitigating environment pollution as well as potability of water and its quality control. 2. Describe the role of microbes in solid and liquid waste management, gaining knowledge of various methods employed in sewage treatment and solid waste treatment. 3. Understand the role of microbes in bioremediation of environmental pollutants and also utility of microbes in mineral and oil recovery. 4. Understand applications of biotechnology in environment monitoring
Credits	4
Contact Hours/ week	4
Max. Marks: 100 **Internal Assessment Marks: 30** **End Term Exam Marks: 70**	**Time: 3h**
Part B - Contents of the Course	

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	**Environmental Biotechnology:** An overview, concept, scope and market Biological control of air pollution. Bacterial examination of water for potability. Testing of water for physiochemical parameters including BOD & COD. Solid waste: Sources and management (composting, vermicomposting and methane production).	12
II	**Waste water:** Origin, composition and treatment. Physical, chemical and biological treatment of waste water. Aerobic processes: activated sludge, oxidation ponds, trickling filter towers, and rotating discs. Anaerobic processes: anaerobic digesters, anaerobic filters and up flow sludge blanket reactors. Microbiology and biochemistry of aerobic and anaerobic waste water treatment processes. **Treatment of industrial effluents:** distillery effluent, paper and pulp mill effluent, tannary effluent, textile dye effluent, removal of heavy metals from waste waters.	18
III	**Bioremediation:** Introduction of Bioremediation; advantages and applications; Types of bioremediation, Natural (attenuation), Ex-situ and In-situ, Bioaugmentation and biostimulation, Solid phase and slurry phase bioremediation. **Biodegradation**: Aerobic vs. anaerobic Degradation; Microbial basis of Biodegradation; Biodegradation of Xenobiotics; Microbial degradation of pesticides **Biotechnological methods of pollution detection:** General bioassays in pollution monitoring, cell biology in environmental monitoring, molecular biology in environmental monitoring and biosensors in environmental analysis.	18
IV	**Microbial Insecticides:** Bacteria, fungi and viruses. Use of R-DNA technology to enhance the efficacy microbial insecticides. Biofertilizers, Microbes in oil recovery and bioleaching. Biodeterioration of stored plant food materials,	12

	leather, wool, metals, textiles, stone & related building. Control of microbial biodeterioration.	

Suggested Evaluation Methods

Internal Assessment: 30 Marks •Class Participation: 5 •Seminar/ presentation/ assignment/quiz/ class test etc.: 10 •Mid-Term Exam: 15	**End Term Examination:** 70 Marks

Part C- Learning Resources

Suggested Reading

1. Environmental Biotechnology: Principles and Applications, Second Edition (2020). By Bruce E. Rittman, Perry L. McCarty. Pub. Mc GrawHills
2. Introduction to Biodeterioration. D. Allsopp and K.J. Seal, ELBS/ Edward Arnold.
3. Advanced Environmental Biotechnology by S.K. Agarwal. APH Publishing, New Delhi, (2005).
4. Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development. By Jeyabalan Sangeetha, Devarajan Thangadurai, Muniswamy David, Mohd Azmuddin Abdullah (2016) Pub. Apple Academic Press
5. Environmental Science and Technology. Stankey E.M. (1997), Lewis Publishers, New York.
6. Microbial Biotechnology: Basic Research and Applications (2020). Edit. Singh *et al.* Pub. Springer
7. Biodegradation and Bioremediation: Soil Biology. Singh A. and Ward O.P. (2004), Springer

PC-H1

Session: 2025-2026	
Part A - Introduction	
Subject	Biotechnology
Semester	VII
Name of the course	Practical based on B23-BTY-701 TO 704/705
Course Code	B23-BTY-706
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	PC- H1
Level of the course (As per Annexure-I)	400-499
Pre-requisite for the course (if any)	NA
Course Learning Outcomes (CLO):	After completing this course, the learner will be able to: 1. Exhibit the skill to study any damage and mutations in the isolated DNA 2. Understand the online/ offline/ wet lab protocols involved in Pharmaceutical Biotechnology for developing pharmaceutical products. 3. Understand different essential processes of cell. 4. Students will able to use different diagnostic tools. Learn practical knowledge to test the potability of water samples and imbibe the value of team spirit while working together during practical sessions.
Credits	4
Contact Hours/ week	8
Max. Marks: 100 Internal Assessment Marks: 30 End Term Exam Marks:70	Time: 6h

Part B - Contents of the Course	**Contact Hours**
Practicals based on B23-BTY- 701 1. To study *in vitro* DNA damage and analysis by agarose gel electrophoresis by using either purified DNA or plasmid. 2. Designing primers for PCR using online tools. 3. To study mutagenesis concept by using cancer-causing agents	Total - 120 (30 per course)

4. Perform any method to be used for the selection of recombinant DNA clone
5. Gene expression in *E. coli* and analysis of gene product
6. Demonstration about Mammalian cell expression system with uses of CRE-LOX system
7. Demonstration about Mammalian cell expression system with uses of CRISPR/Cas9 system

Practicals based on B23-BTY- 702

1. To characterize the physical properties of biopharmaceuticals.
2. To purify a recombinant protein from a cell culture supernatant using downstream processing techniques.
3. To perform protein concentration experiment.
4. To perform protein purification experiment.
5. Characterization of proteins using methods such as SDS-PAGE or Western blotting.
6. Culturing of mammalian cells in the laboratory using cell culture techniques.
7. Maintenance of cell lines.
8. Scale-up cultures, and operate bioreactors for large-scale production of biopharmaceuticals.
9. Protein purification techniques such as:- affinity chromatography, ion exchange chromatography, gel filtration.

Practicals based on B23-BTY- 703

1. To study DNA amplification via PCR/cloning.
2. To study reverse mutation.
3. To demonstrate the mechanism of oncogenes and tumour suppressing genes.
4. To demonstrate the process of cell signaling.

Practicals based on B23-BTY- 704

1. Perform Immunoblotting by using housekeeping gene product
2. Perform Nucleic acid based PAGE
3. Perform Column Chromatography (any) and demonstrate about GLC/HPLC.
4. Perform PCR based diagnosis of human/plant pathogen
5. Perform Rapid Diagnostic Assay (as per availability)
6. Determination of MIC of streptomycin against *E.coli* by broth method
7. Demonstrate Nucleic acid labeling and Southern Hybridization
8. Demonstrate flow cytometery

Or Practicals based on B23-BTY- 705

1. To determine TDS, DO, COD, BOD of given water sample. 2. Total bacterial population of given samples of water by standard plate count technique (SPC) 3. To check the potability of given water sample. 4. To check the presence of coliform in given water sample by Multiple- tube fermentation test or most probable number test (Presumptive, confirmed and completed test) 5. To check the presence of coliforms using membrane filter method.	

Suggested Evaluation Methods

Internal Assessment: 30 marks • Class Participation: 5 • Seminar/ Demonstration/ Viva-voce/Lab records etc.: 10 • Mid-Term Exam: 15	**End Term Examination:** 70 Marks **(**Demonstration/ Viva-voce/Lab records etc.**)**

Part C- Learning Resources

Recommended Books/e-resources/LMS:

5. Principles of gene manipulation and Genomics (2006) 7th edition, S.B Primose and R.M Twyman, Blackwell publishing.
6. Jain, K. K. (2020). *Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs.* Wiley.
7. Singh, R. S., & Upadhyay, S. K. (Eds.). (2021). *Biotechnology for Pharmaceutical Industries: Perspectives and Challenges.* Elsevier.
8. Cell and Molecular Biology: Concepts and Experiments, 5th Edition, Gerald Karp: Wiley2007
9. Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker
10. Bioinstrumentation, Webster
11. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van Impe, Kluwer Academic
12. Microbial Biotechnology: Basic Research and Applications (2020). Edit. Singh *et al.* Pub. Springer
13. Biodegradation and Bioremediation: Soil Biology. Singh A. and Ward O.P. (2004), Springer

CC-H4

Session: 2025-26	
Part A- Introduction	
Subject	**Biotechnology**
Semester	**VIII**
Name of the Course	***In vitro* culture techniques-Animal**
Course Code	**B23-BTY-801**
Course Type: (CC/MCC/MDC/CC-/DSEC/VOC/DSE/PC/AEC/ VAC)	**CC-H4**
Level of the course (As per Annexure-I	**400-499**
Pre-requisite for the course (if any)	NA
Course Learning Outcomes (CLO):	After completing this course, the learner will be able to: 1. Learn the fundamental principles and techniques in animal cell culture. 2. Learn media preparation, sterile handling, and sub culturing methods of Animal Cell Culture. 3. Ability to characterize and authenticate cell lines using molecular and phenotypic assays, ensuring reproducibility and reliability of experimental results. 4. Understanding of the diverse applications of animal cell culture in biopharmaceutical production, tissue engineering, and drug discovery.
Credits	4

Contact Hours/ week	4

Max. Marks:100 **Internal Assessment Marks:30** **End Term Exam Marks: 70**	**Time: 3h**

Part B-Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting one question from each unit. All questions carry equal marks.

Unit	Topic	Contact Hours
I	**Introduction to Animal Cell Culture:** Overview of animal cell culture techniques, history, principles, and applications of cell culture in biomedical research and biotechnology. Cell laboratory layout and safety procedures, equipment used in animal cell culture, cell culture sterility, aseptic techniques	15
II	**Culture Media:** Defined media and supplements. Physicochemical properties of media. Role of antibiotics. Balanced salt solutions. Complete media. Role of serum in media. Serum free media: Advantages and disadvantages of serum free media. Protein free media.	15
III	**Primary Culture and Sub-culturing:** Requirement for primary culture. Multiple paths to obtain cell lines. Primary explant culture. Warm and cold disaggregation techniques by trypsin and collagenase. Mechanical disaggregation techniques. Sub-culturing of cells: Monolayer and Stirrer techniques.	15

IV	**Characterization of animal cells:** Cell surface antigens, Intermediate filament proteins, differentiated products and functions, enzymatic markers, chromosome analysis, DNA content: DNA profiling and fingerprinting, Enzyme activity. **Applications of Animal Cell Culture**: production of therapeutic products using animal cell culture.	15

Suggested Evaluation Methods

Internal Assessment: 30 Marks • Class Participation: 5 • Seminar/presentation/ assignment/ quiz/ class test etc.: 10 • Mid-Term Exam:15	**End Term Examination:** 70 Marks

Part C- Learning Resources

Recommended Books/ e-resources/ LMS:

1. Freshney, R. I. (2016). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (7th ed.). Wiley.
2. Masters, J. R. W., & Palsson, B. O. (Eds.). (2019). *Human Cell Culture Protocols (4th ed.*). Humana Press.
3. Birnbaum, S., & Alves, P. M. (Eds.). (2020). *Animal Cell Biotechnology: Methods and Protocols*. Springer.
4. Singh, B., Gautam, S.K., Mukesh, M. (2019). *Advances in Animal Biotechnology*. Springer International Publishing
5. Harding, S. E., & Adams, G. G. (Eds.). (2018). *Animal Cell Culture (1st ed.).* Humana Press.
6. Flickinger, M. C., & Drew, S. W. (Eds.). (2017). *Cell Culture Technology for Pharmaceutical and Cell-Based Therapies (1st ed*.). CRC Press.
7. Doyle, A., & Griffiths, J. B. (Eds.). (2016). *Cell and Tissue Culture: Laboratory Procedures in Biotechnology (1st ed.*). John Wiley & Sons.
8. Butler, M. (Ed.). (2018). *Animal Cell Culture and Technology*. Humana Press.
9. Picot, J., & Guerin, C. L. (Eds.). (2018). *Cell and Tissue Culture: Laboratory Procedures in Biotechnology (1st ed.)*. Academic Press.
10. Hewitt, N. (Ed.). (2017). *Animal Cell Culture*. Springer.

CC-H5

Session: 2025-2026	
Part A - Introduction	
Subject	Biotechnology
Semester	VIII
Name of the course	*In vitro* culture techniques- Plant
Course Code	B23-BTY-802
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	CC- H5
Level of the course (As per Annexure-I)	400-499
Pre-requisite for the course (if any)	NA
Course Learning Outcomes (CLO):	After completing this course, the learner will be able to: 1. Understand the concepts, applications and recent theoretical knowledge of tools and techniques related to cell cultures and different modes of *in vitro* regeneration. Know how to develop and establish a PTC laboratory for small scale to industrial level. 2. Attain knowledge about production of novel hybrid plants and their significance in agriculture and plant breeding. They would be able to launch start-ups and become entrepreneurs for various products and processes related to plant tissue culture. 3. Understand bio-safety measures related to plant tissue culture techniques. 4. Communicate and write effectively on scientific principles and ideas in the field of plant tissue culture.
Credits	4

Contact Hours/ week	4
Max. Marks: 100 Internal Assessment Marks: 30 End Term Exam Marks: 70	Time: 3h

Part B - Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	Introduction to plant cell tissue culture and historical perspective. Laboratory organization setup (R & D level and industrial level); Aseptic manipulations and bio-safety aspects; development/formulation of culture media (components, preparation). Types of culture. Callus culture: characteristics, significance and limitations; Initiation and maintenance of cell cultures: techniques of single cell culture, suspension culture, Organogenesis and factors influencing organogenesis. Somatic embryogenesis: process of somatic embryos production, factors influencing and its importance in plant breeding and propagation. Production of synthetic seeds.	18
II	Large scale plant micropropagation – technique, factors affecting *in vitro* culture of plants (physical, chemical, genotypic and others), applications and limitations of micropropagation. Meristem, shoot tip culture, production and indexing of virus free plants. Somaclonal variations, molecular basis of variation and their significance in plant breeding.	15
III	*In vitro* production of haploid plants – Androgenesis (anther and pollen culture) and Gynogenesis, Factors affecting androgenesis, ontogeny of androgenesis, diploidization of haploid plants. Significance and uses of haploids in agriculture. Wide hybridization and embryo rescue technique.	12
IV	Protoplast culture and somatic hybridization – Isolation, culture and fusion of protoplast, selection of fusion products, assessment of	15

	somatic hybrid plants, production of cybrids, applications of protoplast culture and somatic hybridization in the improvement of crop plants. *In vitro* germplasm conservation and cryopreservation.	

Suggested Evaluation Methods

Internal Assessment: 30 marks ➢ Class Participation: 5 ➢ Seminar/ presentation/ assignment/ quiz/ class test etc.:10 ➢ Mid-Term Exam: 15	**End Term Examination:** 70 marks

Part C- Learning Resources

Recommended Books/ e-resources/ LMS:

1. Plant tissue culture–Theory and Practice (2005)by Bhojwani S.S. and Razdan M.K., Elsevier publication.
2. Elements of Biotechnology by P. K. Gupta, 4th Reprint (2nd Edition): 2019-2020, Rastogi pub.
3. Introduction to Biotechnology (2009) by H. S. Chawla, 3rd edition, Science publishers, USA
4. Plant cell, organ and tissue culture (1995) by Gamborg O. L. and Phillips G.C., Springer Verlag pub. Germany.
5. Plant Tissue Culture – Basic & Applied (2005) by Jha T.B. & Ghosh B., Universities press.
6. Plant cell culture – A practical approach (1994) Dixon R.A., Gonzales R.A. Oxford University press, UK.
7. Bhojwani S.S. (2003), Agrobiotechnology & Plant Tissue Culture
8. Smith R.H. (2000), Plant Tissue Culture, Academic Press
9. Evans D.A. (2003), Plant Cell Culture, Taylor &Francis.

CC-H6

Session: 2025-2026	
Part A - Introduction	
Subject	Biotechnology
Semester	VIII
Name of the course	Enzyme Technology
Course Code	B23-BTY-803
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	CC-H6
Level of the course (As per Annexure-I)	400-499
Pre-requisite for the course (if any)	NA
Course Learning Outcomes (CLO):	After completing this course, the learner will be able to: 1. Understand and analyse the importance of enzymes, their salient features & categories of enzymes and exhibit the knowledge of enzyme activity- specific activity calculation, correlate the structural framework with catalytic power of enzyme. 2. Describe what enzymes do and how they do and their regulation in the living system. 3. Describe and analyse the factors affecting enzyme activity, exhibit the knowledge of enzyme kinetics, & describe different types of enzyme inhibitions. 4. Judge the scope and importance of enzymes in various sectors, understand the various strategies for the production-purification of enzymes, and the techniques to modify and increase the stability and reusability of enzymes.
Credits	4
Contact Hours/ week	4
Max. Marks: 100 Internal Assessment Marks: 30 End Term Exam Marks: 70	Time: 3h

Part B - Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	Topics	Contact Hours
I	General characteristics of enzymes; advantages of enzymes over chemical catalysts. Determination of three-dimensional structure of enzyme by X-ray crystallography and NMR spectrometry, importance of 3-D structure of an enzyme; Classification of enzyme structures, structures adopted by enzymes, principles that govern the 3-D structure adopted by enzymes; Forces for stability of 3-D structure; Denaturation and renaturation; cofactors and mode of action, prosthetic group, enzyme specificity, isoenzymes and multienzyme complex, enzyme activity unit, turn over number and specific activity.	15
II	Enzyme action; effect of enzyme on the rate and equilibrium of a reaction; principles that explain catalytic power and substrate specificity of enzymes; enzyme substrate complex(Lock & Key Model, Induced Fit Theory, Substrate Strain Theory), factors responsible for catalytic efficiency of enzyme; proximity and orientation effect, acid-base catalysis, covalent catalysis, strain and distortion theory; Nature of active site, identification of functional groups at active sites; regulatory enzymes- covalently modulated enzymes, allosteric enzymes and their mode of action; regulation of enzyme activity in the living system.	15
III	An introduction to enzyme kinetics and its importance, Methods used for investigating the kinetics of enzyme catalysed reactions; factors that influence the velocity of enzyme catalysed reaction (effect of substrate concentration, enzyme concentration, pH, temperature, presence of activator/ inhibitor etc.); Michaelis- Menten equation under steady state condition, MM-curve and its limitation. Vmax, Km and its significance; LineweaverBurkplot-itsadvantagesandlimitations,Eadie-HofsteeandHanesplots and advantages;enzyme inhibition, types of enzyme inhibitions-	15

	competitive, uncompetitive, non-competitive, mixed type inhibition and determination of Ki, Determination of K_m and V_{max} in the presence and absence of inhibitor; feed- back inhibition; Bisubstrate reactions- brief introduction to sequential and Ping-Pong mechanism with examples.	
IV	Strategies used for enzyme production, isolation and purification at laboratory and industrial scale from plant, animal and microbial sources , method of calculating the purification fold; estimation of enzyme activity; characterization of an enzyme, criteria of enzyme purity, determination of the molecular weight (MW) and the number of sub-units of an enzyme; enzyme immobilization and its importance, enzyme engineering;, enzyme therapy, enzyme inhibitors and drug design; Applications of enzymes in medicine, textile, leather, detergent, paper, bakery, dairy industry, beverage and fruit processing, food processing and preservation, clinical applications of enzyme estimation.	15

Suggested Evaluation Methods

Internal Assessment: 30 marks ➢ Class Participation: 5 ➢ Seminar/presentation/assignment/ quiz/ class test etc.: 10 ➢ Mid-Term Exam: 15	**End Term Examination:** 70 marks

Part C- Learning Resources

Recommended Books/ e-resources/ LMS:

1. Segal, L.H. (1975) Enzyme Kinetics, Wiley Interscience, USA
2. Walsh, C. (1979) Enzymatic reaction mechanism, Freeman and Company, USA.
3. Gerhartz, W. (1990) Enzyme in Industry, Production and Application, VCH.
4. Shultz, A.R. (1994) Enzyme Kinetics, Cambridge Press.
5. Fresht (1995) Enzyme structure and mechanism, 2nd edition, Freeman and Company.
6. Palmer, T. and Bonner P.L. (2007) Enzymes, Woodhead Publishing Limited.
7. Dixon, M and Webb E.C. (1997) Enzymes, 3rd edition, Academic Press, NewYork.
8. Price N.C. and Stevens L. (2001) Fundamentals of Enzymology, Oxford University Press

DSE-H2

Session: 2025-2026	
Part A - Introduction	
Subject	Biotechnology
Semester	VIII
Name of the course	Bioinformatics-II
Course Code	B23-BTY-804
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	DSE-H2
Level of the course (As per Annexure-I)	400-499
Pre-requisite for the course (if any)	NA
Course Learning Outcomes (CLO):	After completing this course, the learner will be able to: 1. To understand the basic principles and goals of bioinformatics. 2. To gain proficiency in using bioinformatics tools and databases. 3. To analyze biological data using computational methods. 4. To interpret and visualize bioinformatics results effectively.
Credits	4
Contact Hours/ week	4
Max. Marks: 100 Internal Assessment Marks: 30 End Term Exam Marks:70	Time: 3h

Part B - Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No. 1 comprising of objective/ short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Question No. 1 and four others selecting one question from each unit. All questions will carry equal marks.

Unit	**Topics**	**Contact Hours**
I	Bioinformatics: Introduction, Goal, Scope, Applications, Limitations, and New Themes Biological Databases: Introduction, Types of Databases, Biological Databases, Pitfalls of Biological Databases, Information Retrieval from Biological Databases Sequence Alignment Pairwise Sequence Alignment: Evolutionary Basis, Sequence Homology versus Sequence Similarity, Sequence Similarity versus Sequence	18

	Identity, Methods, Scoring Matrices, Statistical Significance of Sequence Alignment Database Similarity Searching: Unique Requirements of Database Searching, Heuristic Database Searching, Basic Local Alignment Search Tool (BLAST), FASTA, Comparison of FASTA and BLAST, Database Searching with the Smith– Waterman Method Multiple Sequence Alignment: Scoring Function, Exhaustive Algorithms, Heuristic Algorithms.	
II	Gene and Promoter Prediction Gene Prediction: Categories of Gene Prediction Programs, Gene Prediction in Prokaryotes, Gene Prediction in Eukaryotes Promoter and Regulatory Element Prediction: Promoter and Regulatory Elements in Prokaryotes, Promoter and Regulatory Elements in Eukaryotes,	14
III	Prediction Algorithms Molecular Phylogenetics Phylogenetics Basics: Molecular Evolution and Molecular Phylogenetics, Terminology, Gene Phylogeny versus Species Phylogeny, Forms of Tree Representation, Why Finding a True Tree Is Difficult, Procedure Phylogenetic Tree Construction Methods and Programs: Distance-Based Methods, Character-Based Methods, Phylogenetic Tree Evaluation, Phylogenetic Programs	14
IV	Hidden Markov Models: Position-Specific Scoring Matrices, Profiles, Markov Model and Hidden Markov Model Protein Motifs and Domain Prediction: Identification of Motifs and Domains in Multiple Sequence Alignment, Motif and Domain Databases Using Regular Expressions, Motif and Domain Databases Using Statistical Models, Protein Family Databases, Motif Discovery in Unaligned Sequences	14

Suggested Evaluation Methods	
Internal Assessment: 30 marks ➢ Class Participation: 5 ➢ Seminar/ presentation/ assignment/ quiz/ class test etc.: 10 ➢ Mid-Term Exam: 15	**End Term Examination: 70 marks**

Part C- Learning Resources

Recommended Books/ e-resources/ LMS:

1. "Bioinformatics: Sequence and Genome Analysis" by David W. Mount

2**.** "Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins" by Andreas D. Baxevanis and B. F. Francis Ouellette

3. "Essential Bioinformatics" by Jin Xiong

4."Introduction to Bioinformatics" by Arthur M. Lesk

DSE-H2

Session: 2025-26	
Part A- Introduction	
Subject	**Biotechnology**
Semester	**VIII**
Name of the Course	**Mathematics and Calculations in Biotechnology**
Course Code	**B23- BTY- 805**
Course Type:(CC/MCC/MDC/CC-M /DSEC/VOC/DSE/PC/AEC/ VAC)	**DSE-H2**
Level of the course (As per Annexure-I	**400-499**
Pre-requisite for the course (if any)	NA
Course Learning Outcomes (CLO):	After completing this course, the learner will be able to: 1. Proficiency in applying fundamental mathematical concepts such as algebra, logarithms, and calculus to solve problems in biotechnology. 2. Ability to develop and validate mathematical models to describe and predict the behavior of biological systems and design experiments in biotechnological research. 3. Competence in utilizing statistical methods and techniques to analyze experimental data and draw meaningful conclusions in biotechnology. 4. Familiarity with computational tools and software packages such as MATLAB, R, and Python for mathematical modeling, statistical analysis, and visualization of

	biological data, enabling effective problem-solving and data-driven decision-making in biotechnological applications.
Credits	4
Contact Hours/ week	4

Max.Marks:100 **Internal Assessment Marks: 30** **End Term Exam Marks: 70**	**Time: 3h**

Part B-Contents of the Course

Instructions for Paper- Setter

Nine questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining eight questions will be set taking two questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting one question from each unit. All questions carry equal marks.

Unit	Topic	Contact Hours
I	**Fundamentals of Mathematics in Biotechnology: F**undamental mathematical concepts relevant to biotechnology, including algebraic equations, logarithms, and basic calculus. Mathematical functions, units and dimensions, and the use of mathematical models in biotechnological processes.	15
II	**Mathematical Modeling in Biotechnology:** Mathematical modeling techniques used to describe and analyze biological systems and processes. Deterministic and stochastic models, differential equations, and kinetic modeling of enzyme-catalyzed reactions.	15

III	**Statistical Methods in Biotechnology:** statistical methods and techniques commonly used in biotechnology research and data analysis. Hypothesis testing, analysis of variance (ANOVA), regression analysis, and experimental design. Statistical tests to analyze experimental data, interpret results, and draw conclusions from biological experiments.	15
IV	**Computational Tools and Software in Biotechnology:** Computational tools and software packages used for mathematical modeling, data analysis, and simulation in biotechnology. Use of software such as MATLAB/R or Python for mathematical modeling, statistical analysis, and visualization of biological data**.**	15

	Suggested Evaluation Methods
Internal Assessment:30 Marks ➢ Class Participation: 5 ➢ Seminar/ presentation/ assignment/ quiz/ class test etc.: 10 ➢ Mid-Term Exam: 15	**End Term Examination:** 70 Marks

Part C- Learning Resources

Recommended Books/ e-resources/ LMS:

1. Pirt, S. J. (2001). *Mathematics of Fermentation Kinetics.* Butterworth-Heinemann.
2. Stephanopoulos, G., Aristidou, A. A., & Nielsen, J. (1998). *Metabolic Engineering: Principles and Methodologies.* Academic Press.
3. Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts.* Prentice Hall.
4. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals.* McGraw-Hill Education.
5. Domach, M. M., & Palsson, B. O. (1994). *Biochemical Engineering and Biotechnology Handbook.* Nature Publishing Group.
6. Blanch, H. W., & Clark, D. S. (1997). *Biochemical Engineering.* Marcel Dekker.
7. King, R. W., & Ward, A. C. (2018). *Introduction to Practical Biochemistry.* Garland Science.
8. Lide, D. R. (Ed.). (2003). *CRC Handbook of Chemistry and Physics.* CRC Press.
9. McQuarrie, D. A., & Simon, J. D. (2011). *Mathematical Methods for Scientists and Engineers.* University Science Books.
10. Atkinson, K. E. (1989). *An Introduction to Numerical Analysis.* John Wiley & Sons.

PC-H2

Session: 2025-2026	
Part A - Introduction	
Subject	Biotechnology
Semester	VIII
Name of the course	Practical based on B23-BTY-801 TO 804/805
Course Code	B23-BTY-806
Course Type: (CC/MCC/MDC/CC-M/DSEC/VOC/DSE/PC/AEC/VAC)	PC- H2
Level of the course (As per Annexure-I)	400-499
Pre-requisite for the course (if any)	NA
Course Learning Outcomes (CLO):	After completing this course, the learner will be able to: 1. Understand the online/ offline/ wet lab protocols involved in animal cell culture for developing pharmaceutical products. 2. Get acquainted with different tools and techniques used in Plant Tissue Culture. 3. Work on enzymes, their activity estimation, kinetics and will be able to analyze factors effecting enzymes activity, production, purification and immobilisation of particular enzyme. 4. To apply bioinformatics techniques to solve biological problems. Familiarity with computational tools and software packages enabling effective problem-solving and data-driven decision-making in biotechnological applications.
Credits	4
Contact Hours/week	8
Max. Marks: 100 Internal Assessment Marks: 30 End Term Exam Marks: 70	Time: 6h

Part B - Contents of the Course	**Contact Hours**
Practicals based on B23-BTY- 801 1. Laboratory layout of animal cell culture lab. 2. Introduction to various cell culture vessels used in animal cell culture. 3. Aseptic techniques used in cell culture.	Total -120 (30 per course)

4. Cell Line Establishment.
5. Seed primary cells or establish immortalized cell lines from tissue samples, embryos, or cell suspensions
6. Subculture adherent cells by detaching them from the culture vessel
7. Passing of animal cells after sub culturing.
8. Cryopreservation of animal cells :Freeze down cells at low temperatures using cryoprotective agents, store in liquid nitrogen/-80C
9. Thawing of cryopreserved cells.
10. Trypan blue assay for checking viability of animal cells
11. Counting of cells using hemocytometer

Practicals based on B23-BTY- 802

1. To study the PTC laboratory organization..
2. Preparation and sterilization of Murashige and Skoog's basal and regeneration media.
3. Preparation of aseptic plant material by surface sterilization.
4. Callus induction using various explants.
5. Regeneration of shoots (micro-propagation), root induction, role of hormones in morphogenesis.
6. Seed gemination and hardening of plant
7. Development of synthetic seeds.

Practicals based on B23-BTY- 803

1. Important points to remember for Enzyme Technology work in Lab.
2. To estimate the quantity of protein by UV-absorption method and Bradford method.
3. To estimate the activity of amylase enzyme in serum/urine, saliva.
4. Production of enzyme through solid-state fermentation.
5. Production of enzyme through Sub-merged fermentation approach.
6. To study the time course of enzyme catalysed reaction.
7. To study the effect of substrate concentration on the activity of enzyme.
8. To determine the Km and Vmax value.
9. To determine pH optima for the enzyme.
10. Immobilization of enzyme by entrapment in agarose gel, calcium alginate gel or other available material and comparison with free enzyme.

Practicals based on B23-BTY- 804

1. Detailed study of NCBI Homepage. 8.
2. To perform BLAST for Nucleotide Sequence
3. To perform virtual library via NCBI
4. To perform BLAST for a protein sequence
5. . To perform multiple sequence alignment via CLUSTAL
6. To perform phylogenetic analysis
7. To display PDB structure using Rasmol
8. Comparative study of the two formats: Gene Bank/ Genepept and FASTA
9. Analysis of Prosite pattern

Or Practicals based on B23-BTY- 805

1. Algebraic Equations in Bioprocess Engineering.
2. Perform dilution series calculations using logarithmic functions to determine cell

concentrations, enzyme activities, or compound concentrations in biological samples.
3. Basic Calculus for Growth Kinetics.
4. Kinetic Modeling of Enzyme Reactions.
5. Statistical analysis of experimental data using methods such as t-tests, ANOVA, and regression analysis.
6. Mathematical models using experimental data and estimate model parameters using regression analysis or curve fitting techniques

Suggested Evaluation Methods

Internal Assessment:30 marks	**End Term Examination: 70 marks**
• Class Participation: 5 • Seminar/ Demonstration/ Viva-voce/Lab records etc.: 10 • Mid-Term Exam: 15	**(**Demonstration/ Viva-voce/Lab records etc.)

Part C- Learning Resources

Recommended Books/e-resources/LMS:

1. Freshney, R. I. (2016). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (7th ed.). Wiley.
2. Masters, J. R. W., & Palsson, B. O. (Eds.). (2019). *Human Cell Culture Protocols (4th ed.*). Humana Press.
3. Birnbaum, S., & Alves, P. M. (Eds.). (2020). *Animal Cell Biotechnology: Methods and Protocols*. Springer.
4. Plant cell culture – A practical approach (1994) Dixon R.A., Gonzales R.A. Oxford University press,UK.
5. Bhojwani S.S. (2003), Agrobiotechnology & Plant TissueCulture
6. Smith R.H. (2000), Plant Tissue Culture, Academic Press
7. An introduction to Practical Biochemistry, 3rd Edition, by David Plummer (2017). Tata Mc-Graw Hill
8. Introductory Practical Biochemistry by S.K. Sawhney & R. Singh (2014). Narosa Publishers
9. Essential Bioinformatics by Jin Xiong
10. Introduction to Bioinformatics by Arthur M. Lesk
11. McQuarrie, D. A., & Simon, J. D. (2011). *Mathematical Methods for Scientists and Engineers.* University Science Books
12. Atkinson, K. E. (1989). *An Introduction to Numerical Analysis*. John Wiley & Sons.

Project/Dissertation

Session: 2025-26	
Part A- Introduction	
Subject	**Biotechnology**
Semester	**VIII**
Name of the Course	**Project/Dissertation**
Course Code	**B23- BTY- 807**
Course Type:(CC/MCC/MDC/CC-M /DSEC/VOC/DSE/PC/AEC/ VAC)	**Project/Dissertation**
Level of the course (As per Annexure-I)	**400-499**
Pre-requisite for the course (if any)	NA
Course Learning Outcomes (CLO)	-
Credits	8+4
Contact Hours/ week	-

Max. Marks: 300 Internal Assessment Marks: N.A End Term Exam Marks: 300	Time: -

Part B-Contents of the Course

Instructions for Paper- Setter

Unit	Topic	Contact Hours

Suggested Evaluation Methods

Internal Assessment: N.A.	End Term Examination: 300 marks (Evaluation by examiner/viva-voce etc.)

Part C- Learning Resources

Recommended Books/ e-resources/ LMS:

PLOs and CLO – PLO mapping matrix

PLOs	Under Graduate Programme in Life Sciences
After the completion of Under Graduate Programme in Life Sciences, the student should be able to:	
PLO_1: Knowledge and Understanding	• Demonstrate the comprehensive and specialized knowledge and deep understanding of principles, concepts, and facts about current and emerging issues relevant to chosen subjects of Life sciences.
PLO_2: Skills And creativity	• Selecting and using relevant methods, tools, and materials to assess the appropriateness of approachesfor solving specific problems associated with the chosen subjects of Life sciences.
PLO_3: Application of knowledge and Skills	• Apply the acquired operational or theoretical knowledge, and a range of practical skills to analyze quantitative and qualitative data to assess the different approaches to generate solutions to specific problems related to the chosen subjects of Life sciences.
PLO_4: Critical thinking	• Listen carefully, read texts, make judgments and take decisions based on analysis of data and evidences, present complex information in a clear, scientific and concise manner.
PLO_5: Ethics	• Follow ethical practices in all aspects of research and development, including avoiding unethical practices such as fabrication, falsification or misrepresentation of data or committing plagiarism.
PLO_6: Communication	• Able to communicate effectively on complex scientific activities with the scientific community and with society at large, such as, being able to comprehend and write effective scientific reports and design documentation, make effective presentations.
PLO_7:Life Long Learning	• Acquire knowledge and skills including learning 'How to learn' that are necessary for participating in learning activities throughout life.
PLO_8: Environmental Awareness	• Apply knowledge, skills and attitude to mitigate the effects of environmental degradation, climate change and pollution, effective waste management.
PLO_9:Digital Literacy	• To use ICT in a variety of learning and work situations, appropriate software to analysis the data.
PLO_10:Research Aptitude	• Ask relevant/appropriate questions, identifying, formulating and analyzing the research problems and to draw conclusion from the analysis.

Table: CLO-PLO Mapping Matrix for the course: Introduction of Biotechnology (B23-BTY-101) CC-I/ MCC-I

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-101.1	3	3	3	3	2	3	3	3	3	3
B23-BTY-101.2	3	3	3	3	3	3	3	3	3	3
B23-BTY-101.3	3	3	3	3	3	3	3	3	3	3
B23-BTY-101.4	3	3	3	3	3	3	3	3	3	3
B23-BTY-101.5	3	3	3	3	3	3	3	3	2	3
Average	3	3	3	3	2.8	3	3	3	2.8	3

Table: CLO-PLO Mapping Matrix for the course: Basics of Bio-molecules (B23-BTY-102) MCC-2

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-102.1	3	1	2	3	3	3	3	2	2	3
B23-BTY-102.2	3	3	3	3	3	3	3	2	2	3
B23-BTY-102.3	2	3	3	3	3	3	3	2	2	3
B23-BTY-102.4	3	2	3	3	3	3	3	2	2	3
B23-BTY-102.5	3	3	3	3	3	3	3	3	2	3
Average	2.8	2.4	2.8	3	3	3	3	2.2	2	3

Table: CLO-PLO Mapping Matrix for the course: Laboratory Techniques & Practices (B23-BTY-103) CC-M1

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-103.1	3	1	2	3	3	3	3	2	2	3
B23-BTY-103.2	3	3	3	3	3	3	3	2	2	3
B23-BTY-103.3	2	3	3	3	3	3	3	2	2	3
B23-BTY-102.4	3	2	3	3	3	3	3	2	2	3
B23-BTY-102.5	3	3	3	3	3	3	3	3	1	3
Average	2.8	2.	2.8	3	3	3	3	2.2	1.8	3

Table: CLO-PLO Mapping Matrix for the course: Biology-I (B23-BTY-104) MDC-I

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-104.1	3	3	3	3	3	3	3	3	2	3
B23-BTY-104.2	3	2	3	3	2	3	3	3	2	3
B23-BTY-104.3	3	3	3	3	3	3	3	3	2	3
B23-BTY-104.4	3	3	3	3	2	3	3	3	2	3
B23-BTY-104.5	3	3	3	3	3	3	3	3	2	3
Average	3	2.8	3	3	2.6	3	3	3	2	3

Table: CLO-PLO Mapping Matrix for the course: General Microbiology (B23-BTY-201) CC-2/ MCC-3

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-201.1	3	1	1	3	3	3	3	3	3	3
B23-BTY-201.2	3	3	3	3	3	3	3	3	3	3
B23-BTY-201.3	3	2	2	3	3	3	3	3	3	3
B23-BTY-201.4	3	3	3	3	2	3	3	3	3	3
B23-BTY-201.5	3	3	3	3	3	3	3	3	2	3

Average	3	2.4	2.4	3	2.8	3	3	3	2.8	3

Table: CLO-PLO Mapping Matrix for the course: Diagnostic Laboratory Techniques (B23-BTY-202) DSEC -1

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-202.1	3	1	3	3	3	3	3	3	3	3
B23-BTY-202.2	3	2	3	3	3	3	3	3	3	3
B23-BTY-202.3	3	3	2	3	3	3	3	3	3	3
B23-BTY-202.4	3	3	3	3	3	3	3	3	3	3
B23-BTY-202.5	3	3	3	3	3	3	3	3	3	3
Average	3	2.4	2.8	3	3	3	3	3	3	3

Table: CLO-PLO Mapping Matrix for the course: Introduction of Biological Chemistry (B23-BTY-203) CC-M2

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-203.1	3	3	2	3	3	3	3	2	2	3
B23-BTY-203.2	3	2	3	3	3	3	3	2	2	3
B23-BTY-203.3	3	3	3	2	3	3	3	2	2	3
B23-BTY-203.4	3	3	3	3	3	3	3	2	2	3
B23-BTY-203.5	3	3	3	3	3	3	3	3	2	3
Average	3	2.8	2.8	2.8	3	3	3	2.2	2	3

Table: CLO-PLO Mapping Matrix for the course: Biology-II (B23-BTY-204) MDC- 2

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-204.1	3	3	3	2	3	3	3	3	2	3
B23-BTY-204.2	3	2	2	3	3	3	3	3	2	3
B23-BTY-204.3	2	3	3	3	3	3	3	3	2	3
B23-BTY-204.4	3	2	2	3	3	3	3	3	2	3
B23-BTY-204.5	3	3	3	3	3	3	3	3	2	3
Average	2.8	2.6	2.6	2.8	3	3	3	3	2	3

Table: CLO-PLO Mapping Matrix for the course: Cell Biology (B23-BTY-301) CC-3/ MCC-4

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-301.1	3	1	3	3	3	3	3	2	3	3
B23-BTY-301.2	3	2	3	3	3	3	3	2	3	3
B23-BTY-301.3	3	3	2	3	3	3	3	1	3	3
B23-BTY-301.4	3	3	3	3	3	3	3	1	3	3
B23-BTY-301.5	3	3	3	3	3	3	3	2	2	3
Average	3	2.4	2.8	3	3	3	3	1.6	2.8	3

Table: CLO-PLO Mapping Matrix for the course: Genetics (B23-BTY-302) MCC -5

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-302.1	3	1	3	3	3	3	3	3	1	3
B23-BTY-302.2	3	2	3	3	3	3	3	3	1	3
B23-BTY-302.3	3	3	2	3	3	3	3	3	1	3
B23-BTY-302.4	3	3	3	3	3	3	3	3	1	3
B23-BTY-302.5	3	3	3	3	3	3	3	3	2	3
Average	3	2.4	2.8	3	3	3	3	3	1.2	3

Table: CLO-PLO Mapping Matrix for the course: Biology-III (B23-BTY-303) MDC-3

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-303.1	3	3	3	3	3	3	3	3	2	3
B23-BTY-303.2	3	2	3	3	3	3	3	3	2	3
B23-BTY-303.3	3	3	3	3	2	3	3	3	2	3
B23-BTY-303.4	3	3	3	3	3	3	3	3	2	3
B23-BTY-303.5	3	3	3	3	3	3	3	3	2	3
Average	3	2.8	3	3	2.8	3	3	3	2	3

Table: CLO-PLO Mapping Matrix for the course: Recombinant DNA Technology-I (B23-BTY-401) CC-4/MCC-6

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-401.1	3	3	3	3	3	3	3	3	3	3
B23-BTY-401.2	3	3	3	3	3	3	3	3	3	3
B23-BTY-401.3	3	3	3	3	2	2	3	3	3	3
B23-BTY-401.4	3	3	2.5	2.5	2.5	2.5	3	3	3	3
B23-BTY-401.5	3	3	3	3	3	3	3	3	3	3
Average	3	3	2.9	2.9	2.7	2.7	3	3	3	3

Table: CLO-PLO Mapping Matrix for the course: Bioinformatics-I (B23-BTY-402) MCC-7

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-402.1	3	3	3	3	3	3	3	3	3	3
B23-BTY-402.2	3	3	3	3	3	3	3	3	3	3
B23-BTY-402.3	3	3	3	3	2	2	3	3	3	3
B23-BTY-402.4	3	3	2.5	2.5	2.5	2.5	3	3	3	3
B23-BTY-402.5	3	3	3	3	3	3	3	3	3	3
Average	3	3	2.9	2.9	2.7	2.7	3	3	3	3

Table: CLO-PLO Mapping Matrix for the course: Metabolism (B23-BTY-403) MCC-8

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-403.1	3	1	3	3	3	3	3	3	2	3
B23-BTY-403.2	3	2	3	3	3	3	2.5	3	2	3
B23-BTY-403.3	3	3	2	3	3	3	2.5	3	2	3
B23-BTY-403.4	3	3	3	3	3	3	2.5	3	2	3
B23-BTY-403.5	3	3	3	3	3	3	2	3	2	3
Average	3	2.4	2.8	3	3	3	2.5	3	2	3

Table: CLO-PLO Mapping Matrix for the course: IPR, Biosafety & Bioethics (B23-BTY-404) DSE-1

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-404.1	3	3	2.5	2.5	2.5	2.5	3	3	3	3
B23-BTY-404.2	3	3	3	3	3	3	3	3	3	3
B23-BTY-404.3	3	3	2.5	2.5	2	2	3	3	3	3
B23-BTY-404.4	2.5	2.5	2.5	2.5	2	2	3	3	3	3
B23-BTY-404.5	3	3	3	3	3	3	3	3	3	3

Average	2.9	2.9	2.7	2.7	2.5	2.5	3	3	3	3

Table: CLO-PLO Mapping Matrix for the course: Foundations of Forensic Biotechnology (B23-BTY-405) DSE -1

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-405.1	3	3	3	2	3	3	3	3	3	3
B23-BTY-405.2	3	2	2	3	3	3	3	3	3	3
B23-BTY-405.3	2	3	3	3	3	3	3	3	3	3
B23-BTY-405.4	3	2	2	3	3	3	3	3	3	3
B23-BTY-405.5	3	3	3	3	3	3	3	3	3	3
Average	2.8	2.6	2.6	2.8	3	3	3	3	3	3

Table: CLO-PLO Mapping Matrix for the course: Immunology (B23-BTY-501) CC-5/MCC-9

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-501.1	3	2	1	2	3	2	3	2	1	3
B23-BTY-501.2	3	3	3	3	3	3	3	2	1	3
B23-BTY-501.3	2	2	2	3	3	2	3	2	1	3
B23-BTY-501.4	3	2	3	3	3	3	3	2	1	3
B23-BTY-501.5	3	3	3	3	3	3	3	1	2	3
Average	2.75	2.25	2.25	2.75	3	2.5	3	1.8	1.2	3

Table: CLO-PLO Mapping Matrix for the course: Microbial Genetics (B23-BTY-502) MCC-10

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-502.1	3	2	2	3	3	3	2.5	3	2	3
B23-BTY-502.2	3	2	3	3	3	3	2.5	3	2	3
B23-BTY-502.3	3	3	3	3	3	3	2.5	3	2	3
B23-BTY-502.4	3	3	3	3	2	2	2.5	3	2	3
B23-BTY-502.5	3	3	3	3	3	3	3	3	2	3
Average	3	2.6	2.8	3	2.8	2.8	2.6	3	2	3

Table: CLO-PLO Mapping Matrix for the course: Fundamentals of Enzymology (B23-BTY-503) DSE-2

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-503.1	3	2	2	3	3	2	2	2	2	3
B23-BTY-503.2	3	2	3	3	3	3	2	2	2	3
B23-BTY-503.3	3	3	3	3	2	3	2	2	2	3
B23-BTY-503.4	3	3	3	3	3	3	2	2	2	3
B23-BTY-503.5	3	3	3	3	3	3	2	3	2	3
Average	3	2.6	2.8	3	2.8	2.8	2	2.2	2	3

Table: CLO-PLO Mapping Matrix for the course: Fermented Foods (B23-BTY-504) DSE-2

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-504.1	3	3	3	2	2	2	3	3	2	3
B23-BTY-504.2	3	3	2	2	2	3	3	3	2	3

B23-BTY-504.3	3	3	3	3	3	3	3	3	2	3
B23-BTY-504.4	3	3	2	2	2	2	3	3	2	3
B23-BTY-504.5	3	3	3	3	3	3	3	3	2	3
Average	3	3	2.6	2.4	2.4	2.6	3	3	2	3

Table: CLO-PLO Mapping Matrix for the course: Foundations of Environment and Ecology (B23-BTY-505) DSE-3

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-505.1	3	2	3	3	3	3	3	3	1	3
B23-BTY-505.2	3	2	3	3	3	3	3	3	1	3
B23-BTY-505.3	3	3	3	3	3	3	3	3	1	3
B23-BTY-505.4	3	3	3	3	3	3	3	3	1	3
B23-BTY-505.5	3	3	3	3	3	3	3	3	1	3
Average	3	2.6	3	3	3	3	3	3	1	3

Table: CLO-PLO Mapping Matrix for the course: Foundations of Nano-Biotechnology (B23-BTY-506) DSE -3

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-506.1	3	3	3	2	2	3	2	2	2	3
B23-BTY-506.2	3	3	3	3	2	3	2	2	2	3
B23-BTY-506.3	3	3	3	2	2	2	2	2	2	3
B23-BTY-506.4	3	3	3	3	3	3	2	2	2	3
B23-BTY-506.5	3	3	3	3	3	3	2	2	2	3
Average	3	3	3	2.6	2.4	2.8	2	2	2	3

Table: CLO-PLO Mapping Matrix for the course: Microbial Technology (B23-BTY-601) CC6/ MCC-11

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-601.1	3	1	2	3	3	3	3	3	2	3
B23-BTY-601.2	3	3	3	3	3	3	3	3	2	3
B23-BTY-601.3	3	2	3	2	2	3	3	3	2	3
B23-BTY-601.4	2	2	2	3	2	3	3	3	2	3
B23-BTY-601.5	3	3	3	3	3	3	3	3	1	3
Average	2.8	2.2	2.6	2.8	2.6	3	3	3	1.8	3

Table: CLO-PLO Mapping Matrix for the course: Bio-analytical Techniques (B23-BTY-602) MCC-12

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-602.1	3	3	3	2	2	2	3	3	3	3
B23-BTY-602.2	2	2	2	2	2	2	3	3	3	3
B23-BTY-602.3	2	2	2	2	2	2	3	3	3	3
B23-BTY-602.4	3	3	3	2.5	2.5	2.5	3	3	3	3
B23-BTY-602.5	3	3	3	3	3	3	3	3	3	3
Average	2.6	2.6	2.6	2.3	2.3	2.3	3	3	3	3

Table: CLO-PLO Mapping Matrix for the course: Medical Microbiology (B23-BTY-603) DSE-4

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-603.1	3	2	2	3	2	3	3	2.5	1	3
B23-BTY-603.2	3	3	3	3	3	3	3	2.5	1	3

B23-BTY-603.3	3	3	3	3	3	3	3	2.5	1	3
B23-BTY-603.4	3	2	3	3	3	3	3	2.5	1	3
B23-BTY-603.5	3	3	3	3	3	3	3	3	1	3
Average	3	2.6	2.8	3	2.8	3	3	2.6	1	3

Table: CLO-PLO Mapping Matrix for the course: Molecular Medicine and Gene Therapy (B23-BTY-604) DSE -4

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-604.1	3	1	2	3	3	3	1	1	2	3
B23-BTY-604.2	3	3	3	3	3	3	1	1	2	3
B23-BTY-604.3	2	3	3	3	3	3	1	1	2	3
B23-BTY-604.4	3	2	3	3	3	3	1	1	2	3
B23-BTY-604.5	3	3	3	3	3	3	1	1	2	3
Average	2.8	2.8	2.8	3	3	3	1	1	2	3

Table: CLO-PLO Mapping Matrix for the course: Biostatistics (B23-BTY-605) DSE-5

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-605.1	3	3	3	3	3	3	2	1	2	3
B23-BTY-605.2	3	3	3	3	3	3	2	1	2	3
B23-BTY-605.3	3	3	3	3	3	3	2	1	2	3
B23-BTY-605.4	3	3	3	2	3	2	2	1	2	3
B23-BTY-605.5	3	3	3	3	3	3	2	3	3	3
Average	3	3	3	2.8	3	2.8	2	1.4	2.2	3

Table: CLO-PLO Mapping Matrix for the course: Bio-entrepreneurship (B23-BTY-606) DSE-5

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-606.1	3	3	3	3	3	3	3	1	3	3
B23-BTY-606.2	3	2	2	3	3	3	3	1	3	3
B23-BTY-606.3	3	3	3	3	3	3	3	1	3	3
B23-BTY-606.4	3	3	2	3	3	3	3	1	3	3
B23-BTY-606.5	3	3	3	3	3	3	3	1	3	3
Average	3	2.75	2.5	3	3	3	3	1	3	3

Table: CLO-PLO Mapping Matrix for the course: Recombinant DNA Technology-II (B23-BTY-701) CC-H1

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-701.1	3	3	2	3	3	3	3	2	3	3
B23-BTY-701.2	3	2	2	3	3	3	3	2	3	3
B23-BTY-701.3	3	3	3	3	2	3	3	2	3	3
B23-BTY-701.4	3	2	3	3	3	3	3	2	3	3
Average	3	2.5	2.5	3	2.75	3	3	2	3	3

Table: CLO-PLO Mapping Matrix for the course: Pharmaceutical Biotechnology (B23-BTY-702) CC-H2

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-702.1	3	1	3	3	3	3	3	1	2.5	3
B23-BTY-702.2	3	2	3	3	3	3	3	1	2.5	3
B23-BTY-702.3	3	3	2	3	3	3	3	1	2.5	3
B23-BTY-702.4	3	3	3	3	3	3	3	1	2.5	3
Average	3	2.25	2.75	3	3	3	3	1	2.5	3

Table: CLO-PLO Mapping Matrix for the course: Molecular Cell Biology (B23-BTY-703) CC-H3

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-703.1	3	1	3	3	3	3	2	1	3	3
B23-BTY-703.2	3	2	3	3	2	3	2	1	3	3
B23-BTY-703.3	2	3	3	3	3	3	2	1	3	3
B23-BTY-703.4	3	3	3	3	3	3	2	1	3	3
Average	2.75	2.25	3	3	2.75	3	2	1	3	3

Table: CLO-PLO Mapping Matrix for the course: Molecular Diagnostics (B23-BTY-704) DSE-H1

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-704.1	3	2	2	3	2	3	3	1	3	3
B23-BTY-704.2	3	3	3	3	3	3	3	1	3	3
B23-BTY-704.3	3	3	3	3	3	3	3	1	3	3
B23-BTY-704.4	3	2	3	3	3	3	3	1	3	3
Average	3	2.5	2.75	3	2.75	3	3	1	3	3

Table: CLO-PLO Mapping Matrix for the course: Biotechnology in Environment Protection (B23-BTY-705) DSE-H1

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-705.1	3	2	3	3	3	3	3	3	2	3
B23-BTY-705.2	3	3	3	2	3	3	3	3	1	3
B23-BTY-705.3	3	3	3	3	3	3	3	3	1	3
B23-BTY-705.4	3	3	3	3	3	3	3	3	1	3
Average	3	2.75	3	2.75	3	3	3	3	1.25	3

Table: CLO-PLO Mapping Matrix for the course: Practical based on B23-BTY-701 to 704/705 (B23-BTY-706) PC-H1

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-706.1	3	2	3	3	3	3	3	1	2	3
B23-BTY-706.2	3	3	3	2	3	3	3	1	3	3
B23-BTY-706.3	3	3	3	3	3	3	2	1	1	3
B23-BTY-706.4	3	3	3	3	3	3	3	1	2	3
Average	3	2.75	3	2.75	3	3	2.75	1	2	3

Table: CLO-PLO Mapping Matrix for the course: *In vitro* culture techniques-Animal (B23-BTY-801) CC-H4

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-801.1	3	3	3	2	3	3	2	1	2	3
B23-BTY-801.2	3	2	2	3	3	3	2	1	2	3
B23-BTY-801.3	2	3	3	3	3	3	2	-	3	3
B23-BTY-801.4	3	2	2	3	3	3	2	-	3	3
Average	2.75	2.5	2.5	2.75	3	3	2	1	2.5	3

Table: CLO-PLO Mapping Matrix for the course: *In-vitro* culture techniques-Plants (B23-BTY-802) CC-H5

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-802.1	3	3	3	3	2	3	3	2	2	3
B23-BTY-802.2	3	3	3	3	3	3	3	2	2	3
B23-BTY-802.3	3	2	2	3	3	3	2	2	1	3
B23-BTY-802.4	2	1	2	2	3	3	2	-	2	3
Average	2.75	2.25	2.75	2.75	2.75	3	2.5	2	1.75	3

Table: CLO-PLO Mapping Matrix for the course: Enzyme Technology (B23-BTY-803) CC-H6

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-803.1	3	3	3	3	3	3	3	2	2	3
B23-BTY-803.2	3	2	2	3	2	3	2	1	1	3
B23-BTY-803.3	3	3	2	3	3	3	2	1	1	3
B23-BTY-803.4	3	2	3	3	3	3	3	3	2	3
Average	3	2.5	2.5	3	2.75	3	2.5	1.4	1.5	3

Table: CLO-PLO Mapping Matrix for the course: Bioinformatics-II (B23-BTY-804) DSE-H2

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-804.1	3	3	3	3	3	3	2	-	3	3
B23-BTY-804.2	3	3	3	3	3	3	2	-	3	3
B23-BTY-804.3	3	3	3	3	3	3	2	1	3	3
B23-BTY-804.4	3	3	3	3	3	3	1	1	3	3
Average	3	3	3	3	3	3	1.75	1	3	3

Table: CLO-PLO Mapping Matrix for the course: Mathematics and Calculations in Biotechnology (B23-BTY-805) DSE-H2

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-805.1	3	1	3	3	3	3	3	2	3	3
B23-BTY-805.2	3	2	3	3	3	3	3	3	3	3
B23-BTY-805.3	3	3	2	3	3	3	3	3	3	3
B23-BTY-805.4	3	3	3	3	3	3	3	3	3	3
Average	3	2.25	2.75	3	3	3	3	2	3	3

Table: CLO-PLO Mapping Matrix for the course: Practical based on B23-BTY-801 to 804/805 (B23-BTY-806) PC-H2

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
B23-BTY-806.1	3	2	3	3	3	3	3	-	3	3
B23-BTY-806.2	3	3	3	2	3	3	3	1	1	3
B23-BTY-806.3	3	3	3	3	3	3	3	2	1	3
B23-BTY-806.4	3	3	3	3	3	3	3	-	3	3
Average	3	2.75	3	2.75	3	3	3	1.5	2	3