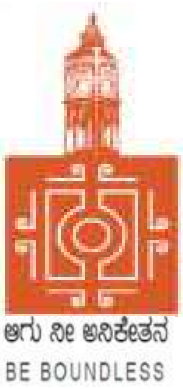

BENGALURU CITY UNIVERSITY

CHOICE BASED CREDIT SYSTEM

(Semester Scheme with Multiple Entry and Exit Options for Under Graduate Course)

Syllabus for B.Sc. Biotechnology
(V & VI Semester)

2023-24 onwards

B.Sc. Biotechnology 5th Semester

Program Name	**B.Sc. Biotechnology**		Semester	**5th Semester**
Course Title	**Genetic Engineering (Theory + Practical)**			
Course Code:	**DSC –A9 (T)**	No. of Theory Credits		**04**
Contact hours	**60 hrs**	Duration of ESA/Exam		**03 Hours**
Formative Assessment Marks	**40**	Summative Assessment Marks		**60**

Course Objectives

1. Understand the fundamental principles and techniques of genetic engineering.
2. Explore the applications of genetic engineering in agriculture, medicine, biotechnology,and environmental science.
3. Develop practical skills in genetic engineering techniques and laboratory procedures.
4. Gain knowledge of gene expression regulation and genetic modification methods.
5. Enhance critical thinking and problem-solving skills through discussions and case studies.
6. Stay updated on emerging trends and advancements in genetic engineering.

Course Outcomes:

1. Demonstrate a thorough understanding of the fundamental principles and techniques of genetic engineering.
2. Apply the knowledge of genetic engineering to diverse applications in agriculture, medicine, biotechnology, and environmental science.
3. Perform laboratory procedures and develop practical skills in genetic engineering techniques.
4. Explain gene expression regulation mechanisms and apply genetic modification methods effectively.
5. Evaluate genetic engineering's ethical, social, and legal implications and propose responsible solutions.
6. Stay updated with recent advancements in genetic engineering, critically evaluate emerging trends, and assess their potential impact on various fields.

Genetic Engineering - Content of Theory	60 hrs
Unit I- Fundamentals of Genetic Engineering	**15**
Definition, scope, and historical overview of genetic engineering. Importance and applications in various fields. **DNA Structure and Manipulation** - Techniques for DNA isolation and purification. Methods for quantification and characterization of DNA samples. **RNA Analysis and Gene Expression**- Methods for RNA isolation and purification. Analysis of gene expression. **Recombinant DNA technology** – Introduction to molecular cloning. Overview of cloning vectors. Plasmids, phage, cosmid, BAC, and YAC. Features and applications of cloning vectors in genetic engineering. Enzymes used in recombinant DNA technology: Restriction endonucleases, Polymerases, Ligase, kinases, and phosphatases. Techniques for molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems.	
Unit II- Practices in Genetic Engineering	**15**
Recombinant Protein Expression and Purification, affinity tags. Techniques for expressing recombinant proteins using bacterial, animal, and plant expression systems. Strategies for protein purification and characterization. Hybridization techniques, Southern, Northern, Western, FISH, Polymerase Chain Reaction (PCR) and its types, molecular probes, DNA sequencing- Sanger's, Next Generation Sequencing **Gene Manipulation Techniques** - Methods of gene delivery. Physical, chemical, and biological methods. Transformation, transfection, electroporation and micro-injection. Gene knockout techniques in bacterial and eukaryotic organisms. **Genome Editing** - Introduction to genome editing techniques- Principles and applications of genome editing techniques. CRISPR-Cas9, site-directed mutagenesis, and other genome editing methods.	
Unit III- Applications of Genetic Engineering	**15**
Introduction to Applications. Overview of the diverse applications of genetic engineering. Gene therapy and its potential in treating genetic disorders. Strategies for gene delivery in therapeutic applications. Diagnostic Applications. DNA fingerprinting and its applications in forensics. Molecular diagnostic techniques and their role in disease diagnosis. Use of genetic engineering in the development of therapeutics and vaccines. Production of biopharmaceuticals using recombinant DNA technology.	
Unit IV- Advances in Genetic Engineering and Ethics	**15**
Industrial Applications. Industrial applications of genetic engineering, such as enzyme production, biofuel production, and bioremediation. Scale-up techniques and process optimization in industrial settings. Introduction to synthetic biology and its integration with genetic engineering. Design and construction of artificial biological systems **Ethical and Regulatory Considerations** - Discussion of ethical implications associated with genetic engineering. Introduction to regulatory guidelines and safety considerations for genetic engineering research and applications	

Pedagogy: Lectures, Seminars, Industry Visits, Debates, Quiz and Assignments

Summative Assessment = 60 Marks	
Formative Assessment / type	**Weightage in Marks**
Attendance	10
Seminar	10
Debates and Quiz	10
Test	10
Total FA	**40**
Total (FA + SA)	**100 marks**

Course Title	**Genetic Engineering**	Practical Credits	**02**
Course Code:	**DSC–A10 (P)**	Contact hours	**60 hrs**

Practical Content

1. **Introduction to Laboratory Techniques -** Safety guidelines and laboratory protocols Aseptic techniques and proper handling of materials. Basic equipment and instrument operationPreparation of reagents and media
2. **Nucleic Acid Extraction and Quantification-** DNA extraction from different sources (e.g., bacteria, plant, animal). RNA extraction and purification methods. Quality assessment and quantification of nucleic acids (spectrophotometry, gel electrophoresis).
3. **Polymerase Chain Reaction (PCR)**
   Primer design and optimization PCR setup and cycling conditions
   Agarose gel electrophoresis for PCR product analysis
4. **Cloning and Plasmid Manipulation**
   Isolation of Plasmid
   Restriction enzyme digestion
   Ligation reactions
   Transformation of bacterial cells with recombinant plasmids
   Colony selection and screening for successful cloning
5. **Gel Electrophoresis and DNA Analysis**
   Agarose gel electrophoresis for DNA fragment separation and analysisDNA size determination using molecular weight markers
   DNA band visualization techniques (e.g., Ethidium bromide staining, DNA intercalating dyes)

Practical Assessment

Formative Assessment		**Summative Assessment**	**Total Marks**
Assessment Occasion/ type	**Weightage in Marks**	**Practical Exams**	
Record	05	25	**50**
Test	10		
Attendance	05		
Performance	05		
Total	**25**	**25**	

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4. Introduction to Genomics (2015) 2nd ed., Lesk, AM, Oxford University Press India, ISBN: 978-0198745891.
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9. Introduction to Genomics and Proteomics (2015) 2nd ed., Burrell, MM, Wiley, ISBN: 978-0470850075.
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13. Genomic Medicine: Principles and Practice (2014) 2nd ed., Ginsburg, GS, and Willard, HF, Oxford University Press, ISBN: 978-0199334468.
14. Genomic Medicine in Resource-limited Countries: Genomics for Every Nation (2019) 1st ed., Wonkam, A, Puck, JM, and Marshall, CR, Academic Press, ISBN: 978-0128133003.
15. Molecular Genetics and Genomics (2020) 1st ed., Krebs, JE, and Goldstein, ES, Jones & Bartlett Learning, ISBN: 978-1284154544.
16. Bioinformatics and Functional Genomics (2015) 3rd ed., Pevsner, J, Wiley-Blackwell, ISBN: 978-1118581780.
17. Genomic Approaches for Cross-Species Extrapolation in Toxicology (2019) 1st ed., Wichard, J, and Maertens, A, CRC Press, ISBN: 978-0815348023.
18. Introduction to Genetic Analysis (2020) 12th ed., Griffiths, AJF, Wessler, SR, Carroll, SB, and Doebley, J, W.H. Freeman, ISBN: 978-1319149609.
19. Genetic Engineering: Principles and Methods (2019) 3rd ed., Fowler, MR, CABI, ISBN: 978-1789240605.

B.Sc. Biotechnology 5th Semester

Program	**B.Sc. Biotechnology**		Semester	**5th Semester**
Course Title	**Plant and Animal Biotechnology (Theory + Practical)**			
Course Code:	**DSC-A11 (T)**		No. of Theory Credits	**04**
Contact hours	**60 hrs**		Duration of ESA/Exam	**3 Hours**
Formative Assessment Marks		**40**	Summative Assessment Marks	**60**

Course Objectives

1. To understand the fundamental aspects of plant and animal biotechnology.
2. Learn about biotechnological tools and techniques used in plant and animal research.
3. Explore methods of introducing foreign genes into plants and animals through transformation techniques.
4. Gain practical skills in plant tissue culture and animal cell culture for improvement.
5. Design strategies for plant genetic manipulation against biotic and abiotic stressors.
6. Hypothesize strategies to increase plant yield and fruit/seed quality.
7. Apply knowledge to real-world challenges in agriculture, veterinary medicine, conservation, and biomedical research
8. Understand the need for animal biotechnology for human welfare.

Course Outcomes:

After completing this course, the student is expected to learn the following:

1. Demonstrate a comprehensive understanding of plant biology, physiology, genetics, andmolecular biology.
2. Apply biotechnological tools and techniques used in plant research and agriculture, such asplant tissue culture, genetic engineering and transgenics.
3. Execute plant tissue culture techniques for callus induction, somatic embryogenesis, andmicropropagation, and apply them in plant breeding and propagation.
4. Perform plant transformation methods and demonstrate the ability to introduce foreign genesinto plants using different techniques.
5. Apply knowledge about ethical considerations and regulatory frameworks associated with plant biotechnology and genetically modified crops.
6. Understand the biology and characterization of cultured cells, including their adhesion, proliferation, differentiation, morphology, and identification.
7. Gain practical skills in basic mammalian cell culture techniques, measuring growth parameters, assessing cell viability, and understanding cytotoxicity.
8. Learn about germplasm conservation techniques and the establishment of gene banks, along with large-scale culture methods for cell lines.
9. Explore organ and histotypic culture techniques, biotransformation, 3D cultures, whole embryo culture, somatic cell cloning, and the ethical considerations surrounding stem cellsand their applications.

Plant and Animal Biotechnology - Content of Theory	60 hrs
Unit–I – Plant Tissue culture methods	**15**
Introduction, history, definition, hypothesis, and concept of totipotency. Principles of plant tissue culture, media and laboratory organization, types of culture, morphogenesis, differentiation, callus, direct, indirect organogenesis, and somatic embryogenesis, synthetic seeds.*In vitro* propagation and micropropagation, Seed culture, embryo culture, Meristem culture, bud culture, limitations and applications. Secondary metabolites, *In vitro*secondary metabolite production, Suspension cultures, cell cultures, growth vs secondary metabolite production, bioreactors and scaling up of secondary metabolite production, limitations, and applications.	
Unit -II Transgenic Plants and biosafety	**15**
Overview of transgenic plants and their significance in agriculture. - Techniques for introducing foreign genes into plants: Agrobacterium-mediated transformation, biolistics, and other methods. Selection and screening of transformed plants. Applications of Transgenic Plants - Improved crop traits through genetic engineering: pest resistance, herbicide tolerance, disease resistance, and abiotic stress tolerance. Biosafety assessment of transgenic plants: potential risks and benefits. International regulatory frameworks for releasing and commercializing genetically modified organisms (GMOs). Ethical and socio-economic impacts of transgenic crops. Intellectual property rights and access to transgenic technologies.	
Unit–III Animal Cell culture methods	**15**
History and laboratory organisation, Media. Cell types and culture characters. Pluripotency, Multipotency, Differentiation, Trans differentiation Reprogramming, Biology and characterization of cultured cells- cell adhesion, proliferation, differentiation,morphology of cells, and identification. The basic technique of mammalian cell culture in vitro, Measuring parameters of growth in cultured cells, cell viability, and cytotoxicity. Large-scale culture of cell lines- monolayer, suspension, and immobilized cultures. Organ and histotypic culture**:** Technique, advantages, limitations, applications. Stem cells: types (embryonic, adult, induced pluripotent), isolation, identification, expansion, differentiation and uses, stem cell engineering,ethical issues.	
Unit -IV Gene transfer in animals and applications	**15**
Gene constructs promoter/ enhancer sequences for transgene expression in animals. Selectable markers for animal cells- thymidine kinase. Transfection of animal cells- calcium phosphate coprecipitation, electroporation, lipofection, peptides, direct DNA transfer, viral vectors, Retrovirus, microinjection. Transgene identification methods. Transgenic and genome-edited animals. Ethical issues in transgenesis. Recent advances and applications in the field. Manipulation of animal reproduction and characterization of animal genes, Embryo transfer in cattle and applications. Somatic cell cloning - cloning of Dolly. Ethical issues. Production of recombinant vaccines.	

Pedagogy: Lectures, Seminars, Industry Visits, Debates, Quiz, and Assignments. Case studies highlight successful applications and challenges in transgenic crop development.

Summative Assessment = 60 Marks	
Formative Assessment /type	**Weightage in Marks**
Attendance	10
Seminar	10
Debates and Quiz	10
Test	10
Total	**60 marks + 40 marks = 100 marks**

Course Title	**Plant and Animal Biotechnology**	Practical Credits	**2**
Course Code	**DSC-A-12 (P)**	Contact hours	**60 hrs**

Content of Practical

1. Laboratory organization of basic and commercial plant tissue culture
2. Media preparation (MS, B5), solid media preparation, and Liquid media preparation
3. Explant preparation – Leaf, bud, rhizome, and meristem
4. Synthetic seed production
5. Callus culture- Initiation and establishment of different types of callus cultures
6. Micropropagation with a suitable example – Stage 0. 1, 2, 3, and 4
7. Staining, cell viability, and cell count of cell cultures
8. Preparation of cell culture media: Preparation of basic cell culture media, such as Dulbecco's Modified Eagle Medium (DMEM), supplemented with fetal bovine serum (FBS), antibiotics, and other required additives.
9. Aseptic techniques and sterile handling: Practicing aseptic techniques, including properly handling tools and equipment, working in a laminar flow hood, and maintaining sterility throughout the cell culture process.
10. Filter sterilization: Practice filter sterilization for sensitive media ingredients.
11. Cell counting and viability assessment: Count cells using a hemocytometer or automated cell counter, and perform viability assays (e.g., trypan blue exclusion) to determine the percentage of viable cells.
12. Cell staining and microscopy: Staining the cultured cells using dyes such as hematoxylin and eosin (H&E), and observe them under a light microscope to study cell morphology and structure.
13. Contamination identification and troubleshooting: Learn to identify and troubleshoot common issues in cell culture, such as contamination by bacteria, fungi, or mycoplasma, and implementappropriate corrective measures.
14. Experimental design and data analysis: Students can design and execute simple experiments, record and analyze data, and interpret the results based on their observations and measurements.

Practical Assessment

Formative Assessment		**Summative Assessment**	**Total Marks**
Assessment Occasion/ type	**Weightage in Marks**	**Practical Exams**	
Record	05	25	**50**
Test	10		
Attendance	05		
Performance	05		
Total	**25**	**25**	

References

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Program Name	**B.Sc. Biotechnology**	Semester	**5th Semester**
Course Title	**Biotechnology Skills and Analytical Techniques**		

Course No.	**SEC- 4**	No. of Theory Credits	**2+1 (Theory+Practical)**
Contact hours	**45 hrs**	Duration of ESA/Exam	**2 hrs**
Formative Assessment Marks	**20**	Summative Assessment Marks	**30**

Course Outcomes (COs): At the end of the course the student should be able to:

1. Demonstrate skills as per National Occupational Standards (NOS) of the "Lab Technician/Assistant" Qualification Pack issued by the Life Sciences Sector Skill Development Council-LFS/Q0509.
2. Develop knowledge of laboratory safety procedures and protocols and acquire skills in handling and maintaining laboratory equipment and instruments.
3. Operate analytical equipment and instruments as per standard operating procedures (SOP)
4. Knowledge about major activities of the biotech industry, regulations and compliance, environment, health and safety (EHS), good laboratory practices (GLP), and Good Manufacturing Practices (GMP) as per the industry standards.
5. Demonstrate soft skills, such as decision-making, planning, organizing, problem-solving, analytical thinking, critical thinking, and documentation.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-13)

Course Outcomes (COs)/Program Outcomes (POs)	1	2	3	4	5	6	7	8	9	10	11	12	13
Develop knowledge of laboratory safetyprocedures and protocols and acquireskills in handling and maintaining laboratory equipment and instruments.	✔	✔											
Operate analytical equipment and instruments as per standard operating procedures (SOP)		✔	✔									✔	
Knowledge about major activities of thebiotech industry, regulations and compliance, environment, health and safety (EHS), good laboratory practices (GLP), and Good Manufacturing Practices (GMP) as per the industry standards.		✔							✔		✔		
Demonstrate soft skills, such as decision making, planning, organizing, problemsolving, analytical thinking, criticalthinking and documentation.	✔	✔						✔	✔				

Biotechnology Skills and Analytical Techniques Content	**30 Hrs**
Unit-I Insights into the biotechnology industry and basic professional skills	**15**

Biotechnology Industry in Indian and Global Context- Organization in the context of large/medium/small enterprises, their structure, and benefits. **Industry-oriented professional skills:** Planning and organizing skills, decision-making, problem-solving skills, analytical thinking, critical thinking, team management, and risk assessment. Interpersonal skills: Writing skills, reading skills, oral communication, conflict resolution techniques, interpretation of research data, and troubleshooting in the workplace. **Digital skills:** Basic computer skills (MS Office, excel, power point, internet) for the workplace. Professional E-mail drafting skills and PowerPoint presentation skills. Overview of good manufacturing practices (GMP), Good Documentation practices (GDP), and good laboratory practices (GLP).
Unit- II Basic laboratory skills and Analytical Techniques **15**
Analytical skills in the laboratory: Preparations of solutions, molarity, molality, normality, mass percent % (w/w), percent by volume (%v/v), parts per million (ppm), parts per billion (ppb), dilution of concentrated solutions. Standard solutions, stock solution, and solution of acids. Reagent bottle label reading and precautions. **Analytical techniques:** Basic principle, operation, application, maintenance, calibration, validation, and troubleshooting of instruments- Microscope-Simple, compound, TEM, SEM, fluorescence. Centrifuge and different types, Hot air oven, pH meter, different types of pH electrodes Autoclave, Incubator, BOD, COD, cell counter, Laminar airflow. Spectroscopy-Colorimeter, UV-Visible spectroscopy. Electrophoresis- Agarose Gel electrophoresis, SDS-PAGE, PCR, Conductivity meter, and Potentiometer. Biosafety cabinets.

Pedagogy: Lectures, Seminars, Industry Visits, Debates, Quiz, and Assignments

Course title	**Quality control methods in biology (Practical)**	**Practical credits-1**	**5th Semester**
Course No.	**SEC -4**	Contact hours	4hrs/week
Content			
Unit-1			
Methods and practices of cleaning and management of lab: Learning and Practice of Integratedclean-in-place (CIP) and sterilize-in-place (SIP) as per industry standards, material requirementsfor cleaning specific areas, equipment, ventilation area, personal protective requirements Calibration of and use of micropipette.			
Unit-2			
Preparation of Standard Operating Procedure (SOP) for various equipment in the QC Lab, Best practices of using and storing chemicals: Knowledge and practice in handling chemicals, labeling, and stock maintenance. SOP and material handling. Procedures to maintain chemicals, labeling, storage, and disposal. **Handling and calibration of lab equipment-** weighing balance, Autoclave, Hot air Oven, Incubator, Centrifuge, Water bath, Colony Counter, and stability chamber, Preparation of Normality, Molarity, and buffer solutions			
Unit-3			

Preparation of media: Maintenance and storage of purified water for media (plant tissue culture media, microbiological media, and animal cell culture media) preparation. Preparation and storage of concentrated stock solutions. Documentation and disposal of expired stocks. Collection ofindents of media requirement, preparation, and storage. Media coding, documentation, and purpose of usage.

Demonstration, handling, and troubleshooting of High-Performance Liquid Chromatography and Gas chromatography.

Demonstration of Polymerase Chain Reaction (PCR), Hands-on training on colorimeter and spectrophotometer, Industry visit, or analytical laboratory visit.

Note: Semester end examination is only in the theory component; questions from the practical partcould be included, if any.

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Program Name	**B.Sc. Biotechnology**	Semester	**6th Semester**
Course Title	**Immunology (Theory + Practical)**		
Course Code:	**DSC-A13(T)**	No. of Theory Credits	**04**
Contact hours	**60 hrs**	Duration of ESA/Exam	**3 Hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Objectives:

1. To understand the various aspects of immunity, elicitation of immune responses, factors determining the outcome of immune responses and major players of immunity, relevancebetween nutritional support and immunity, and immunological techniques.
2. To provide knowledge on essential features of antigens and antibodies and their types and different theories of Antibody formation.
3. To acquire knowledge on types of immunity, phagocytosis, interferons, and the complement system.
4. To explain the concept of hypersensitivity, autoimmunity, and transplantation.
5. To provide knowledge on immune deficiencies and several immunological techniques

Course Outcomes:

At the end of the course, the student should be able to:

1. Demonstrate comprehension of the underlying structure and function of the immunesystem and related disorders.
2. Demonstrate an understanding of the role of cells and molecules in immune reactions andresponses
3. Demonstrate technical skills in immunological tools and techniques
4. Apply the domain-specific knowledge and skills acquired in immunology for innovativetherapies and Immunotechnologies
5. Understand the fundamental concepts of immunity, and the contributions of the organs and cellsin immune responses.
6. Realize how the MHC molecule's function and host encounters an immune insult.
7. Understand the antibodies and complement system
8. Understand the mechanisms involved in the initiation of specific immune responses
9. Differentiate the humoral and cell-mediated immune mechanisms
10. Comprehend the overreaction by our immune system leading to hypersensitive conditions and its consequences
11. Understand unique properties of cancer cells, immune recognition of tumors, immune evasionof cancers

Immunology - Content of Theory	**60 Hrs**
Unit–I Cells and Organs of the Immune System	**15**

Introduction to the Immune System: History of Immunology, Types of Immunity: first and second line of defense, innate and acquired/adaptive immunity, specificity, diversity. Cells of the immune system: Antigen-presenting cells (APCs), Role of B and T-lymphocytes in Humoral immunity and cell-mediated immunity, primary and secondary immune response, Immunization, memory. Organs of the Immune system: Thymus, bone marrow, spleen, Lymph Node, peripheral lymphoid organs	
Unit -II Molecules of the Immune System	**15**
Antigens and haptens: Properties (foreignness, molecular size, heterogeneity). Adjuvants. Antigenicityand Immunogenicity. Affinity and Avidity. B and T cell epitopes, superantigens Immunoglobulins: Classification, structure, and function. Antibody diversity, Monoclonal and polyclonal antibodies. Major histocompatibility complexes: Classification, structure, and function. Antigen processing pathways – Cytosolic and Endocytic, Complement Pathways, Cytokines: Classification and function, Hypersensitivity: Reactions – Types I, II, and III. Delayed Type Hypersensitive Response.	
Unit -III Immunotechniques and vaccines	**15**
Structure and properties of antigens- iso- and allo-antigens, antigen specificity, Cross-reactivity, Precipitation, Immunodiffusion reactions: Radial immunodiffusion, Ouchterlony double diffusion, Immunoelectrophoresis. Agglutination: Agglutination reactions. ELISA, RIA. Immunocytochemistry, Fluorescent Techniques. Vaccines: Conventional, peptide vaccines, subunit, DNA vaccines. Toxoids, antisera, edible vaccines, plantibodies, and Cancer vaccines.	
Unit - IV	**15**
Transplantation immunology: Phases in graft rejection and immuno-suppressors. Autoimmune Disorders: Systemic and Organ-specific Autoimmune disorders with examples Immunodeficiencies: Primary and secondary immunodeficiencies; acquired immunodeficiency syndrome Cancer and the immune system – immune surveillance, immunological escape, cancer antigens, cancerimmunotherapy Microbial diseases in humans**:** Mode of infection, symptoms, epidemiology and control measures of diseases caused by Viruses (Hepatits-B), Bacteria (Typhoid), Fungi (Aspergillosis), Protozoa (Malaria).	

Pedagogy: Lectures, Seminars, Industry Visits, Debates, Quiz and Assignments

Summative Assessment = 60 Marks	
Formative Assessment Occasion/ type	**Weightage in Marks**
Attendance	10
Seminar	10
Debates and Quiz	10
Test	10
Total	**60 marks + 40 marks = 100 marks**

Course Title	**Immunology (Practical)**	Practical Credits	**02**
Course No.	**DSC-A14 (P)**	Contact hours	**60 hrs**
Content of Practical			

1. Hemagglutination of ABO Blood groups
2. Determination of Rh factor
3. Whole Count of WBC using Hemocytometer
4. Cells of the Immune System
5. Radial immunodiffusion
6. Ouchterlony double diffusion
7. ELISA – Demonstrate
8. Serum Immunoelectrophoresis
9. Western Blotting

Practical Assessment			
Formative Assessment		**Summative Assessment**	**Total Marks**
Assessment Occasion/ type	**Weightage in Marks**	**Practical Exams**	
Record	05	25	**50**
Test	10		
Attendance	05		
Performance	05		
Total	**25**	**25**	

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Program Name	**B.Sc. Biotechnology**	Semester	**6th Semester**
Course Title	**Bioprocess and Environmental Biotechnology (Theory)**		
Course Code:	**DSC-A15 (T)**	No. of Theory Credits	**04**
Contact hours	**60 hrs**	Duration of ESA/Exam	**03 Hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Course Objectives:

1. Perform simulations of microbial growth and metabolism
2. Design bioreactors for the production of various products.
3. Present knowledge about major metabolic pathways and those related to biofuel production from microbes.
4. Understand the fundamental concepts and principles of environmental biotechnology and Explore the interrelationship between biotechnology and the environment.
5. Gain knowledge of the variousapplications of biotechnology in environmental conservation, pollution control, and sustainability.
6. Learn about microbial processes and their role in environmental biotechnology.
7. Understand the principles of bioremediation and its application in the clean-up of environmental pollutants.
8. Explore the potential of bioenergy production and waste management through biotechnological approaches.
9. Identify and characterize the most important contaminants in the Bioprocess and other industrial wastes.
10. Reuse/recycle the biological waste to clean technology such as energy, biofuel, bio fertilizer through bioremediation

Course out comes:

1. Exploitation of microorganisms for industrial use and their improvement, and formulation of media for efficient growth and production of microbial or cell-based products.
2. The design, operation, and specific applications of various bioreactors.
3. Demonstrate a comprehensive understanding of the fundamental concepts and principlesof environmental biotechnology.
4. Apply knowledge of biotechnological techniques to address environmental challenges,such as pollution control and waste management.
5. Analyze and evaluate environmental biotechnology case studies, research findings, andreal-world applications.
6. Design and implement biotechnological approaches for environmental remediation,utilizing microbial processes and biodegradation principles.
7. Evaluate the ethical and sustainable aspects of environmental biotechnology practices andmake informed decisions regarding their application in environmental conservation.
8. Communicate scientific concepts and research findings related to environmentalbiotechnology effectively, both in written and oral forms, to diverse audiences.

Bioprocess and Environmental Biotechnology – Content of Theory	60 hrs.
UNIT- I – Introduction to bioprocess technology	**15**
Basic principle components of fermentation technology. Strain improvement of industrially important microorganisms. Types of microbial culture and its growth kinetics– Batch, Fed-batch, and Continuous culture. Principles of upstream processing – Media preparation, Inocula development, and sterilization.	
UNIT- II-Bioreactors and downstream processing	**15**
Bioreactors- Significance of Impeller, Baffles, Sparger; Specializedbioreactors- design and their functions: airlift bioreactor, tubular bioreactors, membranebioreactors, tower bioreactors, fluidized bed reactor, packed bed reactors Downstream processing- cell disruption, precipitation methods, solid-liquid separation, liquid-liquid extraction, filtration, centrifugation, chromatography, drying devices (Lyophilization and spray dry technology), crystallization, biosensors-construction and applications, Microbial production of ethanol, amylase and Single Cell Proteins.	
Unit III- Fundamentals of Environmental Biotechnology	**15**
Introduction to Environmental Biotechnology- Principles of Environmental Science. Role of Biotechnology in Environmental Conservation. Microbial Processes in Environmental Biotechnology. Pollution and Biotechnology – Major issues in environmental pollution and the role of biotechnology in addressing them. Biotechnological Methods of Pollution Detection-General bioassay methods for pollution detection. Cell biological methods for assessing pollution levels. Use of biosensors in pollution monitoring. Biotechnological Methods in Pollution Abatement-Reduction of CO2 emission using biotechnologicalapproaches. Addressing eutrophication through biotechnological interventions. Application of cell immobilization techniques in pollution abatement.	
Unit IV- Bioremediation and Waste Management	**15**
Importance of bioremediation in environmental cleanup. Types of contaminants suitable for bioremediation. Microorganisms used in bioremediation. *In-situ* Bioremediation Methods. – Bioaugmentation. Biostimulation. Bioventing.Phytoremediation. *Ex-situ* Bioremediation Methods – Composting, Land farming, Biopile and bioslurry systems. Xenobiotics. Bio metallurgy and bio-mining. Waste water Management. Waste water Characterization and Composition. Biological Processes in Waste water Treatment. Activated Sludge Process and Biological Nutrient Removal, Anaerobic Digestion and Biogas Production. Solid Waste Management.	

Pedagogy: Lectures, Seminars, Industry Visits, Debates, Quiz and Assignments

Summative Assessment = 60 Marks	
Formative Assessment Occasion/ type	**Weightage in Marks**
Attendance	10
Seminar	10
Debates and Quiz	10
Test	10
Total	**60 marks + 40 marks = 100 marks**

Course Title	**Bioprocess and Environmental Biotechnology (Practical)**	Practical Credits	**02**
Course No.	**DSC-A16 (P)**	Contact hours	**60 hrs**

Content of Practical

1. Bacterial growth curve.
2. Calculation of the thermal death point (TDP) of a microbial sample.
3. Study of fermentor- Demonstration.
4. Production of wine.
5. Estimation of the percentage of alcohol, total acidity & volatile acidity in wine.
6. Production and analysis of ethanol.
7. Production and analysis of amylase.
8. Production and analysis of lactic acid.
9. Isolation of industrially important microorganisms from natural resources.
10. Standard analysis of Water.

Practical Assessment

Formative Assessment		**Summative Assessment**	**Total Marks**
Assessment Occasion/ type	**Weightage in Marks**	**Practical Exams**	
Record	05	25	**50**
Test	10		
Attendance	05		
Performance	05		
Total	**25**	**25**	

References

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
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Internship for Graduate Programme

Course title	**Internship Discipline specific**
No of contact hours	**90**
No credits	**2**
Method of evaluation	**Presentations/Report submission/Both**

<table>
<tr><td colspan="4">Project Assessment</td></tr>
<tr><td colspan="2">Formative Assessment</td><td>Summative Assessment</td><td rowspan="2">Total Marks</td></tr>
<tr><td>Assessment Occasion/ type</td><td>Weightage in Marks</td><td>Practical Exams</td></tr>
<tr><td>Data maintenance</td><td>10</td><td rowspan="3">Presentation/Report/Both
25</td><td rowspan="4">50</td></tr>
<tr><td>Assessment</td><td>10</td></tr>
<tr><td>Attendance</td><td>05</td></tr>
<tr><td>Total</td><td>25</td><td>25</td></tr>
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- Internship shall be Discipline Specific of 90 hours (2 credits) with duration 4-6 weeks.
- Internship may be full-time/part-time (full-time during semester holidays and part-time in the academic session)
- The student should submit the final internship report (90 hours of Internship) to the mentor for completion of the internship.
- The detailed guidelines and formats shall be formulated by the universities separately as prescribed in accordance to UGC and AICTE guidelines.