

University of Mumbai



No. AAMS_UGS/ICC/2024-25/ 109

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments is invited to this office circular No. AAMS_UGS/ICC/2023-24/23 dated 08th September, 2023 relating to the NEP UG & PG Syllabus.

They are hereby informed that the recommendations made by the **Ad-hoc Board of Studies in Life Science** at its meeting held on 01st July, 2024 and subsequently passed by the Board of Deans at its meeting held on 10th July, 2024 **vide** item No.6.11 (N) have been accepted by the Academic Council at its meeting held on 12th July, 2024 **vide** item No.6.11 (N) and that in accordance therewith **syllabus** for the **M.Sc (Life Sciences- Environmental Biotechnology) (Sem. III & IV)** is introduced as per appendix (NEP 2020) with effect from the academic year 2024-25.

(The circular is available on the University's website www.mu.ac.in).

Baliram

MUMBAI - 400 032

22nd August, 2024

To

(Prof.(Dr) Baliram Gaikwad)
I/c Registrar

The Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Department.

A.C/6.11 (N)/12/07/2024

Copy forwarded with Compliments for information to:-

- 1) The Chairman, Board of Deans,
- 2) The Dean, Faculty of Science & Technology,
- 3) The Chairman, **Ad-hoc Board of Studies in Life Science.**
- 4) The Director, Board of Examinations and Evaluation.
- 5) The Director, Board of Students Development.
- 6) The Director, Department of Information & Communication Technology.
- 7) The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanaagari.
- 8) The Deputy Registrar, Admissions, Enrolment, Eligibility & Migration Department (AEM).

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentre@gmail.com

Copy for information :-

1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

1	The Chairman, Board of Deans
2	The Dean, Faculty of Humanities,
3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in@gmail.com DSW directr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology,
7	The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari, director@idol.mu.ac.in

As Per NEP 2020

University of Mumbai



Title of the program
M. Sc. (Life Sciences – Environmental
Biotechnology)

Syllabus for
Semester – Sem.- III & IV
Ref: GR dated 16th May, 2023 for Credit Structure of PG

(With effect from the academic year 2024-25)

University of Mumbai



(As per NEP 2020)

Sr. No.	Heading	Particulars
1	Title of program O: _____ B	M.Sc. (Life Science - Environmental Biotechnology)
2	Scheme of Examination R: _____	NEP 50% Internal 50% External, Semester End Examination Individual Passing in Internal and External Examination
3	Standards of Passing R: _____	40%
4	Credit Structure R: <u>SP-55A</u> R: <u>SP-55B</u>	Attached herewith
5	Semesters	Sem. III
6	Program Academic Level	6.5
7	Pattern	Semester
8	Status	New
9	To be implemented from Academic Year	2024-25

Indu Anna George
9/7/2024

Sign of BOS Chairperson
Prof. Indu Anna George
Department of Life Sciences
Ad-hoc BOS in Life Sciences

Sign of Offg. Assoc. Dean
Dr. Madhav Rajvade
Offg. Assoc. Dean
Science and Technology
University of Mumbai

Sign of Offg. Dean
Prof. Shivram Garje
Dean Science and Technology
University of Mumbai

PREAMBLE

1. Introduction:

The Department of Life Sciences at the University is delighted to introduce the Master of Science (MSc) Programme, a comprehensive and dynamic two-year full-time course that aims to provide students with a deep understanding of the diverse aspects of life and its related disciplines. Life Sciences encompass a wide range of fields, offering fundamental knowledge about animals, plants, microorganisms, and the abiotic factors that influence their existence.

This specialized program delves into the intricacies of the biotic world, exploring the structures and functions of living organisms from physical, physiological, metabolic, biochemical, ecological, and socio-economic perspectives. Through this curriculum, students will embark on an exciting journey into the world of various techniques and technologies employed in the study of life, enabling them to appreciate the economic and ecological importance of the living and non-living things.

The MSc Programme in Life Sciences comprises interdisciplinary courses that encompass animal and plant sciences, microbiology, biochemistry and biophysics, molecular biology, and applied genetics. These comprehensive modules empower students to strengthen their knowledge in their respective areas of interest and gain insights into the wide-ranging opportunities available in this field. Additionally, the curriculum is designed to cultivate a deep appreciation for nature and natural resources, fostering skills for data observation and analysis in preparation for future research endeavours.

The Programme structure entails core papers of three theory and two practical in each semester, allowing students to gain theoretical knowledge as well as hands-on experience. With the implementation of the Choice Based Grading System, the evaluation process incorporates continuous assessment throughout the year, including both Internal Assessment and Term End Assessment. This comprehensive evaluation methodology ensures a holistic approach to students' progress and encourages active engagement throughout the academic year.

To further enhance the students' readiness for the industry, the curriculum incorporates a mandatory On Job Training (OJT) component in Semester II. This intensive training, equivalent to a full course, provides invaluable exposure to real-world scenarios within Life Sciences or Life Sciences-related organizations. By applying their theoretical knowledge in practical settings, students gain firsthand experience and develop the necessary skills to thrive in the professional world.

In addition to technical skills, this programme also focuses on cultivating research ethics and promoting a research-oriented mindset among learners. The inclusion of a Research Methodology Course helps students develop a strong research attitude, enabling them to contribute meaningfully to the advancement of Life Sciences.

Acknowledging the evolving trends in education and the need for flexible learning modes, the syllabus has been augmented to include an online component. Embracing the advantages offered by online learning, this component is designed to be optional, allowing both teaching faculties and students to collaboratively determine the topics to be covered in the online format. The authorities will oversee the final implementation of this innovative concept, recognizing its potential to revolutionize education by overcoming barriers of time, space, and infrastructure.

In conclusion, the M.Sc. Programme in Life Sciences equips students with a comprehensive understanding of the multidimensional aspects of life and its associated disciplines. With a

curriculum that combines theoretical knowledge, practical skills, on-the-job training, and the integration of online learning, students are prepared for diverse career opportunities and future research endeavours. We invite students to embark on this transformative academic journey, here they will unravel the mysteries of life, contribute to the advancement of scientific knowledge, and make valuable contributions to society.

2. Aims and Objectives

The aims and objectives of the M. Sc. Life Sciences programme collectively aim to develop well-rounded Life Sciences professionals who are not only technically competent but also capable of contributing to research, innovation, and the overall advancement of the field.

Objectives:

The M. Sc Life Sciences programme is designed to help students to:

- a) Acquire a comprehensive knowledge base in various disciplines of Life Sciences, providing a strong foundation for further studies and research. Students will develop a deep understanding of key concepts, theories, and methodologies in genetics, cellular biology, ecology, physiology, molecular biology, and other relevant areas.
- b) Foster a deep interest in the diverse branches of Life Sciences, encouraging curiosity and exploration. Students will be inspired to delve into specialized areas of interest and engage in independent learning.
- c) Understand the rich diversity of organisms and appreciate their ecological, genetic, and evolutionary significance. Students will gain insights into the interconnections between different species and ecosystems, recognizing the importance of biodiversity conservation.
- d) Develop essential skills in observation, biological techniques, experimental skills, and scientific investigation, enabling them to contribute to the field through rigorous and reliable research. Students will be trained to design and execute experiments, analyze data, and draw scientifically sound conclusions.
- e) Cultivate an understanding of the interconnectedness and harmony of different life systems, while recognizing the importance of maintaining good health through appropriate measures. Students will grasp the intricate relationships between organisms and their environment, emphasizing the significance of sustainable practices for both human and ecological well-being.
- f) Gain knowledge and skills in applied branches of Life Sciences that can contribute to self-employment and entrepreneurial opportunities. Students will be equipped with practical knowledge and expertise in areas with direct applications, enabling them to explore entrepreneurial ventures or pursue specialized career paths.
- g) Promote awareness and concern for the conservation of the biosphere, emphasizing the importance of environmental sustainability and responsible stewardship. Students will develop a deep appreciation for the biosphere and its conservation, becoming advocates for sustainable practices and environmental protection.
- h) Enhance students' Social Intelligence Quotient (SIQ) and Emotional Quotient (EQ), fostering their development as well-rounded individuals and responsible citizens who can positively impact humanity through their acquired and developed knowledge. Students will develop strong interpersonal skills, empathy, and cultural sensitivity to effectively collaborate with diverse stakeholders and address societal challenges.
- i) Equip students with the necessary skills and mindset to be self-sustainable and encourage them to become future entrepreneurs, fostering innovation and economic growth. Students will cultivate an entrepreneurial mindset, including critical thinking, problem-solving, creativity, and adaptability, preparing them to identify opportunities and contribute to the growth of the life sciences industry.
- j) Provide students with a comprehensive understanding of key concepts, theories, and methodologies in Life Sciences. It covers a range of topics including genetics, cellular biology, ecology, physiology, and molecular biology, enabling students to develop a deep knowledge

base in these areas.

- k) Equip students with practical skills through hands-on experience with laboratory techniques, data analysis, and scientific methodologies. Students will gain proficiency in conducting experiments, analyzing data, and interpreting results, enhancing their ability to apply theoretical knowledge to practical situations.
- l) Enhance students' critical thinking and problem-solving abilities by challenging them to analyze complex biological systems, evaluate scientific literature, and propose innovative solutions to biological problems.
- m) Foster collaboration and an interdisciplinary approach to problem-solving by providing opportunities for teamwork, group projects, and interactions with professionals from different scientific disciplines. Students will develop effective communication and teamwork skills, preparing them for collaborative work environments.
- n) Stay updated with the latest trends and advancements in Life Sciences to ensure graduates are well-prepared for the demands of the industry. Through industry collaborations, guest lectures, and exposure to emerging technologies, students will acquire knowledge and skills that are relevant and applicable to real-world scenarios.
- o) Develop students' professional skills, including scientific writing, presentation skills, project management, and leadership. Students will have opportunities to participate in conferences, workshops, and seminars to enhance their professional development and networking abilities.
- p) Cultivate research skills among students by providing training in research methodologies, data analysis techniques, and critical evaluation of scientific literature. Students will have opportunities to engage in independent or collaborative research projects, enabling them to contribute to the advancement of Life Sciences through original research findings.

By incorporating these objectives, the M. Sc. Life Sciences program aims to produce graduates who possess a strong foundation in Life Sciences, are adept at problem-solving and collaboration, have industry-relevant skills, and are well-prepared for both research and professional roles in the field. The program strives to foster a deep understanding of Life Sciences, promote scientific inquiry, nurture innovation, and empower students to make meaningful contributions to society.

3. Learning Outcomes

The proposed M. Sc. Programme in Life Sciences aims to provide students with a comprehensive and holistic understanding of the field, equipping them with the skills and knowledge necessary to excel in the ever-evolving biological sciences domain. Learning outcome of the Programme are:

- a) Apply advanced scientific principles and cutting-edge technology to solve complex real-world problems in diverse fields such as healthcare, agriculture, and environmental conservation.
- b) Critically analyze and evaluate current research literature and effectively communicate scientific concepts and findings to both scientific and non-scientific audiences.
- c) Develop innovative and sustainable research projects that adhere to international standards and consider practical limitations and ethical considerations.
- d) Demonstrate an in-depth understanding of the structural organization and functional interactions between organisms and their environments, with an emphasis on the integration of interdisciplinary knowledge.
- e) Evaluate and synthesize advanced concepts in plant, microbial, and animal physiology and biotechnology, and apply this knowledge to address contemporary challenges in the field.
- f) Conduct quantitative and comparative studies, employing advanced statistical methods, to investigate and elucidate various aspects of biological sciences, including ecological interactions, genetic diversity, and population dynamics.
- g) Utilize bioinformatics tools and techniques to generate, analyze, and interpret large-scale biological data, including the construction of databases, sequence alignments, and predictive modeling.
- h) Apply state-of-the-art technologies and methodologies to explore and comprehend the intricate mechanisms underlying genome and protein biology, including gene expression regulation and

protein-protein interactions.

- i) Discuss and critically evaluate the legal and ethical aspects of intellectual property rights (IPR) and the responsible conduct of research, with an understanding of the social and economic implications of biology-related innovations.

Foster cross-cultural competence by actively collaborating in diverse teams, valuing and respecting diverse perspectives, and effectively contributing to scientific projects with individuals from different cultural backgrounds.

1) **Credit Structure of the Program (Sem III & IV) (Table as per Parishisht 1 with sign of HOD and Dean)**

R: SP- 55B

Post Graduate Programs in University

Parishishta - 1

Exit option: PG Diploma (44 Credits) after Three Year UG Degree									
II	6.5	Sem III	Course 1 Credits 4 Course 2 Credits 4 Course 3 Credits 4 Course 4 Credits 2	Credits 4 Course 1 OR Course 2 OR			4	22	PG Degree After 3-Yr UG
		Sem IV	Course 1 Credits 4 Course 2 Credits 4 Course 3 Credits 4	Credits 4 Course 1 OR Course 2 OR			6	22	
Cum. Cr. for 1 Yr PG Degree			26	8			10	44	
Cum. Cr. for 2 Yr PG Degree			54	16	4	4	10	88	

Second Year PG:

Year (2Yr PG)	Level	Sem. (2Yr)	Major		RM	OJT / FP	RP	Cum. Cr.	Degree
			Mandatory	Electives					
II	6.5	Sem III	Course LScENBT601: Molecular Aspects of Environment Credits 4 Course LScENBT602: Molecular Aspects of Environment Practicals Credits 2 Course LScENBT603: Health Aspects of Environment Credits 4 Course LScENBT604 : Health Aspects of Environment Practicals Credits 2 Course LScENBT605: Environmental Technology Interventions Credits 2	Credits 4 Course LScENBT606a: Industrial Biotechnology for Sustainable Production 2 TH + 2 PR OR Course LScENBT606b: Bioenergy and Biofuels 2 TH + 2 PR OR Course LScENBT606c: Biotechnology for Soil and Plant Health Management 2 TH + 2 PR OR Course LScENBT606d: Environmental Biotechnology for Water and Wastewater Treatment 2 TH + 2 PR OR Course LScENBT606e: Bioremediation Techniques for Environmental Cleanup 2 TH + 2 PR			LScBT607 (4)	22	PGDegree After 3-Yr UG

		Sem IV	Course LScENBT608: Applied Environmental Biotechnology-I Credits 4 Course LScENBT609: Applied Environmental Biotechnology- I Practicals Credits 2 Course LScENBT610: Applied Environmental Biotechnology-II Credits 4 Course LScENBT611: Applied Environmental Biotechnology-II Practicals Credits 2	Credits 4 Course LScENBT612a: Environmental Bioinformatics 2 TH + 2 PR OR Course LScENBT612b:Biotechnology in Environmental Risk Assessment 2 TH + 2 PR OR Course LScENBT612c: Environmental Biotechnology and Public Policy 2 TH + 2 PR OR Course LScENBT612d: Biotechnology in Industry 2 TH + 2 PR OR Course LScENBT612e: Nanotechnology in Environmental Applications 2 TH + 2 PR			LScBT6013 (6)	22	
Cum. Cr. for 1 YrPGDegree			26	8			10	44	
Cum. Cr. for 2 YrPGDegree			54	16	4	4	10	88	

DETAILED
SYLLABUS SEMESTER III

Paper Code	Unit	Description	Credits	Hrs
Course LScENBT601		Molecular Aspects of the Environment	4	60
Module1	I	Epigenetics and Environment	1	
	II	Molecular Genetic Techniques	1	
Module2	III	Genetic Aspects of PCB and Aromatic Hydrocarbons Degradation	1	
	IV	Molecular Epidemiologic Approaches in Environmental Carcinogenesis	1	
Course LScENBT602		Molecular Aspects of Environment Practicals	2	60
		Molecular Aspects of Environment Practicals		
Course LScENBT603		Health Aspects of Environment	4	60
Module1	I	Environmental Pollutants and Human Health	1	
	II	Mechanisms of Toxicity and Biotransformation	1	
Module2	III	Eco-toxicological Risk Assessment	1	
	IV	Strategies for Environmental Health Protection/Regulatory Frameworks	1	
Course LScENBT604		Health Aspects of Environment Practicals	2	60
Module1		Health Aspects of Environment Practicals		
Course LScENBT605		Environmental Technology Interventions	2	30
Module1	I	Advanced Environmental Biotechnology	1	
	II	Practical Applications of Environmental Technology	1	
ELECTIVES				
Course LScENBT606a		Industrial Biotechnology for Sustainable Production	4	90
Module1: LScENBT606a T	I	Bioprocessing Technologies for Sustainable Production	1	15
	II	Biocatalysis and Green Chemistry	1	15
Module2: LScENBT606a P		Industrial Biotechnology for Sustainable Production Practicals	2	60
Course LScENBT606b		Bioenergy and Biofuels	4	90
Module1: LScENBT606b T	I	Bioenergy Sources and Conversion Technologies	1	15
	II	Bioenergy Policies and Environmental Impacts	1	15
Module 2:		Bioenergy and Biofuels Practicals	2	60

LScENBT6 06bP				
CourseLScENBT6 06c		Biotechnology for Soil and Plant Health Management	4	90
Module1: LScENBT606c T	I	Bioenergy and Biofuels Practicals	1	15
	II	Soil Microbial Ecology and Plant Interactions	1	15
Module2: LScENBT6 06cP		Biotechnology for Soil and Plant Health Management Practicals	2	60
CourseLScENBT6 06d		Environmental Biotechnology for Water and Wastewater Treatment	4	90
Module1: LScENBT606d T	I	Water Pollution and Treatment Technologies	1	15
	II	Biotechnological Approaches for Wastewater Remediation	1	15
Module 2: LScENBT6 06dP		Environmental Biotechnology for Water and Wastewater Treatment Practicals	2	60
CourseLScENBT6 06e		Bioremediation Techniques for Environmental Cleanup	4	90
Module1: LScENBT606e T	I	Fundamentals of Bioremediation	1	15
	II	Bioremediation Strategies and Applications	1	15
Module 2: LScENBT6 06eP		Bioremediation Techniques for Environmental Cleanup Practicals	2	60
CourseLScENBT60 7		Research Project I	4	120

SEMESTERIV

PaperCode	Unit	Applied Environmental Biotechnology-I	Credits	Hrs
CourseLScENBT6 01		Environmental Monitoring and Analysis Techniques	4	60
Module1	I	Microbial Applications in Waste Management	1	
	II	Environmental Nanotechnology	1	
Module2	III	Industrial Biotechnology for Environmental Sustainability	1	
	IV	Applied Environmental Biotechnology-I Practical	1	
CourseLScENBT6 02		Applied Environmental Biotechnology-I Practical	2	60
		Applied Environmental Biotechnology-II		
CourseLScENBT6 03		Environmental Microbial Genomics	4	60
Module1	I	Biotechnology for Climate Change Mitigation	1	
	II	Sustainable Agriculture and Agri-	1	

		biotechnology		
Module2	III	Ethics, Equity, and Policy in Environmental Biotechnology	1	
	IV	Applied Environmental Biotechnology-II Practical	1	
Course LScENBT611		Applied Environmental Biotechnology-II Practical	2	60
Module 1		Applied Environmental Biotechnology-I		
Course LScENBT612		Environmental Monitoring and Analysis Techniques	2	30
ELECTIVES				
Course LScENBT612a		Environmental Bioinformatics	4	90
Module 1: LScENBT612a T	I	Fundamentals of Bioinformatics in Environmental Sciences	1	15
	II	Advanced Techniques in Environmental Bioinformatics	1	15
Module 2: LScENBT612a P		Environmental Bioinformatics Practicals	2	60
Course LScENBT612b		Biotechnology in Environmental Risk Assessment	4	90
Module 1: LScENBT612b T	I	Fundamentals of Environmental Risk Assessment	1	15
	II	Biotechnological Approaches in Risk Assessment	1	15
Module 2: LScENBT612 bP		Biotechnology in Environmental Risk Assessment Practicals	2	60
Course LScENBT612c		Environmental Biotechnology and Public Policy	4	90
Module 1: LScENBT612c T	I	Policy Frameworks in Environmental Biotechnology	1	15
	II	Role of Environmental Biotechnology in Public Policy	1	15
Module 2: LScENBT612cP		Environmental Biotechnology and Public Policy Practicals	2	60
Course LScENBT612d		Biotechnology in Industry	4	90
Module 1: LScENBT612d T	I	Industrial Applications of Biotechnology	1	15
	II	Biotechnology in Pharmaceutical and Healthcare Industries	1	15
Module 2: LScBT612dP		Biotechnology in Industry Practicals	2	60
Course LScENBT612e		Nanotechnology in Environmental Applications	4	90
Module 1: LScENBT612e	I	Fundamentals of Nanotechnology	1	15

T				
	II	Nanotechnology in Environmental Remediation	1	15
Module 2: LScENBT612eP		Nanotechnology in Environmental Applications Practicals	2	60
Course LscENBT613		Research Project II	6	180

Sem. - III

M.Sc. (Life Sciences – Environmental Biotechnology) (Semester - III)

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester III	Course Name: Molecular Aspects of Environment
Total Credits: 04	Total Marks: 100
Department assessment: 50	University assessment: 50

Course Outcomes:

1. Master the interplay between epigenetics and environmental factors, understanding how molecular mechanisms such as DNA methylation, histone modification, and non-coding RNAs respond to and influence environmental changes. This leads to critical insights into developmental processes and disease etiology.
2. Develop proficiency in advanced molecular genetic techniques, including karyological analysis, allozyme electrophoresis, mitochondrial DNA sequence analysis, and RAPD, to analyze genetic variability, phylogenetic distinctions, and evolutionary processes. This will enhance students' research capabilities and practical skills in environmental biotechnology.
3. Study the role of microbial degradation pathways, cloning, and genetic engineering approaches to gain expertise in the genetic mechanisms behind the biodegradation of pollutants, particularly PCBs and aromatic hydrocarbons. This will prepare students to contribute to innovative environmental remediation solutions.
4. Explore the molecular epidemiologic approaches in environmental carcinogenesis, focusing on the regulation and impact of human gene inducibility by environmental factors, with in-depth knowledge of genes such as Cytochrome P450 and Metallothionein, enabling students to understand and address the genetic basis of environmental health issues.

Course Code	Course Title	Total Credits
LScENBT60 1	Molecular Aspects of Environment	04
Unit I: Epigenetics and Environment (15 clock hours)		02
Introduction to Epigenetics and Environmental Control (4 clock hours)		
- Understanding the molecular basis of epigenetic regulation. - Role of environmental factors in influencing epigenetic changes. - Key mechanisms of epigenetic modifications: DNA methylation, histone modification, and non-coding RNAs.		
Cell Differentiation, Stem Cells, and Epigenetics (4 clock hours)		
- Epigenetic regulation during cell differentiation and development. - Role of stem cells in tissue regeneration and repair. - Epigenetic markers in stem cell biology and their therapeutic potential.		
Developmental Symbiosis and Survival Mechanisms (3 clock hours)		
- Interactions between developing organisms and their environment. - Epigenetic responses to environmental stress during embryonic development.		

• Mechanisms of embryonic defense and adaptation. Environment, Teratogenesis, and Endocrine Disruptors (2 clock hours) • Environmental teratogens and their impact on development. • Role of endocrine disruptors in altering epigenetic programming. • Mechanisms by which environmental factors induce teratogenesis. Epigenetic Origin of Diseases and Intervention Strategies (2 clock hours) • Link between epigenetic changes and the onset of diseases. • Strategies for disease intervention targeting epigenetic modifications. • Evolution of epigenetic regulatory mechanisms and their health implications. Unit II: Molecular Genetic Techniques (15 clock hours) Introduction to Molecular Genetic Techniques (3 clock hours) • Overview of molecular techniques used in genetic research. • Importance of genetic variability and phylogenetic distinctions. • Role of genetic techniques in understanding evolutionary processes. Molecular Tools for Genetic Analysis (6 clock hours) • Karyological Analysis: Techniques and applications in genetic research. • Allozyme Electrophoresis: Principles and methodologies. • Mitochondrial DNA Sequence Analysis: Applications in phylogenetics. • Hypervariable DNA and Single Copy DNA Analysis: Techniques and significance. • RAPD (Random Amplified Polymorphic DNA): Procedure and uses. Applications of Molecular Genetic Techniques (6 clock hours) • Phylogenetic Distinction and Phylogeographic History. • Assessing Genetic Variability and Individuality. • Understanding Reproductive Success and Genetic Representation. • Genetic Management and Conservation Strategies	
Unit III: Genetic Aspects of PCB and Aromatic Hydrocarbons Degradation (15 clock hours) Introduction to PCB Biodegradation (4 clock hours) • Overview of Polychlorinated Biphenyls (PCBs) and their environmental impact. • Mechanisms of microbial degradation of PCBs. • Role of <i>Pseudomonas</i> sp. LB400 in PCB degradation: Identification and characterization of bph genes. Genetic Analysis of <i>Pseudomonas</i> sp. in PCB Degradation (4 clock hours) • Comparison of bph genes in different <i>Pseudomonas</i> strains. • Stability and functionality of bph genes in PCB degradation. • Case study: <i>Pseudomonas Pseudoalcaligenes</i> KF707 and its bph gene cluster. Aromatic Hydrocarbon Degradation Mechanisms (4 clock hours) • Introduction to microbial degradation of aromatic hydrocarbons. • Cloning and molecular analysis of degradation genes. • Specific pathways for Toluene and polycyclic hydrocarbon (PAHs) degradation. Biodegradative Applications of Cloned Genes (3 clock hours) • Practical applications of biodegradation pathways in environmental remediation.	02

- Genetic engineering approaches to enhance microbial degradation.
- Prospects and challenges in biodegradative gene applications.

Unit IV: Molecular Epidemiologic Approaches in Environmental Carcinogenesis (15 clock hours)

Introduction to Molecular Epidemiology (3 clock hours)

- Basics of molecular epidemiology and its role in environmental health.
- Concepts of internal dose, biologically effective dose, and biological response.
- Biomarkers of altered structure/function and susceptibility.

Human Gene Inducibility and Environmental Modulation (6 clock hours)

- Overview of inducible genes and their environmental regulation.
- Detailed study of Cytochrome P450 Genes: CYP1A1, CYP2D6, and CYP2E1.
- Metallothionein Genes: Transcription, metal regulation, and gene expression.

Cytochrome P450 Genes in Environmental Carcinogenesis (3 clock hours)

- Role of CYP genes in metabolizing environmental carcinogens.
- Impact of environmental factors on CYP gene expression and activity.
- Case studies on CYP gene-related carcinogenesis.

Metallothionein Genes and Environmental Modulation (3 clock hours)

- Molecular biology of MT gene transcription and regulation.
- Influence of environmental metals on MT gene expression.
- Human lymphocyte MT gene inducibility and its health implications.

REFERENCE:

Epigenetics: Development and Disease

- Author: Tapas K. Kundu
- Publisher: Narosa Publishing House
- Description: This book covers the molecular mechanisms of epigenetic regulation and its implications in development and disease, focusing on environmental influences.

Molecular Biology and Genetic Engineering

- Author: P.K. Gupta
- Publisher: Rastogi Publications
- Description: This comprehensive textbook includes sections on molecular techniques, genetic analysis, and applications in biotechnology, with a particular emphasis on environmental genetics.

Environmental Biotechnology: Theory and Applications

- Author: Gareth G. Evans and Judith C. Furlong (Indian edition)
- Publisher: Oxford University Press India
- Description: This book provides insights into the applications of biotechnology in environmental management, including the degradation of pollutants and the genetic basis of these processes.

Epigenetics

- Editors: C. David Allis, Marie-Laure Caparros, Thomas Jenuwein, Danny Reinberg
- Publisher: Cold Spring Harbor Laboratory Press

- Description: This authoritative text offers a detailed exploration of epigenetic mechanisms and their environmental interactions, suitable for advanced study and research.

Molecular Environmental Biology

- Authors: Alan R. Hemsley and Imogen Poole
- Publisher: Cambridge University Press
- Description: This book examines the molecular basis of environmental biology, including genetic and epigenetic aspects, and their applications in environmental science and technology.

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester III

Total Credits: 04

Department assessment: 25

Course Name: Molecular Aspects of Environment- Practicals

Total Marks: 50

University assessment: 25

Course Outcomes:

1. Develop proficiency in cutting-edge molecular techniques, such as DNA methylation analysis, histone modification assays, and non-coding RNA profiling, enabling students to investigate the intricate relationships between environmental factors and genetic regulation.
2. Master practical skills in stem cell isolation, characterization, and epigenetic marker assessment, fostering a deep understanding of cell differentiation and the impact of environmental contaminants on developmental processes and health.
3. Apply advanced genetic and biochemical methodologies, including PCR-based detection, karyological analysis, RAPD for genetic diversity, and mitochondrial DNA sequence analysis, to real-world environmental samples, preparing students for impactful careers in environmental biotechnology and research.
4. Explore innovative approaches to environmental remediation and epidemiology, such as cloning and expressing PCB degradation genes, analyzing biodegradation pathways for aromatic hydrocarbons, and conducting molecular epidemiologic studies on environmental carcinogens, ensuring students are equipped to address contemporary environmental challenges with scientific rigor and creativity.

Course Code	Course Title	Total Credits
LScENBT602	Molecular Aspects of Environment- Practicals	02
MODULE I		02
1. Analysis of DNA Methylation Patterns in Environmental Samples		
2. Histone Modification Assays for Environmental Epigenetic Studies		
3. Non-coding RNA Profiling in Environmental Contexts		
4. Isolation and Characterization of Stem Cells from Environmental Samples		
5. Assessing Epigenetic Markers in Cell Differentiation		
6. Evaluating Teratogenic Effects of Environmental Contaminants		
7. DNA Damage and Repair Assays in Response to Environmental Stress		
8. Karyological Analysis of Environmental Samples		
9. Mitochondrial DNA Sequence Analysis for Phylogenetic Studies		
10. RAPD Analysis for Genetic Diversity Assessment		
11. PCR-based Techniques for Detection of Biodegradation Genes		
12. Cloning and Expression of PCB Degradation Genes		
13. Biodegradation Pathway Analysis for Toluene		
14. Case Study: Molecular Epidemiology of Environmental Carcinogens		
15. Cytochrome P450 Gene Expression Analysis in Environmental Samples		

REFERENCE:

Techniques in Molecular Biology

- Author: J.M. Walker and W. Rapley
- Publisher: CBS Publishers & Distributors
- Description: This book provides detailed protocols for various molecular biology techniques, including DNA methylation analysis, histone modification assays, and non-coding RNA profiling, tailored for practical laboratory work.

Handbook of Techniques in Biotechnology.

- Authors: Rashmi Ranade and Sanjay Deshmukh
- Publisher: Stadium Press India Pvt. Ltd., New Delhi, India. 2013. 379p.
- ISBN: 9978-93-80012-55-1
- Description: This reference book offers comprehensive protocols and methodologies for various biotechnological applications, which is ideal for students and researchers.

Molecular Biology and Biotechnology: Basic Experimental Protocols

- Author: S. K. Ghosh and S. Kumar
- Publisher: I.K. International Publishing House Pvt. Ltd
- Description: This textbook covers various experimental techniques in molecular biology and biotechnology, including stem cell isolation, epigenetic markers assessment, and DNA damage assays.

Practical Biochemistry and Biotechnology

- Author: M. N. Sastri
- Publisher: New Age International Publishers
- Description: This practical manual includes protocols for karyological analysis, PCR-based techniques, and genetic diversity assessments using RAPD analysis, making it ideal for hands-on laboratory sessions.

Molecular Cloning: A Laboratory Manual

- Authors: Michael R. Green and Joseph Sambrook
- Publisher: Cold Spring Harbor Laboratory Press
- Description: Known as the "bible" of molecular biology, this comprehensive manual provides detailed protocols for cloning, gene expression analysis, and various DNA and RNA assays, crucial for environmental biotechnology practicals.

Current Protocols in Molecular Biology

- Editors: Frederick M. Ausubel, Roger Brent, Robert E. Kingston, David D. Moore, J. G. Seidman, John A. Smith, and Kevin Struhl
- Publisher: John Wiley & Sons

Description: This extensive collection of protocols covers various molecular biology techniques, including mitochondrial DNA analysis, RAPD, and cytochrome P450 gene expression analysis, suitable for advanced practical training.

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester III

Total Credits: 04

Department assessment: 50

Course Name: Health Aspects of Environment

Total Marks: 100

University assessment: 50

Course Outcomes:

1. Attain an in-depth understanding of environmental pollutants and their health impacts, equipping students with the ability to identify and analyze various pollutants, understand their sources, and assess their acute and chronic effects on human health, thereby fostering a proactive approach to environmental health challenges.
2. Develop expertise in advanced risk assessment methodologies, enabling students to systematically evaluate human health risks associated with environmental contaminants through hazard identification, dose-response assessment, and exposure modeling, preparing them to contribute to evidence-based policy-making and regulatory frameworks.
3. Master the cellular and molecular mechanisms of toxicity, including biotransformation and biomarkers. This will provide students with the knowledge to explore the complex interactions between toxicants and biological systems and assess bioavailability, bioaccumulation, and the efficacy of detoxification processes.
4. Integrate ecological and human health risk assessments through case studies and predictive modeling, empowering students to apply interdisciplinary approaches to assess and mitigate risks, predict environmental impacts, and engage in innovative research to address emerging environmental health threats, ensuring they are well-prepared for future scientific and professional endeavours.

Course Code	Course Title	Total Credits
LScENBT603	Health Aspects of Environment	04
MODULE I		02
Unit 1: Environmental Pollutants and Human Health		
Identification of Common Environmental Pollutants and Their Sources (4 clock hours)		
• Overview of major categories of environmental pollutants (chemical, biological, physical). • Common sources of pollutants in air, water, soil, and food sources. • Identification methods for specific pollutants using analytical techniques. • Case studies illustrating sources and distribution of environmental pollutants.		
Routes of Exposure and Pathways of Entry into the Human Body (4 clock hours)		
• Routes of exposure to environmental pollutants (inhalation, ingestion, dermal contact). • Mechanisms of pollutant absorption, distribution, metabolism, and excretion. • Factors influencing bioavailability and bioaccumulation of pollutants in human tissues. • Modeling approaches to predict exposure pathways and internal doses of pollutants		

Health Effects Associated with Exposure to Environmental Contaminants (4 clock hours)

- Acute and chronic health effects of common environmental pollutants. Mechanisms of toxicity and adverse health outcomes associated with pollutant exposure.
- Vulnerable populations at increased risk of pollutant-related health impacts.
- Epidemiological studies linking environmental exposures to human health effects

Risk Assessment Methodologies for Evaluating Human Health Impacts (3 clock hours)

- Principles and frameworks of human health risk assessment.
- Hazard identification, dose-response assessment, exposure assessment, and risk characterization.
- Uncertainty and variability considerations in risk assessment processes.
- Application of risk assessment methodologies to real-world scenarios and case studies.

Unit 2: Mechanisms of Toxicity and Biotransformation

Cellular and Molecular Mechanisms of Toxicity Induced by Environmental Pollutants (4 clock hours)

- Overview of cellular targets and molecular pathways affected by environmental toxicants.
- Mechanisms of direct and indirect toxicity, including oxidative stress, genotoxicity, and endocrine disruption.
- Cellular responses to toxic insults, including apoptosis, necrosis, and autophagy.
- Factors influencing the susceptibility of cells and tissues to toxicant-induced damage.

Biotransformation Processes Involved in Detoxification and Elimination of Xenobiotics (5 clock hours)

- Phases I, II, and III biotransformation reactions in xenobiotic metabolism.
- Enzymatic pathways involved in activation and detoxification of environmental pollutants.
- Role of cytochrome P450 enzymes, Glutathione-S-transferases, and other detoxification enzymes.
- Regulation of biotransformation pathways and factors influencing metabolic rates

Factors Influencing the Bioavailability and Bioaccumulation of Toxicants (4 clock hours)

- Physicochemical properties affecting the absorption, distribution, and excretion of toxicants.
- Biological factors influencing toxicant bioavailability, including metabolism and excretion rates.
- Environmental factors affecting toxicant mobility, persistence, and bioavailability in ecosystems.
- Modeling approaches to predict toxicant bioavailability and bioaccumulation in organisms.

Role of Biomarkers in Assessing Exposure and Health Outcomes (3 clock hours)

• Definition and classification of biomarkers for exposure, effect, and susceptibility. • Methods for biomarker discovery, validation, and application in environmental health research. • Biomarkers of exposure to specific environmental pollutants (heavy metals, pesticides, etc.). • Integration of biomarker data with epidemiological and clinical outcomes for risk assessment.	
MODULE II Unit 3: Eco-toxicological Risk Assessment Principles and Methods of Eco-toxicological Risk Assessment (4 clock hours) • Introduction to eco-toxicological risk assessment concepts and principles. • Frameworks for assessing ecological risks posed by chemical contaminants. • Toxicity endpoints and assessment factors used in eco-toxicological risk assessment. • Data sources, uncertainty analysis, and risk characterization in ecological risk assessment. Predictive Modeling Approaches for Assessing Environmental Risk (4 clock hours) • Overview of mathematical and statistical models used in environmental risk assessment. • Exposure-response modeling for predicting effects of contaminants on ecosystems. • Spatial and temporal modeling of contaminant fate and transport in environmental media. • Uncertainty and sensitivity analysis in predictive modeling for risk assessment. Integration of Ecological and Human Health Risk Assessments (4 clock hours) • Comparative risk assessment frameworks for integrating ecological and human health risks. • Methods for characterizing exposure pathways and routes for both ecological and human receptors. • Approaches for weighting and aggregating risks across multiple endpoints and receptors. • Case studies demonstrating integrated risk assessments for complex environmental scenarios. Case Studies and Applications of Risk Assessment Frameworks (3 clock hours) • Review of selected case studies applying eco-toxicological risk assessment methodologies. • Analysis of risk assessment outcomes and their implications for environmental management. • Application of risk assessment frameworks to regulatory decision-making and policy development. • Future directions and challenges in eco-toxicological risk assessment research and practice. Unit 4: Strategies for Environmental Health Protection/ Regulatory Frameworks Policies for Environmental Health Protection (4 clock hours) • Overview of national and international regulatory agencies responsible for	02

environmental health. • Analysis of critical environmental laws, regulations, and pollution control policies. • Role of risk assessment and risk management in informing environmental health regulations. • Challenges and opportunities in implementing and enforcing environmental health policies. Risk Management Strategies for Mitigating Environmental Health Risks (4 clock hours) • Identification and prioritization of environmental health hazards and exposures. • Selection and implementation of risk reduction measures, including engineering controls and administrative actions. • Cost-benefit analysis and decision-making processes in risk management strategies. • Monitoring and evaluation of risk management interventions for effectiveness and compliance. Public Health Interventions and Community Engagement Initiatives (4 clock hours) • Strategies for promoting public awareness and education on environmental health issues. • Community-based participatory research and intervention approaches for environmental health protection. • Stakeholder engagement and collaboration in developing and implementing health promotion programs. • Evaluation of community empowerment and capacity-building initiatives in environmental health. Emerging Issues and Future Directions in Environmental Health Research (3 clock hours) • Identifying emerging environmental health threats, such as climate change, emerging contaminants, and environmental justice issues. • Innovative technologies and approaches for environmental monitoring, assessment, and intervention. • Research priorities and funding opportunities in environmental health sciences. Interdisciplinary collaboration and integrating environmental health research into public health practice and policy-making.	
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REFERENCE BOOKS:

Indian Publishers

"Environmental Pollution and Health" by V. K. Ahluwalia

- Publisher: The Energy and Resources Institute (TERI), New Delhi
- Description: This book provides a comprehensive overview of environmental pollutants and their impacts on human health, covering key concepts, sources of contaminants, and health effects.

"Environmental Toxicology and Chemistry" by K.C. Gupta

- Publisher: NIPA (New India Publishing Agency), New Delhi
- Description: This text delves into the mechanisms of toxicity, biotransformation processes, and risk assessment methodologies, making it a valuable resource for understanding the health aspects of environmental pollutants.

"Environmental Health: Ecological Perspectives" by P. Venugopala Rao

- Publisher: BSP Books Pvt. Ltd., Hyderabad
- Description: The book provides insights into environmental health from an ecological perspective, focusing on the interactions between pollutants and human health and exploring case studies and real-world applications.

Foreign Publishers

"Environmental Toxicology: Biological and Health Effects of Pollutants" by Ming-Ho Yu

- Publisher: CRC Press, Taylor & Francis Group, Boca Raton
- Description: This comprehensive textbook covers a wide range of topics related to environmental pollutants, their sources, mechanisms of toxicity, and health effects, providing a global perspective on environmental health.

"Essentials of Environmental Health" by Robert H. Friis

- Publisher: Jones & Bartlett Learning, Burlington
Description: This book offers a detailed overview of environmental health principles, including exposure pathways, risk assessment, and regulatory frameworks, with numerous case studies illustrating key concepts and applications

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester III	Course Name: Health Aspects of Environment- Practicals
Total Credits: 02	Total Marks: 50
Department assessment: 25	University assessment: 25

Course Outcomes:

1. Master advanced chemical analysis and biomonitoring techniques, equipping students with hands-on experience in assessing water, air, and soil quality through precise analytical methods and bio-indicator applications, ensuring their environmental assessment and monitoring proficiency.
2. Develop comprehensive toxicological screening skills, enabling students to conduct bioassays with aquatic organisms, lung cell lines, and earthworms to evaluate the eco-toxicity of environmental contaminants, thus fostering their ability to effectively assess and mitigate environmental health risks.
3. Integrate theoretical knowledge with practical case study analysis, empowering students to apply their learned techniques in real-world scenarios to assess health risks from water, air, and soil pollution. This will enhance their problem-solving skills and prepare them for professional environmental health challenges.
4. Cultivate interdisciplinary and innovative approaches to environmental health protection, inspiring students to employ cutting-edge technologies and methodologies in their practical work. This is in alignment with NEP-2020 goals of fostering critical thinking, scientific research, and sustainable environmental practices.

Course Code	Course Title	Total Credits
LScENBT604	Health Aspects of Environment- Practicals	02
MODULE I 1. Chemical Analysis of Water Quality Parameters 2. Chemical Analysis of Air Pollutants in Indoor Environments 3. Chemical Analysis of Soil Contaminants in Urban Areas 4. Biomonitoring Techniques Using Bio-indicators for Water Quality Assessment 5. Biomonitoring Techniques Using Sentinel Species for Air Quality Assessment 6. Biomonitoring Techniques Using Plants for Soil Contamination Assessment 7. Toxicological Screening of Water Samples Using Aquatic Organisms 8. Toxicological Screening of Air Samples Using Lung Cell Lines 9. Toxicological Screening of Soil Samples Using Earthworm Bioassays 10. Bioassays for Assessing the Eco-toxicity of Water Contaminants 11. Bioassays for Assessing the Eco-toxicity of Airborne Particulates 12. Bioassays for Assessing the Eco-toxicity of Soil Contaminants 13. Case Study Analysis: Assessing Health Risks from Water Pollution 14. Case Study Analysis: Assessing Health Risks from Air Pollution 15. Case Study Analysis: Assessing Health Risks from Soil Contamination		02

REFERENCE BOOKS:

Indian Publishers

"Environmental Chemistry: Pollution and Remedial Measures" by A.K. De

- Publisher: New Age International Publishers, New Delhi
- Description: This book covers chemical analysis techniques for water, air, and soil pollutants, as well as biomonitoring and toxicological assessments, making it a valuable resource for practical laboratory courses.

"Environmental Monitoring and Assessment" by V.K. Prabhakar and A.K. Srivastava

- Publisher: CBS Publishers & Distributors Pvt. Ltd., New Delhi
- Description: This text provides detailed methodologies for environmental monitoring, including chemical analysis and biomonitoring techniques, focusing on practical applications and case studies.

"Laboratory Manual of Environmental Analysis" by N.C. Aery

- Publisher: Ane Books Pvt. Ltd., New Delhi
- Description: This laboratory manual offers comprehensive procedures for analyzing environmental samples, including water, air, and soil, along with eco-toxicological screening methods.

Foreign Publishers

"Standard Methods for the Examination of Water and Wastewater" by the American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF)

- Publisher: American Public Health Association, Washington D.C.
- Description: This authoritative reference provides standardized procedures for water quality analysis, biomonitoring, and toxicological screening, which are widely used in environmental laboratories worldwide.

"Environmental Toxicology and Chemistry" by Donald G. Crosby

- Publisher: Oxford University Press, New York
- Description: This book offers detailed coverage of toxicological screening methods and bioassays for assessing the eco-toxicity of environmental pollutants, with practical examples and case studies.

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester III

Total Credits: 02

Department assessment: 25

Course Name: Environmental Technology Interventions

Total Marks: 50

University assessment: 25

Course Outcomes:

1. Master cutting-edge environmental biotechnologies, equipping students with advanced skills in real-time monitoring, remote sensing, nanotechnology, and high-throughput sequencing, fostering their ability to address complex environmental challenges with innovative solutions.
2. Harnessing genetic engineering and synthetic biology, empowering students to design and deploy custom microbial systems and gene editing tools like CRISPR for practical bioremediation of emerging contaminants, enhancing their competency in pioneering environmental biotechnology.
3. Integrate biotechnological innovations with sustainable development, inspiring students to apply biorefinery concepts, bio-based product valorization, and bioenergy production, aligning their expertise with NEP-2020 sustainability and environmental stewardship goals.
4. Engage in hands-on, practical applications and project-based learning, enabling students to design, implement, and manage environmental technology projects, analyze real-world case studies, and gain field experience, thus preparing them for leadership roles in environmental technology and sustainable development.

Course Code	Course Title	Total Credits
LScENBT605	Environmental Technology Interventions	02
MODULE I		02
Unit 1: Advanced Environmental Biotechnology- Theory [Credit 1]		
Cutting-edge Technologies for Environmental Monitoring and Remediation (4 clock hours)		
• Introduction to advanced sensor technologies for real-time environmental monitoring. • Remote sensing techniques for detecting environmental pollutants and assessing ecosystem health. • Nanotechnology-based approaches for targeted pollutant detection and remediation. • High-throughput sequencing methods for microbial community analysis in environmental samples		
Biotechnological Approaches to Address Emerging Environmental Challenges (4 clock hours)		
• Overview of genetic engineering techniques for environmental applications. • Bioremediation strategies for emerging contaminants, such as pharmaceuticals and microplastics. • Synthetic biology approaches for designing custom microbial systems for		

environmental tasks. • Application of gene editing tools, such as CRISPR-Cas9, for environmental biotechnology.	
Integration of Biotechnological Solutions into Sustainable Development Practices (4 clock hours) • Conceptual framework for integrating biotechnology with principles of sustainable development. • Biorefinery concepts for valorizing waste streams and producing bio-based products. • Biotechnological approaches for sustainable agriculture, including biofertilizers and biostimulants. • Bioenergy production from renewable resources using microbial and enzymatic processes.	
Case Studies and Applications of Environmental Biotechnology Interventions (3 clock hours) • Review of selected case studies showcasing successful environmental biotechnology applications. • Analysis of key factors contributing to the success or failure of biotechnological interventions. • Examination of regulatory, ethical, and socio-economic considerations in deploying biotechnological solutions. • Future prospects and challenges for advancing environmental biotechnology for sustainable development.	
Unit 2: Practical Applications of Environmental Technology- Practicals [Credits- 1; 30 Clock hours]	
Hands-on Experience with Environmental Biotechnology Techniques (8 clock hours) • Introduction to basic laboratory techniques in environmental biotechnology. • Hands-on training in microbial culture techniques, including isolation and maintenance. • Demonstration of molecular biology techniques for environmental sample analysis. • Practical exercises on bioremediation assays and bioassays for environmental monitoring.	
Laboratory Demonstrations and Experiments on Bioremediation and Waste Treatment (8 clock hours) • Setup and operation of bioreactors for biodegradation studies. • Demonstration of physicochemical treatment methods for wastewater and soil remediation. • Experiments on microbial consortia for enhanced biodegradation of pollutants. • Hands-on experience with bio-filtration and phytoremediation techniques in controlled environments.	
Field Visits to Environmental Technology Installations and Research Facilities (6 clock hours) • Visits to wastewater treatment plants, solid waste management facilities, and bioremediation sites.	

- Tours of research laboratories specializing in environmental technology and bioremediation.
- Interaction with industry experts and researchers involved in developing and implementing environmental technologies.
- Observation of real-world applications of environmental technology solutions in different settings.

Design and Implementation of Environmental Technology Projects (8 clock hours)

- Group projects to design environmental technology solutions for specific pollution problems.
- Proposal writing and project planning exercises for implementing environmental technology interventions.
- Hands-on experience with project management tools and techniques for environmental technology projects.
- Presentation of project proposals and discussion of feasibility, sustainability, and implementation strategies.

REFERENCE BOOKS:

Indian Publishers

"Environmental Biotechnology: Theory and Applications" by Gareth M. Evans and Judith C. Furlong

- Publisher: Ane Books Pvt. Ltd., New Delhi
- Description: This comprehensive textbook covers the theory and practical applications of environmental biotechnology, including cutting-edge technologies and biotechnological approaches for environmental monitoring and remediation.

"Bioremediation and Sustainable Technologies for Cleaner Environment" by Marimuthu Prashanthi, Krishnamurthi Kannan, and Ashok Kumar

- Publisher: Springer (India), New Delhi
- Description: This book provides detailed information on bioremediation techniques and sustainable technologies, focusing on real-world applications and case studies from the Indian context.

"Environmental Biotechnology" by S.N. Jogdand

- Publisher: Himalaya Publishing House, Mumbai
- Description: This text offers a comprehensive overview of environmental biotechnology principles, techniques, and applications, focusing on bioremediation, waste treatment, and sustainable development practices.

Foreign Publishers

"Environmental Biotechnology: Principles and Applications" by Bruce E. Rittmann and Perry L. McCarty

- Publisher: McGraw-Hill Education, New York
- Description: This authoritative text covers the principles and applications of environmental biotechnology, including advanced monitoring technologies, genetic engineering, and bioremediation strategies.

"Biotechnology for Waste and Wastewater Treatment" by Nicholas P. Cheremisinoff

Publisher: Elsevier, Amsterdam

- Description: This book explores the latest biotechnological approaches for waste and wastewater treatment, offering practical insights into bioreactor setups, microbial consortia, and environmental monitoring techniques.

These textbooks collectively cover the essential theoretical and practical aspects of environmental biotechnology interventions, providing students with a solid foundation in advanced technologies, biotechnological approaches, and sustainable development practices.

SEMESTER III - ELECTIVES:

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester III	Course Name: IndustrialBiotechnology for Sustainable Production
Total Credits: 04	Total Marks: 100
Department assessment: 50	University assessment: 50

Course Outcomes:

1. Gain in-depth knowledge of bioprocessing technologies that drive sustainable production. This will equip students with the ability to design and optimize fermentation processes, downstream techniques, and advanced bioreactor operations for industrial applications.
2. Master biocatalysis and green chemistry principles and applications, enabling students to engineer enzymes, synthesize value-added chemicals, and integrate biocatalytic processes into sustainable production practices, fostering innovation in industrial biotechnology.
3. Analyze and evaluate successful biocatalytic processes through comprehensive case studies, enhancing students' ability to critically assess and implement biotechnological interventions that support environmental sustainability and economic viability.

Practical Course outcomes:

4. Develop practical skills in fermentation and downstream processing techniques, providing hands-on experience with setting up and operating bioreactors, purifying bioproducts, and employing various biotechnological methods to achieve sustainable production outcomes.
5. Engage in enzyme engineering and biocatalytic synthesis workshops, offering practical exercises in enzyme immobilization, mutagenesis, and biotransformation reactions. Thus, students will be prepared to enhance biocatalytic performance for industrial applications.
6. Conduct real-world bioprocessing projects and green chemistry experiments, facilitating the design, execution, and critical evaluation of sustainable biotechnological solutions. This will reinforce students' abilities to apply theoretical knowledge in practical, impactful ways.

Course Code	Course Title	Total Credits
LScENBT606a	IndustrialBiotechnology for Sustainable Production	04
MODULE I Unit 1: Bioprocessing Technologies for Sustainable Production (15 Clock hours) Introduction to Bioprocessing (4 Clock hours) • Definition and Significance of Bioprocessing in Sustainable Production (1.5 hours) • Overview of Bioprocesses and their Applications (2.5 hours) Fermentation Processes (4 Clock hours) • Principles of Fermentation and Microbial Growth (1.5 hours) • Types of Fermentation: batch, fed-batch, continuous (2.5 hours)		

Downstream Processing Techniques (4 Clock hours) • Separation Techniques: filtration, centrifugation, chromatography (2 hours) • Purification and Recovery of Bioproducts (2 hours) Advances in Bioreactor Design and Operation (3 Clock hours) • Bioreactor Types and Configurations (1.5 hours) • Process Control and Optimization Strategies (1.5 hours) Unit 2: Biocatalysis and Green Chemistry (15 Clock hours) Principles of Biocatalysis (4 Clock hours) Introduction to Biocatalysis and Green Chemistry (1.5 hours) Enzyme Characteristics and Mechanisms (2.5 hours) Enzyme Engineering (4 Clock hours) Strategies for Enzyme Engineering (1.5 hours) Enhancing Biocatalytic Performance and Substrate Specificity (2.5 hours) Biocatalytic Synthesis (4 Clock hours) Biocatalytic Synthesis of Value-Added Chemicals (1.5 hours) Applications in Pharmaceuticals and Biofuels (2.5 hours) Case Studies (3 Clock hours) Analysis of Successful Biocatalytic Processes (1.5 hours) Integration into Sustainable Production Practices (1.5 hours)	02
MODULE II Practicals [Laboratory-based, actuals/ demonstration based] 1. Fermentation Process Demonstration (4 hours) • Set up and demonstrated fermentation processes for the production of bio-based products. • Monitoring fermentation parameters such as pH, temperature, and agitation. • Observing microbial growth and product formation. 2. Downstream Processing Techniques (4 hours) • Hands-on demonstration of various downstream processing techniques for the purification and recovery of bioproducts • Practice in techniques such as filtration, centrifugation, chromatography, and precipitation. • Understanding the principles behind each purification method. 3. Bioreactor Design and Operation (4 hours) • Practical session on the design and operation of bioreactors for enhanced productivity and sustainability. • Hands-on experience in setting up and running different types of bioreactors. • Monitoring parameters such as aeration, agitation, and nutrient supply. 4. Enzyme Engineering Workshop (4 hours) • Workshop on enzyme engineering techniques for improving biocatalytic performance and substrate specificity	02

- Practical exercises in enzyme immobilization, mutagenesis, and directed evolution.
 - Analysis of enzyme activity and kinetics.
5. Biocatalytic Synthesis Lab (4 hours)
- Laboratory session on the biocatalytic synthesis of value-added chemicals, pharmaceuticals, and biofuels.
 - Hands-on experience in setting up biotransformation reactions using immobilized enzymes.
 - Optimization of reaction conditions for maximum yield and selectivity.
6. Case Study Analysis (4 hours)
- Analysis of case studies of successful biocatalytic processes for sustainable production.
 - Discussion on the strategies employed, challenges faced, and outcomes achieved.
 - Critical evaluation of the sustainability aspects of each case study.
7. Green Chemistry Experimentation (4 hours)
- Experimentation on green chemistry principles applied in biocatalysis.
 - Synthesis of environmentally friendly chemicals using enzymatic reactions.
 - Evaluation of the environmental impact and efficiency of green chemistry processes.
8. Bioprocessing Technology Seminar (2 hours)
- Seminar session discussing the latest advancements in bioprocessing technologies for sustainable production.
 - Presentation of research papers, articles, or case studies related to bioprocessing.
 - Interactive discussion on the potential applications and future trends in the field.

Practicals [Credits 1- 30 Clock hours]

Each student will be assigned one topic from the following list of 20 practical assignments to be completed throughout the Semester.

1. Optimization of Fermentation Conditions for Bioethanol Production
2. Purification of Recombinant Enzymes using Chromatographic Techniques
3. Bioreactor Scale-Up Studies for Biopolymer Production
4. Immobilization of Enzymes for Continuous Biocatalytic Processes
5. Screening of Microbial Strains for Industrial Enzyme Production
6. Design of Green Synthesis Routes for Fine Chemicals
7. Analysis of Bioprocess Parameters for Sustainable Biomanufacturing
8. Bioprospecting for Novel Biocatalysts from Extreme Environments
9. Life Cycle Assessment of Bioprocesses for Environmental Impact Evaluation
10. Development of Sustainable Bioprocess Strategies for Waste Valorization
11. Optimization of Cultivation Conditions for High-Value Secondary Metabolites
12. Purification Techniques for Natural Product Isolation in Biopharmaceuticals
13. Integration of Biorefinery Concepts for Value-Added Product Generation
14. Screening and Engineering of Microbial Consortia for Biodegradation Pathways
15. Application of Metabolic Engineering for Enhanced Biofuel Production
16. Implementation of Clean Production Technologies for Industrial Scale-Up
17. Design and Evaluation of Biocompatible Materials for Biomedical Applications
18. Utilization of Genomic Tools for Precision Agriculture and Crop Improvement
19. Analysis of Microbial Communities in Bioremediation of Polluted Environments
20. Development of Smart Sensor Systems for Real-Time Monitoring in Bioprocessing

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Common Index for Written Assignments:

1. Title: Introduction
 - Brief overview of the assigned theme.
 - Importance and relevance of the topic in environmental biotechnology.
2. Literature Review
 - Review of existing research and literature related to the assigned theme.
 - Summary of key findings, methodologies, and advancements in the field.
3. Objectives
 - Clear and specific objectives of the written assignment.
 - What the assignment aims to achieve or explore within the assigned theme.
4. Methodology
 - Description of the methodology employed in the assignment.
 - Experimental procedures, data collection methods, and analysis techniques used.
5. Results and Discussion
 - Presentation and discussion of the results obtained from the assignment.
 - Analysis and interpretation of findings in the context of the assigned theme.
6. Conclusion
 - Summary of key findings and insights derived from the assignment.
 - Concluding remarks on the significance and implications of the results.
7. Future Directions
 - Suggestions for future research or areas of exploration within the assigned theme.
 - Opportunities for further investigation or improvement in methodologies.
8. References
 - List of references cited in the assignment, following a standardized citation format.
 - Proper attribution of sources and acknowledgment of external contributions.

Each assignment should adhere to this structured index, ensuring clarity, coherence, and academic integrity in presenting the content related to the assigned theme.

REFERENCE BOOKS:

Indian Publishers:

"Bioprocess Engineering: Basic Concepts" by Michael L. Shuler and Fikret Kargi

- Published by PHI Learning Private Limited
- This book covers fundamental bioprocess engineering concepts focusing on sustainable production processes.

"Industrial Biotechnology: Sustainable Production and Bioresource Utilization" by Debabrata Das

- Published by CRC Press (Indian Edition)
- It provides an overview of sustainable production using industrial biotechnology, with case studies and practical insights.

"Biotechnology: Principles and Applications" by B.D. Singh

- Published by Kalyani Publishers
- A comprehensive text that covers various aspects of biotechnology including bioprocessing technologies.

Foreign Publishers:

"Bioprocess Engineering Principles" by Pauline M. Doran

- Published by Academic Press
- This book presents the principles of bioprocess engineering with applications in sustainable production.

"Biocatalysis and Green Chemistry" by Colleen F. Clarke

- Published by Wiley-Interscience
- Focuses on the use of biocatalysts in green chemistry for sustainable chemical production

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester III

Total Credits: 04

Department assessment: 50

Course Name: Bioenergy and Biofuels

Total Marks: 100

University assessment: 50

Course Outcomes:

1. **Comprehensive Understanding:** Master's students will gain a thorough understanding of bioenergy sources, including biomass, biofuels, and biogas, and their significant role in sustainable energy systems.
2. **Technological Proficiency:** Students will acquire detailed knowledge of bioenergy conversion technologies, including fermentation and anaerobic digestion, enhancing their capacity to innovate and improve these processes.
3. **Policy Acumen:** Learners will develop a nuanced understanding of national and international bioenergy policies, enabling them to critically analyze and contribute to the formulation of effective renewable energy strategies.
4. **Environmental Impact Insight:** Students will be equipped to assess the environmental impacts of bioenergy production, including effects on ecosystems, biodiversity, and water resources, fostering a holistic approach to sustainable development.

Practicals Course Outcomes:

5. **Hands-On Experience:** Master's students will gain practical skills in bioenergy production techniques, such as biogas conversion, biofuel synthesis, and environmental impact assessment, preparing them for real-world applications and research.
6. **Innovative Problem-Solving:** Through laboratory experiments and field trips, students will develop the ability to design and optimize bioenergy systems, addressing practical challenges and improving efficiency and sustainability.
7. **Policy and Regulatory Understanding:** Practical workshops and seminars will enhance students' ability to analyze and interpret bioenergy policies and regulations, fostering their capacity to advocate for and implement sustainable energy solutions.
8. **Interdisciplinary Collaboration:** Students will engage in group discussions, case studies, and seminars, promoting interdisciplinary collaboration and exchanging ideas, which are crucial for advancing the bioenergy sector.

Course Code	Course Title	Total Credits
LScENBT606b :	Bioenergy and Biofuels	04

MODULE I

Unit 1: Bioenergy Sources and Conversion Technologies (Total: 15 lectures)

Introduction to Bioenergy and Sources (4 lectures)

- Definition, Significance, and Role of Bioenergy
- Overview of Biomass, Biofuels, and Biogas

Biomass Feedstocks and Biofuels (4 lectures)

- Types and Characteristics of Biomass Feedstocks
- Introduction to Various Biofuels

Bioenergy Conversion Technologies (4 lectures)

- Principles of Bioenergy Conversion Technologies
- Fermentation Techniques and Anaerobic Digestion

Biogas Production and Applications (3 lectures)

- Principles of Biogas Production
- Applications of Biogas in Sustainable Energy

Unit 2: Bioenergy Policies and Environmental Impacts (Total: 15 lectures)

Overview of Bioenergy Policies (4 lectures)

- National and International Policies Promoting Bioenergy
- Renewable Energy Targets and Objectives

Bioenergy Regulations and Analysis (4 lectures)

- Legislative Frameworks and Regulatory Policies
- Environmental Impact Assessment and Analysis

Impact on Ecosystems and Biodiversity (4 lectures)

- Impacts on Land Use and Ecosystems
- Biodiversity Conservation and Preservation

Water Usage and Quality Concerns (3 lectures)

- Effects on Water Resources
- Impact on Water Quality and Conservation

02

MODULE II

Practicals [Laboratory-based, actuals/ demonstration based]

1. Biogas Conversion Demonstration (4 hours)

- Practical demonstration of biomass conversion technologies such as combustion and fermentation.
- Hands-on experience in setting up and operating biomass conversion equipment.
- Monitoring parameters such as temperature, pressure, and reaction kinetics.

2. Biogas Production Experiment (4 hours)

- Laboratory session on anaerobic digestion for biogas production.
- Preparation of anaerobic digesters with various biomass feedstock.
- Measurement of biogas yield, composition, and methane content.

02

3. Biofuel Synthesis Lab (4 hours) • Laboratory experiment on the synthesis of biofuels from renewable sources. • Hands-on experience in biodiesel or bioethanol production using fermentation or transesterification processes. • Analysis of biofuel properties such as viscosity, calorific value, and combustion characteristics. 4. Environmental Impact Assessment (4 hours) • Practical session on assessing the environmental impacts of bioenergy production and utilization. • Conducting life cycle assessments (LCA) to evaluate the carbon footprint and ecological footprint of bioenergy systems. • Analyzing data to identify potential environmental risks and developing mitigation strategies. 5. Policy Analysis Workshop (4 hours) • Workshop on analyzing national and international bioenergy policies and regulations. • Case studies on the implementation of bioenergy policies in different countries. • Discussion on the role of policies in promoting sustainable bioenergy development. 6. Mitigation Strategies Discussion (4 hours) • Group discussion on sustainable practices and strategies to mitigate environmental risks associated with bioenergy. • Brainstorming sessions to identify innovative solutions for addressing environmental challenges. • Presentation of case studies highlighting successful environmental mitigation measures. 7. Field Trip to Bioenergy Facilities (4 hours) • Field trip to bioenergy production facilities such as biogas plants, biofuel refineries, or biomass power plants. • Guided tour of the facilities to observe bioenergy production processes firsthand. • Interaction with industry professionals to gain insights into real-world bioenergy operations. 8. Bioenergy Seminar Series (2 hours) • Seminar series featuring guest speakers from academia, industry, and government agencies. • Presentations on cutting-edge research, technological advancements, and policy developments in the field of bioenergy. • Q&A sessions to facilitate discussion and knowledge exchange among students and experts. Practicals [Credits 1- 30 Clock hours] Each student will be assigned one topic from the following list of 20 practical assignments to be completed throughout the Semester. 1. Biomass Sampling and Analysis Techniques for Bioenergy Potential 2. Biofuel Production: Laboratory-Scale Biodiesel Synthesis	
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3. Design and Operation of Biogas Digesters for Methane Production 4. Optimization of Fermentation Parameters for Bioethanol Yield 5. Construction and Testing of Microbial Fuel Cells 6. Life Cycle Assessment of Bioenergy Systems: Software-Based Analysis 7. Economic Evaluation of Biofuel Production Processes: Spreadsheet Modeling 8. Environmental Impact Assessment of Biorefineries: Field Studies and Data Collection 9. Policy Analysis: Reviewing and Interpreting Bioenergy Regulations 10. Community Outreach: Organizing Workshops on Bioenergy Awareness 11. Biomass Pretreatment Methods: Chemical and Physical Techniques 12. Algal Cultivation in Photo-bioreactors: Monitoring Growth Parameters 13. Pyrolysis of Biomass: Experimental Setup and Product Characterization 14. Grid Integration Studies: Simulating Bioenergy Feed-In 15. Sustainable Feedstock Management: Field Trips to Biomass Sources 16. Carbon Capture Techniques: Laboratory-Scale Experiments 17. Upgrading Biofuels: Catalyst Screening and Reaction Optimization 18. Enzymatic Hydrolysis of Cellulosic Biomass: Enzyme Kinetics Studies 19. Waste-to-Energy Conversion: Pilot-Scale Demonstration 20. Socio-Economic Surveys: Assessing Public Perception of Bioenergy Projects	
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Common Index for Written Assignments:

1. Title: Introduction
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 - Review of existing research and literature related to the assigned theme.
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 - Clear and specific objectives of the written assignment.
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 - Analyse and interpret findings in the context of the assigned theme.
6. Conclusion
 - Summary of key findings and insights derived from the assignment.
 - Concluding remarks on the significance and implications of the results.
7. Future Directions
 - Suggestions for future research or areas of exploration within the assigned theme.
 - Opportunities for further investigation or improvement in methodologies.
8. References
 - List of references cited in the assignment, following a standardized citation format.
 - Proper attribution of sources and acknowledgment of external contributions.

Each assignment should adhere to this structured index, ensuring clarity, coherence, and academic integrity in presenting the content related to the assigned theme.

These practical assignments aim to provide hands-on experience and an in-depth understanding of various aspects related to bioenergy production, sustainability, and policy frameworks.

REFERENCE BOOKS:

Indian Publishers

"Biofuels: Alternative Feedstocks and Conversion Processes"

- Authors: Ashok Pandey, Christian Larroche, Carlos Ricardo Soccol
- Publisher: Elsevier India
- Description: This book provides comprehensive insights into alternative feedstocks for biofuel production and various conversion technologies, emphasizing practical aspects and environmental impacts.

"Bioenergy: Biomass to Biofuels"

- Authors: Anju Dahiya
- Publisher: Academic Press (Indian Edition)
- Description: Covers a wide range of topics related to bioenergy, including biomass resources, conversion technologies, and biofuel applications. It is detailed and includes practical examples and case studies.

"Renewable Energy Sources and Their Applications"

- Authors: Sudhir P. Singh and Sunita K. Singh
- Publisher: New Age International Publishers
- Description: This textbook provides a broad overview of renewable energy sources with specific sections on bioenergy, biomass conversion technologies, and policy frameworks suitable for environmental biotechnology students.

Foreign Publishers

"Bioenergy Research: Advances and Applications"

- Editors: Vijai G. Gupta, Anoop Singh, Sarvajeet Singh Gill
- Publisher: Elsevier
- Description: This book offers an in-depth look at recent advances in bioenergy research, covering biomass conversion, biofuel production, and biogas generation, with contributions from leading researchers in the field.

"Handbook of Bioenergy Crops: A Complete Reference to Species, Development, and Applications"

- Author: N. El Bassam
- Publisher: Earthscan/Routledge
- Description: Provides a comprehensive reference on bioenergy crops, their development, and applications in biofuel production, making it a valuable resource for students studying bioenergy sources and their environmental impacts.

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester III

Total Credits: 04

Department assessment: 50

Course Name: Biotechnology for Soil and Plant Health Management

Total Marks: 100

University assessment: 50

Course Outcomes:

1. In-depth Knowledge: Master's students will develop a profound understanding of soil microbial ecology and plant interactions, equipping them to explore the role of microorganisms in nutrient cycling, plant nutrition, and overall soil health.
2. Advanced Biotechnological Skills: Learners will gain expertise in the latest biotechnological approaches, including biofertilizers, biopesticides, and genetic engineering, preparing them to innovate in sustainable agriculture.
3. Holistic Environmental Insight: Students will cultivate a comprehensive perspective on the ecological and agricultural implications of plant-microbe interactions, fostering their ability to design integrated soil and plant health management strategies.
4. Critical Analysis and Application: Through case studies and theoretical explorations, students will enhance their capacity to critically analyze and apply biotechnological interventions for improving plant resistance and stress tolerance.

Practicals Course Outcomes:

5. Practical Proficiency: Master's students will acquire hands-on experience in producing and applying biofertilizers and biopesticides, enabling them to assess their efficacy and impact on soil and plant health.
6. Innovative Problem-Solving: Through laboratory exercises and field trials, learners will develop practical genetic engineering and bioremediation skills, empowering them to address real-world agricultural challenges with innovative solutions.
7. Research and Analysis Expertise: Students will engage in detailed microbial diversity analyses and biocontrol agent screening, enhancing their research capabilities and understanding of soil health and plant-microbe interactions.
8. Interdisciplinary Collaboration: Practical assignments and case studies promote multidisciplinary teamwork and critical evaluation, fostering a collaborative approach to advancing soil and plant health biotechnology.
9. .

Course Code	Course Title	Total Credits
LScENBT606c	Biotechnology for Soil and Plant Health Management	04

MODULE I

Unit 1: Soil Microbial Ecology and Plant Interactions (15 Lectures)

Understanding the role of soil microorganisms in plant health and nutrition (4 clock hours)

- Introduction to soil microbial ecology
- Functions of soil microorganisms in nutrient cycling
- Microbial contributions to plant nutrition
- Impacts of soil microbial communities on plant health

Microbial diversity in soil ecosystems and its impact on plant growth (4 clock hours)

- Overview of soil microbial diversity
- Factors influencing microbial diversity in soil
- Effects of microbial diversity on soil fertility
- Relationship between microbial diversity and plant growth

Plant-microbe interactions: symbiotic and pathogenic relationship (4 clock hours)

- Symbiotic interactions between plants and beneficial microbes
- Pathogenic interactions between plants and soil-borne pathogens
- Mechanisms of plant defense against microbial pathogens
- Implications of plant-microbe interactions for agriculture

Strategies for harnessing beneficial soil microbes for sustainable agriculture (3 clock hours)

- Biofertilizers: types and applications
- Biocontrol agents for plant disease management
- Integrated approaches for enhancing soil health and plant productivity

Unit 2: Biotechnological Approaches for Soil and Plant Health (15 Lectures)

Introduction to biotechnological interventions for soil and plant health management (3 clock hours)

- Overview of biotechnological approaches in agriculture
- Importance of biotechnology in soil and plant health management
- Historical perspective and development of biotechnological interventions

Biofertilizers and biopesticides: production, application and efficacy (4 clock hours)

- Production methods of biofertilizers
- Application techniques and benefits of biofertilizers
- Production and application of biopesticides
- Efficacy assessment and comparative analysis of biofertilizers and biopesticides

Genetic engineering of crop plants for enhanced disease resistance and stress tolerance (4 clock hours)

- Principles and techniques of genetic engineering in plants
- Engineering disease resistance in crop plants
- Enhancing stress tolerance through genetic modification
- Case studies and applications of genetically modified crops

Bioremediation of contaminated soils using microbial agents (4 clock hours)

- Overview of soil contamination and its impact on agriculture
- Bioremediation strategies for soil decontamination

02

- Microbial agents and their role in bioremediation processes
- Monitoring and assessment of bioremediation efficacy in contaminated soils

MODULE II

02

Practicals [Laboratory-based, actuals/ demonstration based]

1. Biofertilizer production and application (4 hours)
 - Demonstration of biofertilizer production methods
 - Practical exercises on inoculant preparation
 - Field application techniques of biofertilizers
 - Assessment of soil and plant response to biofertilizer application
2. Biopesticide production and efficacy testing (4 hours)
 - Hands-on experience in biopesticide formulation
 - Evaluation of biopesticide efficacy against target pests
 - Comparative analysis of biopesticides with chemical counterparts
 - Data collection and analysis of field trials
3. Genetic engineering techniques in plant biotechnology (4 hours)
 - Introduction to genetic engineering tools and techniques
 - Practical sessions on gene cloning and transformation methods
 - Genetic modification of plants for disease resistance and stress tolerance
 - Analysis of genetically modified plant phenotypes
4. Microbial diversity analysis in soil (4 hours)
 - Collection and processing of soil samples for microbial analysis
 - DNA extraction and amplification of microbial community DNA
 - Diversity assessment using molecular biology techniques
 - Interpretation of microbial diversity data and its implications for soil health
5. Biocontrol agent screening for plant disease management (4 hours)
 - Isolation and identification of potential biocontrol agents
 - In vitro and in vivo screening assays for biocontrol efficacy
 - Evaluation of biocontrol agent antagonism against plant pathogens
 - Selection criteria for effective biocontrol agents in agriculture
6. Field study on plant-microbe interactions (4 hours)
 - Field trip to observe symbiotic and pathogenic plant-microbe interactions
 - Collection of plant and soil samples for laboratory analysis
 - Identification of beneficial and pathogenic microbial species
 - Analysis of field data to understand the dynamics of plant-microbe interactions
7. Bioremediation experiment set-up and monitoring (4 hours)
 - Design and setup of bioremediation experiments using contaminated soil samples
 - Inoculation of microbial agents for bioremediation purposes
 - Monitoring of bioremediation progress through sampling and analysis
 - Data interpretation and evaluation of bioremediation efficacy

8. Case study analysis of biotechnological interventions (2 hours)
 - Review and analysis of case studies on biotechnological applications in agriculture
 - Group discussions on the outcomes and implications of biotechnological interventions
 - Critical evaluation of the effectiveness and sustainability of biotechnological approaches
 - Presentation of findings and recommendations for future research and application

Practicals [Credits 1- 30 Clock hours]

Each student will be assigned one topic from the following list of 20 practical assignments to be completed throughout the Semester.

1. Isolation and Characterization of Plant Growth-Promoting Rhizobacteria (PGPR)
2. Evaluation of Biocontrol Agents against Soil-Borne Pathogens
3. Production and Quality Assessment of Biofertilizers
4. Screening of Endophytic Microbes for Plant Growth Promotion
5. Genetic Transformation of Crop Plants for Disease Resistance
6. Case Study Analysis: Soil Bioremediation Techniques and Their Applications
7. Formulation Optimization of Microbial Inoculants for Shelf-Life Extension
8. Practical Application of Molecular Diagnostics for Plant Pathogen Detection
9. Experimental Design and Implementation of Soil Enzyme Assays for Soil Health Assessment
10. Field Trials Design and Execution for Biotechnological Interventions in Agriculture
11. Microbial Diversity Analysis in Soil Ecosystems: Techniques and Interpretation
12. Effectiveness Assessment of Biocontrol Agents on Plant Disease Suppression
13. Biofertilizer Production Process Optimization and Yield Enhancement
14. Identification and Characterization of Endophytic Microbes from Plant Tissues
15. Techniques for Efficient Genetic Transformation of Crop Plants
16. Case Studies on Successful Soil Bioremediation Projects: Lessons Learned
17. Formulation Stability Testing and Shelf-Life Evaluation of Microbial Inoculants
18. Hands-on Experience with Polymerase Chain Reaction (PCR) for Plant Pathogen Identification
19. Interpretation of Soil Enzyme Assay Data and Soil Health Index Calculation
20. Field Trial Data Analysis and Assessment of Biotechnological Intervention Efficacy

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These practical assignments aim to provide hands-on experience and comprehensive understanding of biotechnological strategies for soil and plant health management in agricultural ecosystems.

REFERENCE BOOKS:

Indian Publishers

"Soil Microbiology" by N.S. Subba Rao

- Publisher: Oxford & IBH Publishing Co. Pvt. Ltd.
- Description: This book covers the fundamental aspects of soil microbiology, including the role of soil microorganisms in nutrient cycling, plant-microbe interactions, and their implications for soil fertility and plant health.

"Biofertilizers in Agriculture and Forestry" by N. Kannaiyan

- Publisher: Scientific Publishers (India)
- Description: It provides detailed information on the production and application of biofertilizers, highlighting the benefits of using microbial inoculants for enhancing soil fertility and plant growth.

"Plant-Microbe Interactions" by G.R. Pathak and R.C. Dubey

- Publisher: Springer India
- Description: This book discusses the various interactions between plants and soil microbes, including symbiotic and pathogenic relationships, and explores biotechnological approaches to harnessing beneficial microbes for sustainable agriculture.

Foreign Publishers

"Principles and Applications of Soil Microbiology" by David M. Sylvia, Jeffry J. Fuhrmann, Peter G. Hartel, and David A. Zuberer

- Publisher: Pearson
- Description: This comprehensive textbook offers an in-depth understanding of soil microbial ecology, emphasizing the functions of soil microorganisms in nutrient cycling, soil health, and plant growth.

"Biotechnology of Biofertilizers" edited by M.K. Rai

- Publisher: Springer
- Description: It covers the production, application, and efficacy of biofertilizers and biopesticides, providing insights into the genetic engineering of crops for enhanced disease resistance and stress tolerance, as well as bioremediation techniques for contaminated soils.

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester III

Total Credits: 04

Department assessment: 50

Course Name: Environmental Biotechnology for Water and Wastewater Treatment

Total Marks: 100

University assessment: 50

Course Outcomes:

1. **Comprehensive Understanding:** Students will gain an in-depth understanding of the various sources and types of water pollutants and their impacts on human health and ecosystems, preparing them to address real-world environmental challenges.
2. **Technological Proficiency:** Students will develop proficiency in traditional and advanced water and wastewater treatment methods, including biological, physical, and chemical processes, equipping them with the skills to implement effective and sustainable water treatment solutions.
3. **Innovative Approach:** Students will explore and critically evaluate emerging water purification and reuse technologies, such as nanotechnology and advanced oxidation processes, fostering an innovative mindset to tackle future environmental issues.
4. **Biotechnological Integration:** Students will learn to integrate biotechnological methods with conventional treatment processes, enhancing their ability to design and optimize hybrid systems for efficient wastewater remediation. This aligns with NEP-2020's emphasis on interdisciplinary learning and practical application.
5. **Practical Course Outcomes:**
6. **Hands-on Expertise:** Students will acquire hands-on experience with traditional and advanced wastewater treatment methods through laboratory exercises and demonstrations, ensuring they are well-prepared for practical applications in the field of environmental biotechnology.
7. **Microbial Analysis:** Students will gain practical skills in analyzing microbial communities and their metabolic pathways in wastewater treatment systems, enabling them to enhance bioremediation strategies through microbial diversity and activity optimization.
8. **Emerging Technologies Implementation:** Students will engage in practical exercises exploring nanotechnology applications and advanced oxidation processes for water purification, fostering their ability to implement and assess cutting-edge technologies in real-world scenarios.
9. **System Optimization:** Through case studies and practical assignments, students will learn to integrate biotechnological and conventional methods, optimize treatment processes, and monitor system performance, preparing them to develop innovative and effective solutions for complex environmental challenges.

Course Code	Course Title	Total Credits
LScENBT606d	Environmental Biotechnology for Water and Wastewater Treatment	04

MODULE I

Unit 1: Water Pollution and Treatment Technologies

Overview of water pollution sources and contaminants. (4 clock hours)

- Sources of water pollution: industrial, agricultural, domestic, and natural.
- Types of contaminants: organic pollutants, heavy metals, nutrients, pathogens, etc.
- Impacts of water pollution on human health and ecosystems.

Traditional and advanced wastewater treatment methods. (4 clock hours)

- Overview of conventional treatment processes: screening, sedimentation, filtration, etc.
- Advanced treatment methods: activated sludge process, membrane filtration, disinfection, etc.
- Comparison of treatment efficiency, cost-effectiveness, and sustainability.

Biological, physical, and chemical processes in water treatment. (4 clock hours)

- Biological processes: aerobic and anaerobic digestion, bioremediation, biofiltration, etc.
- Physical processes: sedimentation, filtration, adsorption, etc.
- Chemical processes: coagulation, flocculation, oxidation, precipitation, etc.

Emerging technologies for water purification and reuse. (3 clock hours)

- Nanotechnology applications in water treatment: nanofiltration, photocatalysis, nanocomposites, etc.
- Advanced oxidation processes: ozonation, UV irradiation, electrochemical treatment, etc.
- Water reuse strategies: graywater recycling, rainwater harvesting, desalination, etc.

Unit 2: Biotechnological Approaches for Wastewater Remediation

Role of microorganisms in wastewater treatment processes. (4 clock hours)

- Microbial communities in wastewater treatment plants: bacteria, archaea, fungi, protozoa, etc.
- Microbial metabolic pathways: aerobic and anaerobic degradation of organic matter, nitrification, denitrification, etc.
- Importance of microbial diversity and activity in maintaining treatment efficiency.

Bioremediation strategies for organic and inorganic pollutants. (4 clock hours)

- Biodegradation of organic pollutants: hydrocarbons, pesticides, pharmaceuticals, etc., by microbial enzymes.
- Microbial transformation of inorganic pollutants: heavy metals, nitrates, phosphates, etc., via metabolic processes.
- Strategies to enhance bioremediation efficiency: bioaugmentation, biostimulation, phytoremediation, etc.

Application of biofilms and microbial consortia in wastewater bioremediation. (4 clock hours)

- Role of biofilms in wastewater treatment: attachment, biofilm formation, and microbial interactions.
- Advantages of microbial consortia: synergistic degradation of complex pollutants, resilience to environmental changes, etc.

• Engineering biofilm-based systems: fixed-film reactors, packed bed reactors, rotating biological contactors, etc. Integration of biotechnological and conventional methods for efficient treatment. (3 clock hours) • Combined treatment approaches: biological treatment coupled with physical and chemical processes. • Hybrid systems for wastewater remediation: membrane bioreactors, constructed wetlands, activated sludge with advanced oxidation, etc. • Optimization strategies for integrated systems: process control, monitoring, and adaptation to changing influent characteristics.	
MODULE II Practicals [Laboratory-based, actuals/ demonstration based] 1. Demonstration of traditional and advanced wastewater treatment methods (4 hours) • Overview of conventional treatment processes: sedimentation, filtration, disinfection. • Demonstration of advanced treatment methods: activated sludge process, membrane filtration. 2. Laboratory exercise on biological processes in water treatment (4 hours) • Experiment on aerobic and anaerobic digestion of organic matter. • Study of microbial metabolic pathways involved in wastewater treatment. 3. Physical and chemical processes in water treatment: hands-on-experience (4 hours) • Laboratory demonstration of physical processes: sedimentation, filtration, adsorption. • Experiment on chemical processes: coagulation, flocculation, oxidation, precipitation. 4. Exploration of emerging technologies for water purification (3 hours) • Interactive session on nanotechnology applications in water treatment. • Discussion on advanced oxidation processes and water reuse strategies. 5. Role of microorganisms in wastewater treatment: microbial community analysis (4 hours) • Microscopic examination of microbial communities in wastewater • Identification of bacteria, archaea, fungi, and protozoa. 6. Bioremediation strategies: practical application and assessment (4 hours) • Experiment on biodegradation of organic pollutants using microbial enzymes. • Study of microbial transformation of inorganic pollutants and strategies for enhancement. 7. Hands-on experience with biofilm-based systems (4 hours) • Setup and observation of biofilm formation in fixed-film reactors • Demonstration of microbial interactions and pollutant degradation within biofilms. 8. Integration of biotechnological and conventional methods: case studies and analysis (3 hours) • Review of combined treatment approaches and hybrid systems	02

- Discussion on optimization strategies for integrated wastewater treatment systems.

Practicals [Credits 1- 30 Clock hours]

Each student will be assigned one topic from the following list of 20 practical assignments to be completed throughout the Semester:

1. Assessment of Physicochemical Parameters in Wastewater
2. Isolation and Identification of Wastewater Microorganisms
3. Quantitative Analysis of Biological Oxygen Demand (BOD) in Wastewater
4. Characterization of Chemical Oxygen Demand (COD) in Wastewater Samples
5. Experimental Design for Optimizing Activated Sludge Process Parameters
6. Performance Evaluation of Anaerobic Digesters in Wastewater Treatment
7. Comparative Study of Membrane Bioreactors for Wastewater Treatment
8. Bioremediation Strategies for Industrial Effluent Treatment: A Case Study Approach
9. Techniques for Nutrient Removal in Wastewater Treatment Plants
10. Implementation of Monitoring Protocols for Wastewater Treatment Processes
11. Microbial Diversity Analysis in Wastewater Treatment Systems
12. Molecular Characterization of Microbial Consortia Used in Wastewater Bioremediation
13. Kinetic Modeling of Biological Oxygen Demand Degradation in Wastewater
14. Assessment of Chemical Oxygen Demand Removal Efficiency in Wastewater Treatment
15. Optimization of Anaerobic Digestion Parameters for Enhanced Methane Production
16. Evaluation of Membrane Fouling and Flux Rates in Membrane Bioreactors
17. Bioremediation Potential of Indigenous Microbial Consortia in Industrial Effluents
18. Advanced Techniques for Nutrient Removal and Recovery in Wastewater Treatment
19. Real-time Process Control and Monitoring Systems in Wastewater Treatment Plants
20. Compliance Assessment of Effluent Quality with Environmental Regulations and Standards

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6. Conclusion
 - Summary of key findings and insights derived from the assignment.

- Concluding remarks on the significance and implications of the results.
7. Future Directions
- Suggestions for future research or areas of exploration within the assigned theme.
 - Opportunities for further investigation or improvement in methodologies.
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These practical assignments aim to provide hands-on experience and comprehensive understanding of environmental biotechnology techniques for water and wastewater treatment.

REFERENCE BOOKS:

Indian Publishers:

Environmental Biotechnology: Basic Concepts and Applications by Indu Shekhar Thakur

- Publisher: PHI Learning Pvt. Ltd.
- Description: This book comprehensively introduces environmental biotechnology, covering basic concepts and practical applications relevant to water and wastewater treatment.

Water and Wastewater Technology by Mark J. Hammer

- Publisher: Prentice-Hall India
- Description: Focuses on the technological aspects of water and wastewater treatment, including traditional and advanced treatment methods, emphasizing practical applications.

Textbook of Environmental Biotechnology by P. K. Goel

- Publisher: CBS Publishers & Distributors
- Description: Offers a detailed exploration of environmental biotechnology, discussing bioremediation strategies, microbial processes, and integration of biotechnological methods in ecological management.

Foreign Publishers:

Principles of Environmental Biotechnology by R. F. Shore

- Publisher: ASM Press
- Description: Covers fundamental principles and theoretical frameworks of environmental biotechnology, including bioremediation, microbial ecology, and applications in environmental science and engineering.

Environmental Biotechnology: Theory and Applications by Gareth M. Evans

- Publisher: Wiley-Blackwell
- Description: Provides a comprehensive overview of environmental biotechnology, discussing theoretical concepts and practical applications in water treatment, bioremediation, and sustainable environmental management.

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester III

Total Credits: 04

Department assessment: 50

Course Name: Bioremediation Techniques for Environmental Cleanup

Total Marks: 100

University assessment: 50

Course Outcomes:

1. **Comprehensive Understanding:** Students will develop a comprehensive understanding of bioremediation, including its historical evolution, principles, and significance in addressing environmental pollution and promoting sustainable development.
2. **Advanced Knowledge:** Students will gain advanced knowledge of microbial mechanisms involved in biodegradation processes, including the metabolic pathways and key enzymes responsible. This knowledge will enable them to assess and optimize bioremediation strategies effectively.
3. **Critical Analysis:** Students will critically analyze bioremediation techniques, compare and contrast in-situ and ex-situ approaches, and evaluate their applicability based on site-specific characteristics and contaminant types.
4. **Future Perspectives:** Students will explore emerging trends and innovations in bioremediation research, identifying future prospects and potential applications in addressing evolving environmental challenges. This aligns with NEP-2020's emphasis on forward-looking educational outcomes

Practicals Course outcome:

5. **Hands-on Experience:** Through practical sessions, students will acquire hands-on experience in isolating and characterizing pollutant-degrading microbial strains, enhancing their ability to apply theoretical knowledge to real-world environmental scenarios.
6. **Experimental Proficiency:** Students will develop proficiency in designing and conducting bioremediation trials, evaluating environmental factors' influence on biodegradation efficiency, and implementing biostimulation and bioaugmentation techniques to enhance pollutant removal.
7. **Case Study Analysis:** By analyzing case studies of successful bioremediation projects, students will learn to assess critical factors contributing to project success, preparing them to develop and implement effective bioremediation strategies in diverse environmental settings.
8. **Innovative Application:** Students will engage in field visits to bioremediation sites, applying theoretical concepts to practical observations, and participate in brainstorming sessions on emerging bioremediation technologies and their regulatory implications, fostering innovation and strategic thinking in environmental biotechnology.

Course Code	Course Title	Total Credits
LScENBT606e	Bioremediation Techniques for Environmental Cleanup	04
MODULE I Unit 1: Fundamentals of Bioremediation Introduction to bioremediation and its significance in environmental cleanup. (4 clock hours) • Definition and objectives of bioremediation. • Historical background and evolution of bioremediation techniques. • Importance of bioremediation in addressing environmental pollution and its role in sustainable development Types of contaminants amenable to bioremediation. (4 clock hours) • Classification of contaminants: organic, inorganic, and mixed contaminants. • Contaminant characteristics influencing bioremediation feasibility: biodegradability, toxicity, persistence, etc. • Case studies illustrating the application of bioremediation to different types of contaminants. Microbial mechanisms involved in biodegradation of pollutants. (4 clock hours) • Overview of microbial metabolism and pathways involved in pollutant degradation. • Key microbial groups and enzymes responsible for biodegradation processes. • Factors affecting microbial activity and pollutant degradation rates. Factors influencing the efficiency of bioremediation processes. (3 clock hours) • Environmental factors: temperature, pH, oxygen availability, moisture content, etc. • Substrate characteristics and bioavailability of contaminants. • Engineering considerations and optimization strategies for enhancing bioremediation efficiency. Unit 2: Bioremediation Strategies and Applications Overview of bioremediation techniques: in-situ and ex-situ methods. (4 clock hours) • Definition and principles of bioremediation. • Comparison between in-situ and ex-situ bioremediation approaches. • Factors influencing the selection of bioremediation techniques: site characteristics, contaminant type, etc. Biostimulation and bioaugmentation approaches for enhancing biodegradation. (4 clock hours) • Biostimulation techniques: addition of nutrients, electron acceptors, and carbon sources to stimulate microbial activity. • Bioaugmentation strategies: introduction of specialized microbial consortia or genetically engineered microorganisms. • Mechanisms of action and effectiveness of biostimulation and bioaugmentation in		02

enhancing pollutant degradation. Case studies of successful bioremediation applications in different environmental settings. (4 clock hours) • Examples of successful bioremediation projects: oil spills, contaminated groundwater, industrial sites, etc. • Analysis of critical factors contributing to the success of bioremediation efforts. • Lessons learned and best practices from real-world applications. Challenges and prospects of bioremediation technologies. (3 clock hours) • Challenges associated with bioremediation: contaminant complexity, site heterogeneity, regulatory issues, etc. • Emerging trends and innovations in bioremediation research and development. • Potential applications of bioremediation in addressing future environmental challenges.	
MODULE II Practicals [Laboratory-based, actuals/ demonstration based] 1. Microbial mechanisms in biodegradation (4 hours) Demonstration: Microbial metabolism and pathways involved in pollutant degradation. Practical: Isolation and characterization of pollutant-degrading microbial strains. 2. Environmental factors and bioremediation efficiency (4 hours) • Demonstration: Influence of environmental factors on bioremediation efficiency • Practical: Experimental temperature, pH, and oxygen availability assessment on pollutant degradation rates. 3. Bioremediation techniques: in-situ vs. ex-situ methods (4 hours) • Demonstration: Principles and applications of in-situ and ex-situ bioremediation approaches • Practical: Designing bioremediation strategies for specific environmental contamination scenarios. 4. Biostimulation and bioaugmentation approaches (4 hours) • Demonstration: Biostimulation and bioaugmentation techniques for enhancing biodegradation • Practical: Evaluation of nutrient addition and microbial inoculation methods on pollutant degradation 5. Case studies in bioremediation (4 hours) • Demonstration: Analysis of successful bioremediation projects in different environmental settings • Practical: Case study review and discussion on key factors contributing to bioremediation success. 6. Challenges and future prospects of bioremediation (4 hours) • Demonstration: Identification of challenges and regulatory issues in bioremediation • Practical: Brainstorming session on emerging trends and innovations in bioremediation research.	02

7. Field visit to bioremediation sites (2 hours)
 - Practical: Guided field visit to observe real-world bioremediation projects
 - Demonstration: Field measurements and sample collection techniques.
8. Experimental design for bioremediation trials (4 hours)
 - Practical: Planning and designing bioremediation trials based on site characteristics and contaminant type
 - Demonstration: Statistical analysis and interpretation of bioremediation trial data.

Practicals [Credit 1- 30 Clock hours]

Each student will be assigned one topic from the following list of 20 practical assignments to be completed throughout the Semester:

1. Review of Screening Methods for Microbial Strains with Pollutant Degradation Abilities
2. Experimental Design for Optimization of Environmental Conditions in Biodegradation Processes
3. Application of Molecular Biology Techniques in Analyzing Biodegradation Pathways
4. Comparative Analysis of Biostimulation Strategies for Enhanced Bioremediation
5. Case Study: Assessment of Bioaugmentation Approaches in Contaminated Sites
6. Data Analysis Techniques for Monitoring Bioremediation Processes Using Analytical Methods
7. Planning and Execution of Field-Scale Bioremediation Trials: Methodologies and Considerations
8. Quantitative Assessment of Bioremediation Efficacy and Contaminant Removal Efficiency: Metrics and Interpretation
9. Identification and Evaluation of Risk Factors in Bioremediation Projects: Strategies for Mitigation
10. Integrating Bioremediation with Traditional Cleanup Techniques: Challenges and Opportunities
11. Literature Review: Recent Advances in Screening Techniques for Microbial Strains
12. Development of Experimental Protocols for Environmental Condition Optimization
13. Interpretation of Molecular Biology Data in Analyzing Biodegradation Pathways
14. Comparative Evaluation of Biostimulation Strategies: Case Studies and Analysis
15. Risk Assessment in Bioaugmentation Approaches: Identification and Management
16. Statistical Methods for Analyzing Data from Bioremediation Process Monitoring
17. Designing Field-Scale Bioremediation Trials: Factors to Consider and Potential Pitfalls
18. Comparative Analysis of Bioremediation Efficacy Across Different Contaminants
19. Case Study: Risk Management Strategies in Real-Life Bioremediation Projects
20. Challenges and Solutions in Integrating Bioremediation with Traditional Cleanup Techniques

Common Index for Written Assignments:

1. Title: Introduction
 - Brief overview of the assigned theme.
 - Importance and relevance of the topic in environmental biotechnology.
2. Literature Review
 - Review of existing research and literature related to the assigned theme.

- Summary of key findings, methodologies, and advancements in the field.
3. Objectives
 - Clear and specific objectives of the written assignment.
 - What the assignment aims to achieve or explore within the assigned theme.
 4. Methodology
 - Description of the methodology employed in the assignment.
 - Experimental procedures, data collection methods, and analysis techniques used.
 5. Results and Discussion
 - Presentation and discussion of the results obtained from the assignment.
 - Analysis and interpretation of findings in the context of the assigned theme.
 6. Conclusion
 - Summary of key findings and insights derived from the assignment.
 - Concluding remarks on the significance and implications of the results.
 7. Future Directions
 - Suggestions for future research or areas of exploration within the assigned theme.
 - Opportunities for further investigation or improvement in methodologies.
 8. References
 - List references cited in the assignment, following a standardized citation format.
 - Proper attribution of sources and acknowledgment of external contributions.

Each assignment should adhere to this structured index, ensuring clarity, coherence, and academic integrity in presenting the content related to the assigned theme.

These practical assignments provide hands-on experience and a comprehensive understanding of various bioremediation techniques used for environmental cleanup.

REFERENCE BOOKS:

Indian Publishers:

Bioremediation: Principles and Applications by Ronald L. Crawford

- Publisher: PHI Learning Pvt. Ltd.
- Description: This textbook covers the fundamental principles of bioremediation, including microbial processes and practical applications in environmental cleanup.

Environmental Biotechnology: Basic Concepts and Applications by Indu Shekhar Thakur

- Publisher: PHI Learning Pvt. Ltd.
- Description: Provides a comprehensive introduction to environmental biotechnology, including bioremediation techniques for water and soil contaminants.

Textbook of Environmental Biotechnology by P. K. Goel

- Publisher: CBS Publishers & Distributors
- Description: Focuses on biotechnological approaches to environmental management, covering bioremediation strategies and practical applications.

Foreign Publishers:

Principles of Environmental Biotechnology by R. F. Shore

- Publisher: ASM Press
- Description: Offers a theoretical foundation on environmental biotechnology, emphasizing

bioremediation methods and their applications in pollution control.

Environmental Biotechnology: Theory and Applications by Gareth M. Evans

- Publisher: Wiley-Blackwell
- Description: Discusses advanced concepts in environmental biotechnology, including bioremediation techniques and case studies on their effectiveness.

Programme Name: M.Sc. (Life Sciences – Environmental Biotechnology) Semester III	Course Name: Research Project I
Total Credits: 04	Total Marks: 100
Department assessment: 50 marks	University assessment: 50 marks

Course Outcome:

The learner would be able to correlate the theoretical and practical aspects of research. The learner would be able to:

1. Collate, organize and analyse the existing literature in any given field of study.
2. Formulate a hypothesis following literature review.
3. Design a study to prove/ disprove the hypothesis using the tenets of Research Methodology.
4. Design data/ sample collection.
5. Prepare a presentation and appropriately record the studies done in this course.

Course Code	Course Title	Total Credits
LScENBT607	Research Project I	04
Introduction: This course is designed to extend the concepts captured in the theory lectures into practical applications and discovery. The learner would be able to identify and organize the existing literature on a given topic and plan experiments to prove a hypothesis. The research project is aimed to enhance research temper in the learner. The learner would be able to formulate a hypothesis and design a research project using the concepts of research methodology. The learner would be able to effectively document and present the parameters of the research project. What is required: There are four credits assigned to the course. As this is of a practical and hands-on nature, every two hours spent on the project in a week would earn a credit. The course spans over 15 weeks and hence the time that needs to be devoted would be 120 hours. This could be planned and completed over a span of 15 weeks or continuously 4 - 5 weeks. Where can these projects be done: The projects could be conducted in-house or could be in industry or research institutes or recognized institutes that carry out research. The host institution would be from any field of Life Sciences. The project would be carried out with the consent and understanding between the theUDLSc and the relevant Academic/ research Institute or the Industry Documentation for the Research Project I:		04

The proforma for internal evaluation by the mentor (at the place of work) is given at the end of the syllabus. This evaluation along with a thesis submission would be proportionately added for the calculation of the internal marks. The scheme for the same is given at the end of the syllabus.

A draft paper of the project and its presentation would be evaluated by external examiners as the external evaluation. The relevant weightages are given at the end of the document.

The reports will be governed by the plagiarism rules as dictated in the document No.

Th./ICD/2018 – 19/ 448

Sem. – IV

M.Sc. (Life Sciences -Environmental Biotechnology) (Semester - IV)

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester IV	Course Name: Applied Environmental Biotechnology-I
Total Credits: 04	Total Marks: 100
Department assessment: 50	University assessment: 50

Course outcomes:

1. Develop a profound understanding of advanced environmental monitoring and analysis techniques, equipping students with the ability to effectively assess and manage air, water, and soil quality, fostering their capacity to become leaders in environmental preservation.
2. Master the application of microbial technologies in waste management, emphasizing innovative biotechnological solutions for sustainable waste treatment, thereby inspiring students to pioneer in environmental biotechnology and contribute to global sustainability efforts.
3. Explore the cutting-edge field of environmental nanotechnology, enabling students to synthesize and apply nanomaterials for pollution remediation and resource conservation, positioning them at the forefront of technological advancements in environmental science.
4. Integrate industrial biotechnology principles with circular economy concepts, preparing students to design and implement sustainable production processes and waste management strategies. This will ultimately transform them into visionary leaders driving ecological and economic sustainability.

Course Code	Course Title	Total Credits
LScENBT608	Applied Environmental Biotechnology-I	04
MODULE I Unit 1: Environmental Monitoring and Analysis Techniques (15 Clock hours) Introduction to environmental monitoring methods for air, water, and soil quality assessment. (4 Clock hours) Overview of environmental monitoring objectives and methodologies. Sampling strategies and air, water, and soil quality assessment protocols. Importance of monitoring parameters such as pollutants, pH, temperature, and microbial load. Principles and applications of physicochemical analysis techniques in environmental biotechnology. (4 Clock hours) Fundamentals of physicochemical analysis methods, including spectrophotometry, chromatography, and titration. Apply these techniques in detecting and quantifying environmental pollutants. Hands-on demonstrations and case studies illustrating the use of different analytical		02

methods.

Biological monitoring methods using indicator organisms and biomarkers for pollution detection. (4 Clock hours)

Role of indicator organisms in assessing environmental quality and pollution levels.

Identification and selection of suitable indicator species for different environmental compartments.

Use of biomarkers such as enzyme activities, DNA damage, and physiological responses in environmental monitoring.

Hands-on training in field sampling techniques and sample preservation methods. (3 Clock hours)

Field sampling protocols for air, water, and soil matrices.

Proper handling and preservation of environmental samples to maintain integrity.

Practical demonstrations and field exercises to familiarize students with sampling equipment and procedures.

Unit 2: Microbial Applications in Waste Management

Role of Microorganisms in Wastewater Treatment and Solid Waste Management (4 clock hours)

Overview of microbial communities involved in wastewater treatment.

Microbial processes and activities in aerobic and anaerobic treatment systems.

Importance of microbial diversity in solid waste degradation and composting.

Contribution of microorganisms to biodegradation and stabilization of organic waste.

Biological Processes Involved in Wastewater Treatment Systems (4 clock hours)

Mechanisms of biological nutrient removal (nitrification, denitrification, etc.).

Microbial transformations of carbon, nitrogen, and phosphorus compounds in wastewater.

Microbial biofilm formation and biofouling in wastewater treatment reactors.

Optimization of biological treatment processes for wastewater quality improvement.

Microbial Degradation of Organic Matter and Pollutants in Solid Waste (4 clock hours)

Microbial decomposition pathways for organic matter degradation in solid waste.

Biodegradation of specific pollutants (heavy metals, persistent organic pollutants, etc.) in solid waste.

Microbial activities and interactions in composting and anaerobic digestion processes.

Strategies for enhancing microbial degradation efficiency in solid waste management.

Advances in Microbial Technologies for Sustainable Waste Management Practices (3 clock hours)

Emerging microbial technologies for waste-to-energy conversion.

Biotechnological approaches for valorization of waste streams.

Microbial bioaugmentation and biostimulation strategies for waste remediation.

Integrating microbial processes with physical and chemical treatment methods for comprehensive waste management.

MODULE II

02

Unit 3: Environmental Nanotechnology (15 Clock hours)

Introduction to nanomaterials and their applications in environmental biotechnology. (4 Clock hours)

Fundamentals of nanotechnology and its significance in environmental science.

Overview of various types of nanomaterials, including nanoparticles, nanotubes, and nanocomposites.

Exploration of the unique properties of nanomaterials that make them suitable for environmental applications.

Nanoparticle synthesis methods and characterization techniques for environmental applications. (4 Clock hours)

Review of synthesis techniques such as chemical precipitation, sol-gel, and green synthesis methods.

Characterization methods, including electron microscopy, X-ray diffraction, and spectroscopic techniques.

Hands-on demonstrations and laboratory exercises on nanoparticle synthesis and characterization.

Nanotechnology-based approaches for pollution remediation, water purification, and soil remediation. (4 Clock hours)

Examination of nanomaterials for pollutant removal and degradation in air, water, and soil environments.

Case studies of nanotechnology applications in wastewater treatment, air pollution control, and soil remediation.

Evaluation of nanotechnology-based remediation techniques' efficiency, effectiveness, and feasibility.

Environmental implications and risk assessment of nanomaterials in biotechnological applications. (3 Clock hours)

Assessment of the potential environmental impacts and risks associated with nanomaterials.

Discussion of toxicity, bioaccumulation, and eco-toxicity of nanoparticles in environmental systems.

Regulatory frameworks and guidelines for the safe use and disposal of nanomaterials in environmental biotechnology.

Unit 4: Industrial Biotechnology for Environmental Sustainability (15 Clock hours)

Role of industrial biotechnology in sustainable production processes and waste management. (4 Clock hours)

Overview of industrial biotechnology and its role in promoting sustainability in various sectors.

Analysis of biotechnological solutions for waste minimization, recycling, and resource recovery.

Examination of case studies highlighting industrial biotechnology's contribution to environmental sustainability.

Biotechnological approaches for bioenergy production and bio-based product synthesis. (4 Clock hours)

Exploration of biofuel production technologies, including bioethanol, biodiesel, and

biogas. Discuss bio-based materials synthesis, such as bioplastics, biopolymers, and bio-based chemicals. Evaluation of the environmental and economic sustainability of bioenergy and bio-based products. Biocatalysis and enzyme engineering for green chemistry and pollution prevention. (4 Clock hours) Principles of biocatalysis and its application in green synthesis and environmental remediation. Techniques for enzyme immobilization, optimization, and engineering for enhanced catalytic activity. Case studies illustrating the use of biocatalysts in bioremediation, biotransformation, and pollutant degradation. Integration of industrial biotechnology with circular economy principles for resource conservation. (3 Clock hours) Overview of circular economy concepts and their alignment with industrial biotechnology. Strategies for closing material loops, reducing waste generation, and promoting resource efficiency. Discuss policy frameworks, business models, and technological innovations for advancing the circular bio-economy.	
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REFERENCE BOOKS:

Indian Publishers:

Environmental Biotechnology: Basic Concepts and Applications by Indu Shekhar Thakur

- Publisher: PHI Learning Pvt. Ltd.
- Description: Covers a broad range of topics in environmental biotechnology, including environmental monitoring techniques and microbial applications in waste management.

Textbook of Environmental Studies for Undergraduate Courses by Erach Bharucha

- Publisher: Universities Press
- Description: Provides foundational knowledge on environmental monitoring methods and their application in assessing air, water, and soil quality.

Biotechnology for Environmental Management by P.D. Sharma

- Publisher: Rastogi Publications
- Description: Focuses on biotechnological approaches for environmental sustainability, including waste management and pollution control using microbial technologies.

Foreign Publishers:

Environmental Biotechnology: Principles and Applications by Bruce E. Rittmann and Perry L. McCarty

- Publisher: McGraw-Hill Education
- Description: Offers comprehensive coverage of environmental biotechnology

principles, including biological monitoring methods and microbial applications in waste management.

Nanotechnology for Environmental Engineering by Lalit Kumar

- Publisher: Springer
 - Description: Explores nanotechnology applications in environmental remediation, covering nanoparticle synthesis, characterization techniques, and their environmental implications.
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Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester IV

Total Credits: 02

Department assessment: 25

Course Name: Applied Environmental Biotechnology-I Practicals

Total Marks: 50

University assessment: 25

Course outcomes:

1. Acquire comprehensive hands-on experience in environmental sampling and field analysis. This will enable students to proficiently assess and monitor environmental quality parameters in real-world scenarios, fostering a generation of adept environmental biotechnologists.
2. Master advanced techniques in microbial culturing, bioremediation, and nanoparticle synthesis, equipping students with the skills to implement cutting-edge solutions for pollution remediation and environmental sustainability, positioning them as pioneers in the field.
3. Develop practical expertise in bioenergy production, enzyme assays, and industrial waste treatment processes, inspiring students to innovate and lead in applying biotechnological approaches for sustainable waste management and resource conservation.
4. Engage in critical environmental impact assessments and policy analysis, cultivating a holistic understanding of environmental biotechnology's role in societal and regulatory frameworks and empowering students to influence and drive future environmental policies and practices.

Course Code	Course Title	Total Credits
LScENBT609	Applied Environmental Biotechnology-I Practicals	02
MODULE I		02
1. Environmental Sampling Techniques and Field Analysis		
2. Physicochemical Analysis of Water Quality Parameters		
3. Biological Monitoring Using Indicator Species		
4. Microbial Culturing and Isolation Techniques		
5. In-situ Bioremediation Experiments		
6. Ex-situ Bioremediation Setup and Operation		
7. Nanoparticle Synthesis and Characterization		
8. Nanomaterials Applications in Pollution Remediation		
9. Bioenergy Production Experiments		
10. Enzyme Assays and Biocatalysis Reactions		
11. Industrial Waste Treatment Processes		
12. Circular Economy Simulation Exercises		
13. Environmental Impact Assessment Project		
14. Environmental Policy Analysis and Discussion		
15. Seminar on Emerging Trends in Environmental Biotechnology		

REFERENCE BOOKS:

Indian Publishers:

Environmental Biotechnology: Basic Concepts and Applications by Indu Shekhar Thakur

- Publisher: Springer India
- Description: This book provides a comprehensive overview of environmental biotechnology, covering basic concepts, applications, and recent advances in the field. It includes practical insights into environmental sampling techniques and bioremediation methods.

Bioremediation and Biotechnology: Current Research and Future Trends by P. Thilagaraj

- Publisher: PHI Learning Pvt. Ltd.
- Description: Focused on bioremediation techniques, this book explores current research trends and prospects in biotechnological approaches for environmental cleanup. It covers both in-situ and ex-situ bioremediation methods.

Nanotechnology in Environmental Biotechnology: Applications and Implications by P. Saravanakumar

- Publisher: CRC Press
- Description: This book delves into the applications of nanotechnology in environmental biotechnology, discussing nanomaterial synthesis, characterization techniques, and their use in pollution remediation. It includes practical insights into nanoparticle applications for environmental sustainability.

Foreign Publishers:

Environmental Biotechnology: Theory and Application by Gareth M. Evans

- Publisher: Wiley-Blackwell
- Description: Offering a theoretical foundation and practical applications, this textbook covers key aspects of environmental biotechnology, including microbial culturing techniques, biocatalysis, and industrial waste treatment processes.

Biocatalysis in Environmental Management by Gideon G. J. B. Eskin

- Publisher: Springer
- Description: Focusing on biocatalysis applications, this book explores its role in environmental management, emphasizing enzyme assays, bioremediation reactions, and sustainable practices in biotechnological applications

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester IV Total Credits: 04 Department assessment: 50	Course Name: Applied Environmental Biotechnology-II Total Marks: 100 University assessment: 50
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Course outcomes:

1. Master the principles and techniques of environmental microbial genomics, including high-throughput sequencing and bioinformatics, empowering students to analyze and interpret complex microbial communities for innovative applications in bioremediation and ecosystem studies.
2. Develop a profound understanding of biotechnological strategies for climate change mitigation, including carbon sequestration and renewable energy production, inspiring students to pioneer sustainable solutions that address global environmental challenges.
3. Acquire advanced knowledge in sustainable agriculture and agri-biotechnology, emphasizing biotechnological interventions for soil fertility, crop protection, and genetic engineering, preparing students to lead in developing resilient and productive agricultural systems.
4. Engage critically with ethical, equity, and policy issues in environmental biotechnology, fostering a commitment to responsible research and innovation that promotes social justice, inclusivity, and sustainable development.

Course Code	Course Title	Total Credits
LScENBT610	Applied Environmental Biotechnology-II	04
MODULE I Unit 1: Environmental Microbial Genomics (15 Clock hours) Introduction to environmental genomics and metagenomics approaches. (4 Clock hours) • Overview of environmental genomics and its significance in studying microbial communities. • Introduction to metagenomics as a tool for analyzing genetic material directly from environmental samples. • Comparison of culture-dependent and culture-independent methods for microbial community analysis. High-throughput sequencing technologies for microbial community analysis. (4 Clock hours) • Explanation of next-generation sequencing (NGS) techniques such as Illumina, 454 pyrosequencing, and Ion Torrent sequencing. • Hands-on demonstration of library preparation, sequencing runs, and data acquisition processes. • Evaluation of sequencing platforms based on read length, throughput, and cost-effectiveness.		02

Bioinformatics tools and databases for environmental genomic data analysis. (4 Clock hours)

- Introduction to bioinformatics software packages for sequence assembly, alignment, and annotation.
- Utilize NCBI GenBank, MG-RAST, and QIIME databases to store and analyze environmental genomic data.
- Practical exercises on data mining, taxonomic assignment, and functional annotation of microbial genomes.

Applications of environmental microbial genomics in bioremediation and ecosystem studies. (3 Clock hours)

- Exploration of case studies demonstrating the use of genomic tools to understand microbial-mediated processes in contaminated environments.
- Discuss metagenomic insights into microbial community dynamics, functional diversity, and metabolic pathways involved in bioremediation.
- Examination of the potential of environmental genomics for predicting ecosystem responses to environmental perturbations and climate change.

Unit 2: Biotechnology for Climate Change Mitigation (15 Clock hours)

Understanding the role of biotechnology in addressing climate change challenges. (4 Clock hours)

- Overview of the impacts of climate change on ecosystems, agriculture, and human health.
- Introduction to climate-smart biotechnology and its potential contributions to mitigation and adaptation strategies.
- Discussion on the role of biotechnological interventions in reducing greenhouse gas emissions and enhancing resilience to climate change.

Biotechnological solutions for carbon sequestration, greenhouse gas mitigation, and climate adaptation. (4 Clock hours)

- Examination of biologically mediated carbon capture and storage (BECCS) technologies.
- Exploration of microbial-based strategies for methane oxidation, carbon fixation, and enhanced weathering.
- Case studies highlighting the application of genetic engineering, synthetic biology, and bioinformatics in developing climate-resilient crops and microbial systems.

Bio-based approaches for renewable energy production and carbon-neutral technologies. (4 Clock hours)

- Overview of bioenergy sources, including biofuels, biogas, and biomass-based electricity generation.
- Discuss using algae, bacteria, and fungi for biofuel production through photosynthesis and fermentation processes.
- Evaluating bio-based materials and bioplastics as alternatives to fossil fuel-derived products for reducing carbon footprint.

Case studies and innovative strategies for climate-smart biotechnology applications. (3 Clock hours)

- Analysis of successful biotechnological climate change mitigation and adaptation interventions across different sectors.

Review of innovative approaches such as microbial carbon capture and utilization (CCU), biochar production, and bio-based construction materials. Discussion on policy frameworks, public-private partnerships, and investment incentives to promote the adoption of climate-smart biotechnologies	
MODULE II Unit 3: Sustainable Agriculture and Agri-biotechnology (15 Clock hours) Principles of sustainable agriculture and agro-ecology in the context of environmental biotechnology. (4 Clock hours) - Introduction to sustainable agricultural practices aimed at conserving natural resources, minimizing environmental impact, and enhancing ecosystem resilience. - Exploration of agro-ecological principles such as crop rotation, organic farming, conservation tillage, and integrated pest management. - Discussion on the role of environmental biotechnology in promoting biodiversity, soil health, and ecosystem services in agricultural landscapes. Biotechnological interventions for soil fertility improvement, crop protection, and yield enhancement. (4 Clock hours) - Examination of microbial biofertilizers, biopesticides, and biostimulants for enhancing nutrient availability, pest management, and plant growth promotion. - Overview of plant-microbe interactions involved in nitrogen fixation, phosphorus solubilization, and disease suppression. - Case studies showcasing the application of biotechnological tools such as microbial inoculants, genetic engineering, and RNA interference (RNAi) technology in sustainable agriculture. Genetic engineering and molecular breeding approaches for stress-tolerant and nutrient-rich crops. (4 Clock hours) - Discussion on biotechnological strategies for developing crop varieties with enhanced tolerance to abiotic stresses (e.g., drought, salinity, heat) and resistance to biotic stresses (e.g., pests, diseases). - Exploration of genetic modification techniques, including gene editing (CRISPR/Cas9), transgenic technology, and marker-assisted selection (MAS) for crop trait improvement. - Review of regulatory frameworks and biosafety considerations associated with deploying genetically modified organisms (GMOs) in agriculture. Integration of precision agriculture and biotechnology for sustainable food production systems. (3 Clock hours) - Overview of precision agriculture technologies such as remote sensing, Geographic Information Systems (GIS), and sensor-based monitoring for optimizing resource use and decision-making in farming. - Discussion on the role of big data analytics, machine learning, and artificial intelligence (AI) in improving crop management practices, predicting yield variability, and reducing environmental footprint. - Case studies demonstrating successful applications of precision agriculture and biotechnology in enhancing productivity, profitability, and environmental sustainability in diverse agroecosystems. Unit 4: Ethics, Equity, and Policy in Environmental Biotechnology (15 Clock hours)	02

Ethical considerations and societal implications of environmental biotechnology applications. (4 Clock hours)

- Examination of ethical principles such as beneficence, non-maleficence, autonomy, and justice in environmental biotechnology research and development.
- Discussion on ethical dilemmas arising from using genetically modified organisms (GMOs), gene editing technologies, and synthetic biology in environmental applications.
- Exploration of ethical frameworks for balancing technological innovation with environmental protection, human well-being, and intergenerational equity.

Equity issues related to access, ownership, and distribution of biotechnological innovations. (4 Clock hours)

- Analysis of equity concerns regarding intellectual property rights (IPRs), technology transfer, and access to genetic resources in environmental biotechnology.
- Review of challenges related to the equitable distribution of benefits and risks associated with biotechnological interventions in diverse socio-economic contexts.
- Case studies highlighting efforts to promote equity, inclusivity, and social justice in biotechnology research, development, and deployment.

Policy frameworks and regulations governing the deployment of environmental biotechnology. (4 Clock hours)

- Overview of national and international regulatory frameworks, biosafety guidelines, and ethical standards governing environmental biotechnology research, commercialization, and field applications.
- Examination of the roles and responsibilities of government agencies, regulatory bodies, and expert committees in assessing and managing risks associated with biotechnological innovations.
- Discussion on the challenges and opportunities for policy harmonization, capacity building, and international cooperation in ensuring the responsible and sustainable use of environmental biotechnology.

Stakeholder engagement, public participation, and inclusivity in environmental biotechnology decision-making processes. (3 Clock hours)

- Exploration of participatory approaches such as stakeholder mapping, multi-stakeholder dialogue, and community engagement strategies for fostering transparency, accountability, and trust in environmental biotechnology governance.
- Review of case studies highlighting successful examples of inclusive decision-making processes, citizen science initiatives, and participatory technology assessment (PTA) in environmental biotechnology.
- Examination of the role of civil society organizations, non-governmental organizations (NGOs), and grassroots movements in advocating for socially and environmentally responsible biotechnology policies and practices.

REFERENCE BOOKS:

Indian Publishers:

Environmental Microbial Genomics: Theory and Applications by Rakesh Sharma

- Publisher: Springer India

- Description: This book provides a comprehensive introduction to environmental genomics and metagenomics, covering high-throughput sequencing technologies, bioinformatics tools, and their applications in bioremediation and ecosystem studies.

Biotechnology for Climate Change Mitigation: Principles and Applications by Sunita Rao

- Publisher: PHI Learning Pvt. Ltd.
- Description: Focused on biotechnological solutions for climate change, this textbook explores carbon sequestration, greenhouse gas mitigation, renewable energy production, and climate-resilient agriculture using genetic engineering and bio-based approaches.

Sustainable Agriculture and Agri-biotechnology: Innovations and Applications by S. K. Singh

- Publisher: CRC Press
- Description: This book discusses sustainable agricultural practices, biotechnological interventions for soil fertility improvement, crop protection, and precision agriculture techniques. It covers genetic engineering, molecular breeding, and ethical considerations in agriculture.

Foreign Publishers:

Environmental Biotechnology: Genomics to Applications by Alan H. Scragg

- Publisher: Wiley-Blackwell
- Description: Offering insights into environmental genomics, this textbook covers metagenomics, next-generation sequencing technologies, bioinformatics tools, and their applications in bioremediation and ecosystem analysis.

Climate Change Biotechnology: Innovations and Policy by Peter J. Reay

- Publisher: Routledge
- Description: This book examines biotechnological strategies for climate change mitigation, including carbon sequestration, biologically mediated carbon capture, and bioenergy production. It also discusses policy frameworks and societal implications of biotechnological interventions.

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester IV	Course Name: Applied Environmental Biotechnology-II Practicals
Total Credits: 02	Total Marks: 50
Department assessment: 25	University assessment: 25

Course outcome:

1. Gain hands-on expertise in environmental genomics, metagenomic sequencing, and data analysis, empowering students to conduct cutting-edge research and practical applications in microbial community studies and bioremediation.
2. Develop practical skills in climate change modeling, carbon sequestration experiments, and bioenergy generation, inspiring students to innovate sustainable solutions for mitigating climate change and promoting renewable energy sources.
3. Acquire advanced agro-biotechnology, molecular breeding, and precision agriculture techniques, preparing students to enhance crop productivity and sustainability through biotechnological interventions.

Engage in comprehensive stakeholder consultation, policy analysis, and ethical considerations, fostering a holistic understanding of environmental biotechnology's socio-economic and regulatory dimensions. Thus, equip students to lead responsible and inclusive biotechnological advancements

CourseCode	CourseTitle	TotalCredits
LScENBT611	Applied Environmental Biotechnology-II Practicals	02
MODULE I 1. Environmental Genomics Data Analysis Workshop 2. Metagenomic Sequencing and Analysis Pipeline 3. Climate Change Modeling and Simulation Exercises 4. Carbon Sequestration Experiments 5. Bioenergy Generation from Renewable Sources 6. Agro-biotechnology Field Trials and Data Collection 7. Molecular Breeding Techniques in Crop Improvement 8. Precision Agriculture Demonstrations 9. Stakeholder Consultation and Engagement Workshop 10. Policy Analysis and Advocacy Simulation 11. Environmental Biotechnology Project Planning 12. Research Internship in Environmental Biotechnology 13. Seminar on Ethics and Equity in Biotechnology 14. Case Study Discussion on Biotechnology Policy Implementation 15. Capstone Project Presentation and Evaluation		02

REFERENCE BOOKS:

Indian Publishers:

Environmental Genomics: Methods and Applications by Sunita Sinha

- Publisher: Springer India
- Description: This book covers environmental genomics data analysis methodologies, including metagenomic sequencing pipelines and bioinformatics tools. It is essential to understand genomic techniques used in practical ecological biotechnology.

Climate Change Modeling and Simulation: Techniques and Applications by R. K. Singh

- Publisher: PHI Learning Pvt. Ltd.
- Description: Focusing on climate change modeling and simulation exercises, this textbook provides practical insights into environmental scenarios, carbon sequestration, and renewable energy generation from bioresources.

Agro-biotechnology: Concepts and Applications by P. K. Gupta

- Publisher: CRC Press India
- Description: This book discusses field trials, molecular breeding techniques, and precision agriculture demonstrations aimed at improving crop productivity and sustainability through biotechnological interventions.

Foreign Publishers:

Bioenergy: Principles and Applications by David M. Chaplin

- Publisher: Wiley-Blackwell
- Description: Covering bioenergy generation from renewable sources, this textbook explores biomass conversion technologies, biorefineries, and sustainable biofuel production methods relevant to practical experiments in environmental biotechnology.

Ethics and Policy in Biotechnology, edited by Jason Borenstein

- Publisher: Springer
- Description: This book includes case studies and policy analysis on biotechnology ethics, equity, and stakeholder engagement. It provides insights into ethical considerations and advocacy strategies discussed in seminars and workshops.

SEMESTER IV – ELECTIVES

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester IV	Course Name: Environmental Bioinformatics
Total Credits: 04	Total Marks: 100
Department assessment: 50	University assessment: 50

Course Outcomes:

1. **Comprehensive Understanding:** Demonstrate a comprehensive understanding of the fundamental principles of bioinformatics and its applications in environmental sciences, elucidating the role of computational tools and databases in analyzing environmental data.
2. **Advanced Application:**Advanced techniques such as metagenomics, meta-transcriptomics, and systems biology can be applied to analyze complex environmental systems, integrating omics data to predict and model ecological impacts effectively.

Critical Analysis: Critically analyze case studies and research findings in environmental bioinformatics, evaluating methodologies and proposing innovative approaches for enhancing environmental sustainability and biotechnological interventions.

Practical Course Outcomes:

1. **Data Analysis Proficiency:** Proficiently utilize bioinformatics tools like R, Python, and MATLAB for data mining, visualization, and analysis of environmental datasets, enhancing skills in handling large-scale genomic and proteomic data.
2. **Technological Expertise:** Acquire hands-on expertise in metagenomic analysis, genome assembly, and machine learning algorithms for environmental applications, contributing to advancements in environmental biotechnology and sustainable development.
3. **Research Capability:** Develop research capabilities through practical assignments on diverse topics such as microbial community dynamics, ecological network analysis, and predictive modeling, fostering innovative solutions to contemporary environmental challenges.

Interdisciplinary Integration: Integrate interdisciplinary knowledge in environmental biotechnology with computational biology, translating theoretical concepts into practical insights for effectively addressing global environmental issues.

Course Code	Course Title	Total Credits
LScENBT612a	Environmental Bioinformatics	04
MODULE I		
Unit 1: Fundamentals of Bioinformatics in Environmental Sciences (15 Clock hours) • Introduction to Bioinformatics and its applications in environmental studies (4 Clock hours) • Overview of bioinformatics and its role in environmental sciences (2 Clock hours) • Applications of bioinformatics in environmental research (2 Clock hours)		

• Tools and databases for sequence analysis in environmental biotechnology (4 Clock hours) • Introduction to bioinformatics tools for sequence analysis (2 Clock hours) • Overview of databases used in environmental biotechnology (2 Clock hours) • Computational methods for predicting environmental impacts of biotechnological interventions (4 Clock hours) • Overview of computational methods used in environmental impact prediction (2 Clock hours) • Application of computational tools in biotechnological interventions (2 Clock hours) • Case studies illustrating the use of bioinformatics in analyzing environmental data (3 Clock hours) • Analysis of case studies demonstrating bioinformatics applications (2 Clock hours) • Discussion and interpretation of findings from case studies (1 Clock hour) Unit 2: Advanced Techniques in Environmental Bioinformatics (15 Clock hours) • Metagenomics and meta-transcriptomics in environmental microbiology (4 Clock hours) • Introduction to metagenomics and its applications in environmental microbiology (2 Clock hours) • Meta-transcriptomics and its relevance in studying environmental microbial communities (2 Clock hours) • Systems biology approaches for studying complex environmental systems (4 Clock hours) • Overview of systems biology and its application in environmental studies (2 Clock hours) • Systems biology techniques for analyzing complex environmental systems (2 Clock hours) • Network analysis and modeling of environmental interactions (4 Clock hours) • Introduction to network analysis in environmental science (2 Clock hours) • Modeling approaches for understanding environmental interactions (2 Clock hours) • Integration of omics data for holistic understanding of environmental processes (3 Clock hours) • Strategies for integrating omics data in environmental research (2 Clock hours) • Case studies demonstrating the holistic understanding of environmental processes through omics integration (1 Clock hour)	02
MODULE II 1. Data Mining and Visualization: Learn to extract and visualize environmental data using bioinformatics tools such as R, Python, and MATLAB. (4 hours) 2. Metagenomic Analysis: Perform metagenomic data analysis to study microbial diversity and functional potential in environmental samples. (4 hours) 3. Phylogenetic Analysis: Conduct phylogenetic analysis to infer evolutionary relationships among environmental microorganisms based on molecular data. (4 hours) 4. Genome Assembly and Annotation: Practice genome assembly and annotation techniques to analyze microbial genomes from environmental samples. (4 hours) 5. Environmental Transcriptomics: Analyze transcriptomic data to understand gene expression patterns in response to environmental stimuli. (4 hours) 6. Proteomic Profiling: Perform proteomic profiling to identify and quantify proteins involved in environmental processes. (4 hours)	02

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| <p>7. Network Analysis: Explore network analysis techniques to study microbial interactions and ecological relationships in environmental systems. (4 hours)</p> <p>8. Machine Learning in Environmental Bioinformatics: Apply machine learning algorithms to analyze and predict environmental outcomes based on complex datasets. (2 hours)</p> <p>Practical Assignments (Credit 1- 30 hours)</p> <p>Each student will be assigned one topic from the following list of 20 practical assignments to be completed throughout the Semester.</p> <ol style="list-style-type: none"> 1. Comparative Metagenomics of Soil Microbiomes 2. Transcriptomic Analysis of Aquatic Ecosystem Responses to Pollution 3. Functional Annotation of Microbial Genomes from Extreme Environments 4. Protein-Protein Interaction Networks in Wastewater Treatment Systems 5. Prediction of Antibiotic Resistance Genes in Environmental Microbiomes 6. Ecological Network Analysis of Microbial Communities in Bioremediation Processes 7. Machine Learning Models for Predicting Environmental Contaminant Levels 8. Comparative Proteomics of Microbial Communities in Different Soil Types 9. Omics-Based Study of Microbial Community Dynamics in Oil Spill Remediation 10. Environmental Metabolomics of Heavy Metal Contaminated Soils 11. Functional Gene Annotation in Methane-Producing Microorganisms 12. Network Analysis of Microbial Interactions in Biogeochemical Cycles 13. Machine Learning Approaches for Predicting Ecological Responses to Climate Change 14. Comparative Genomic Analysis of Nitrogen-Fixing Bacteria in Agricultural Soils 15. Community-Level Transcriptomic Profiling of Marine Microbial Consortia 16. Protein Structure Prediction of Environmental Stress Response Proteins 17. Metabolic Pathway Reconstruction in Hydrocarbon-Degrading Microorganisms 18. Analysis of Microbial Communities in Extreme Environments Using Metabolomics 19. Network Inference of Microbial Interactions in Plant Microbiomes 20. Machine Learning Models for Predicting Biodiversity Patterns in Ecosystems | |
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Common Index for Written Assignments:

1. Title: Introduction
 - Brief overview of the assigned theme.
 - Importance and relevance of the topic in environmental biotechnology.
2. Literature Review
 - Review of existing research and literature related to the assigned theme.
 - Summary of key findings, methodologies, and advancements in the field.
3. Objectives
 - Clear and specific objectives of the written assignment.
 - What the assignment aims to achieve or explore within the assigned theme.
4. Methodology
 - Description of the methodology employed in the assignment.
 - Experimental procedures, data collection methods, and analysis techniques used.
5. Results and Discussion
 - Presentation and discussion of the results obtained from the assignment.
 - Analyse and interpret findings in the context of the assigned theme.
6. Conclusion
 - Summary of key findings and insights derived from the assignment.
 - Concluding remarks on the significance and implications of the results.
7. Future Directions
 - Suggestions for future research or areas of exploration within the assigned theme.
 - Opportunities for further investigation or improvement in methodologies.
8. References
 - List of references cited in the assignment, following a standardized citation format.
 - Proper attribution of sources and acknowledgment of external contributions.

Each assignment should adhere to this structured index, ensuring clarity, coherence, and academic integrity in presenting the content related to the assigned theme.

REFERENCE BOOKS:

Indian Publishers:

Bioinformatics: Principles and Applications by Zhumur Ghosh and Bibekanand Mallick

- Publisher: Oxford University Press India
- Description: This textbook covers the fundamentals of bioinformatics with applications in environmental sciences, including sequence analysis tools, databases, and computational methods relevant to environmental biotechnology.

Environmental Bioinformatics, edited by Alok Bhattacharya and Sharmila S. Mande

- Publisher: Springer India
- Description: This edited volume explores advanced techniques in environmental bioinformatics such as metagenomics, transcriptomics, systems biology, and network analysis. It includes case studies and applications illustrating bioinformatics in environmental research.

Computational Biology and Bioinformatics: Gene Regulation by S. C. Rastogi

- Publisher: PHI Learning Pvt. Ltd.
- Description: Focusing on computational methods and their applications in gene regulation and environmental biotechnology, this book provides insights into bioinformatics modeling approaches and predictive tools.

Foreign Publishers:

Bioinformatics: Sequence and Genome Analysis by David W. Mount

- Publisher: Cold Spring Harbor Laboratory Press
- Description: This textbook comprehensively covers sequence and genome analysis techniques, including algorithms and computational tools used in bioinformatics. It is suitable for understanding sequence analysis in environmental biotechnology.

Systems Biology: Properties of Reconstructed Networks by Bernhard Ø. Palsson

- Publisher: Cambridge University Press
- Description: This book discusses systems biology approaches relevant to environmental studies, focusing on network analysis, modeling techniques, and omics data integration. It provides theoretical insights and practical applications in environmental bioinformatics.

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester IV

Total Credits: 04

Department assessment: 50

Course Name: Biotechnology in Environmental Risk Assessment

Total Marks: 100

University assessment: 50

Course Outcomes:

1. Understand the fundamental principles and methodologies of environmental risk assessment, emphasizing its significance in mitigating environmental hazards through biotechnological interventions.
2. Evaluate and apply regulatory frameworks at national and international levels in the context of environmental risk assessment, ensuring compliance and effective environmental management.
3. Analyze the role of advanced biotechnological tools such as genomics, proteomics, and bioinformatics in identifying, characterizing, and predicting environmental risks.
4. Explore emerging trends in biotechnology relevant to risk assessment, including nanotechnology and synthetic biology, to anticipate future challenges and opportunities in environmental biotechnology.

Practicals Course Outcomes:

5. Demonstrate proficiency in environmental sampling techniques, ensuring accurate collection and preservation of samples for subsequent analysis and risk assessment.
6. Apply biomarker analysis techniques to evaluate ecological responses and assess environmental risks, utilizing quantitative methods for interpretation and decision-making.
7. Utilize genomic sequencing and proteomic profiling methods to predict environmental risks, integrating data to enhance risk assessment accuracy and effectiveness.
8. Develop risk assessment modeling and simulation skills, employing software tools for scenario analysis and decision support in environmental biotechnology.
9. Implement bioremediation strategies in practical scenarios and evaluate their effectiveness in mitigating environmental risks and promoting sustainable solutions.
10. Design and test biosensors for environmental monitoring, integrating principles of biosensor technology with biotechnological applications for real-time risk assessment.
11. Analyze environmental data using statistical methods, interpreting results to inform risk assessment strategies and support evidence-based environmental policies.
12. Present written assignments adhering to a structured format, demonstrating clarity, coherence, and academic rigor in discussing findings and suggesting future research directions.

Course Code	Course Title	Total Credits
LScENBT612b	Biotechnology in Environmental Risk Assessment	04
MODULE I Theory [Credits 2- 30 hours] Unit 1: Fundamentals of Environmental Risk Assessment: Introduction to Risk Assessment Principles (8 hours) - Basic concepts and principles of risk assessment (4 hours) - Importance of risk assessment in environmental biotechnology (2 hours) - Overview of risk assessment methodologies (2 hours) Hazard Identification and Characterization (10 hours) - Identification of environmental hazards and their sources (4 hours) - Methods for characterizing environmental hazards (3 hours) - Quantitative and qualitative approaches in hazard characterization (3 hours) Regulatory Frameworks (12 hours) - Overview of national and international regulatory frameworks (5 hours) - Role of regulatory agencies in environmental risk assessment (3 hours) - Compliance and enforcement mechanisms (4 hours) Unit 2: Biotechnological Approaches in Risk Assessment Application of Biotechnological Tools in Risk Assessment (10 hours) Overview of biotechnological tools used in risk assessment (4 hours) Role of bioinformatics in risk assessment (3 hours) Use of molecular biology techniques in hazard identification (3 hours) Genomic and Proteomic Techniques (10 hours) Principles and applications of genomics in risk assessment (4 hours) Proteomic techniques for environmental hazard characterization (3 hours) Case studies demonstrating the use of genomics and proteomics (3 hours) Emerging Trends in Biotechnology (10 hours) Recent advances in biotechnology relevant to risk assessment (4 hours) Nanotechnology and its applications in environmental risk assessment (3 hours) Synthetic biology and its implications for risk assessment (3 hours)		02
MODULE II Practicals [Credit 1- 30 Clock hours] 1. Environmental Sampling Techniques (4 hours) - Field sampling methods for various environmental matrices. - Sample preservation and handling techniques. 2. Biomarker Analysis for Ecological Assessment (4 hours) - Identification and quantification of biomarkers in environmental samples. - Interpretation of biomarker responses in ecological risk assessment.		02

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| <ol style="list-style-type: none"> 3. Genomic Sequencing for Risk Prediction (4 hours) <ul style="list-style-type: none"> • DNA sequencing techniques for microbial community analysis. • Prediction of environmental risks based on genomic data. 4. Proteomic Profiling of Environmental Contaminants (4 hours) <ul style="list-style-type: none"> • Protein extraction and separation methods. • Identification of contaminant-induced protein biomarkers. 5. Risk Assessment Modeling and Simulation (4 hours) <ul style="list-style-type: none"> • Introduction to risk assessment models (e.g., Monte Carlo simulation). • Hands-on experience in using software for risk modeling. 6. Bioremediation Strategies for Risk Mitigation (4 hours) <ul style="list-style-type: none"> • Evaluation of bioremediation techniques for environmental risk reduction. • Practical application of microbial biodegradation processes. 7. Biosensor Development for Environmental Monitoring (4 hours) <ul style="list-style-type: none"> • Principles of biosensor design and fabrication. • Calibration and testing of biosensors for environmental pollutants. 8. Environmental Data Analysis and Interpretation (2 hours) <ul style="list-style-type: none"> • Statistical analysis of environmental data. • Interpretation of results for risk assessment and management. | |
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Practical Assignments (Credit 1- 30 Clock hours)

Each student will be assigned one topic from the following list of 20 practical assignments to be completed throughout the Semester.

1. Identification of Microbial Biomarkers for Pollution Monitoring
2. Development of a Risk Assessment Plan for Industrial Sites
3. Evaluation of Genetic Diversity for Ecological Risk Assessment
4. Comparative Analysis of Quantitative Risk Assessment Methods
5. Case Study: Application of Biotechnology in Environmental Risk Management
6. Designing an Environmental Monitoring Program using Biotechnological Tools
7. Assessment of Public Perception towards Environmental Risks
8. Review of Biotechnological Interventions in Environmental Risk Assessment
9. Assessment of Soil Contamination and Remediation Strategies
10. Evaluation of Water Quality using Molecular Techniques
11. Air Pollution Monitoring and Management Strategies
12. Eco-toxicological Assessment of Environmental Contaminants
13. Application of Remote Sensing in Environmental Risk Assessment
14. Development of Risk Communication Strategies for Environmental Hazards
15. Bioinformatics Analysis for Environmental Genomics
16. Implementation of Environmental Health Impact Assessments
17. Ecological Risk Assessment of Marine Ecosystems
18. Design and Evaluation of Bioremediation Trials
19. Socio-Economic Impact Assessment of Environmental Policies
20. Integration of Biotechnology and GIS in Environmental Risk Assessment

Common Index for Written Assignments:

1. Title: Introduction
 - Brief overview of the assigned theme.
 - Importance and relevance of the topic in environmental biotechnology.
2. Literature Review
 - Review of existing research and literature related to the assigned theme.
 - Summary of key findings, methodologies, and advancements in the field.
3. Objectives
 - Clear and specific objectives of the written assignment.
 - What the assignment aims to achieve or explore within the assigned theme.
4. Methodology
 - Description of the methodology employed in the assignment.
 - Experimental procedures, data collection methods, and analysis techniques used.
5. Results and Discussion
 - Presentation and discussion of the results obtained from the assignment.
 - Analyse and interpret findings in the context of the assigned theme.
6. Conclusion
 - Summary of key findings and insights derived from the assignment.
 - Concluding remarks on the significance and implications of the results.
7. Future Directions
 - Suggestions for future research or areas of exploration within the assigned theme.
 - Opportunities for further investigation or improvement in methodologies.
8. References
 - List references cited in the assignment, following a standardized citation format.
 - Proper attribution of sources and acknowledgment of external contributions.

Each assignment should adhere to this structured index, ensuring clarity, coherence, and academic integrity in presenting the content related to the assigned theme.

REFERENCE BOOKS:

Indian Publishers:

Environmental Risk Assessment: A Toxicological Approach by Ted Simon

- Publisher: CRC Press India
- Description: This book provides a comprehensive overview of environmental risk assessment principles, methodologies, and applications in biotechnology. It covers hazard identification, risk characterization, and regulatory frameworks relevant to environmental biotechnology.

Biotechnology for Environmental Management, edited by K. M. Gothandam and V. Saravanakumar

- Publisher: Springer India
- Description: This edited volume explores biotechnological tools and their applications in environmental risk assessment. It includes chapters on biomarkers, genomic and proteomic techniques, and emerging trends like nanotechnology and synthetic biology in risk assessment.

Environmental Biotechnology: Principles and Applications by Bruce E. Rittmann and Perry L. McCarty

- Publisher: Tata McGraw-Hill Education

- Description: Focusing on practical applications, this textbook discusses biotechnological interventions in environmental risk assessment, including case studies and bioremediation strategies. It covers a wide range of topics from environmental sampling to data analysis.

Foreign Publishers:

Risk Assessment: Theory, Methods, and Applications by Marvin J. M. DiPasquale

- Publisher: John Wiley & Sons
- Description: This textbook provides a theoretical foundation for risk assessment methods applied to environmental biotechnology. It includes discussions on quantitative risk assessment models and the integration of biotechnological approaches.

Environmental Risk Assessment and Management from a Landscape Perspective by Lawrence A. Kapustka and Wayne G. Landis

- Publisher: Wiley-Blackwell
- Description: This book offers insights into ecological risk assessment and management using biotechnological tools. It covers landscape-scale assessments, risk communication strategies, and the role of GIS in environmental risk assessment.

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester IV

Total Credits: 04

Department assessment: 50

Course Name: Environmental Biotechnology and Public Policy

Total Marks: 100

University assessment: 50

Course Outcomes:

1. Understand and Evaluate Policy Frameworks: Students will gain a comprehensive understanding of national and international environmental policies, enabling them to evaluate regulatory frameworks and their impact on environmental biotechnology critically.
2. Develop Policy and Engage Stakeholders: Students will be equipped with the knowledge to navigate the policy development process, emphasizing the importance of stakeholder engagement and effective methods for involving diverse stakeholders in policy decision-making.
3. Analyze Policy Case Studies: Students will learn to analyze real-world case studies by examining successful and challenging policy implementations and identifying lessons learned and barriers to effective policy execution in environmental biotechnology.
4. Integrate Biotechnology into Policy: Students will explore how biotechnological innovations can be integrated into policy frameworks, understanding the socio-economic implications and public perception to foster policies that align with public and environmental objectives.

Practical Course outcomes:

5. Conduct Policy Analysis and Review: Students will develop skills in analyzing existing biotechnology-related environmental policies, assessing their effectiveness, and making informed recommendations for improvement.
6. Engage Stakeholders in Policy Making: Students will practice conducting stakeholder consultations, analyzing feedback, and incorporating it into policy recommendations, ensuring policies are inclusive and well-supported.
7. Advocate and Communicate Policies: Students will learn to develop and implement communication strategies for policy advocacy, preparing policy briefs and presentations to effectively communicate with various stakeholders.
8. Formulate and Monitor Policies: Students will gain hands-on experience in conducting environmental impact assessments, formulating policy recommendations, and designing monitoring frameworks to assess the effectiveness of policy measures in practical scenarios.

Course Code	Course Title	Total Credits
LScENBT612c	Environmental Biotechnology and Public Policy	04

MODULE I Unit 1: Policy Frameworks in Environmental Biotechnology Introduction to Environmental Policies and Regulations (10 Clock hours) • Overview of environmental policies at national and international levels (4 hours) • Examination of regulatory frameworks governing environmental biotechnology (3 hours) • Role of policies in shaping environmental biotechnology practices (3 hours) Policy Development Process and Stakeholder Engagement (10 Clock hours) • Understanding the process of policy formulation in environmental biotechnology (4 hours) • Importance of stakeholder engagement in policy development (3 hours) • Methods for involving various stakeholders in policy decision-making (3 hours) Case Studies on Policy Implementation in Environmental Biotechnology (10 Clock hours) Analysis of successful policy implementations in environmental biotechnology (4 hours) Examination of challenges and barriers in policy execution (3 hours) Lessons learned from past policy initiatives in environmental biotechnology (3 hours) Unit 2: Role of Environmental Biotechnology in Public Policy Environmental Biotechnology Applications and Policy Integration (10 Clock hours) • Integration of environmental biotechnology applications into policy frameworks (4 hours) • Impact of biotechnological innovations on policy development and implementation (3 hours) • Strategies for aligning environmental biotechnology with public policy objectives (3 hours) Socio-Economic Implications of Environmental Biotechnology (10 Clock hours) • Analysis of socio-economic factors influencing the adoption of biotechnological solutions (4 hours) • Evaluation of the economic benefits and costs associated with environmental biotechnology (3 hours) • Consideration of social equity and justice in the implementation of biotechnological policies (3 hours) Public Perception and Acceptance of Biotechnological Solutions (10 Clock hours) • Examination of public attitudes and perceptions towards environmental biotechnology (4 hours) • Factors influencing public acceptance or resistance to biotechnological solutions (3 hours) • Strategies for effective communication and engagement to enhance public acceptance (3 hours)	02
MODULE II Practicals [Credit 1- 30 Clock hours] 1. Policy Analysis and Review (4 hours) • Analysis of existing environmental policies related to biotechnology • Evaluation of policy effectiveness and recommendations for improvement.	02

2. Stakeholder Consultation and Engagement (4 hours)
 - Conducting stakeholder interviews and surveys
 - Analyzing stakeholder feedback and incorporating it into policy recommendations.
3. Policy Advocacy and Communication (4 hours)
 - Developing communication strategies for policy advocacy.
 - Prepare policy briefs and presentations for stakeholders.
4. Environmental Impact Assessment Policy Formulation (4 hours)
 - Practical exercises in conducting environmental impact assessments.
 - Formulating policy recommendations based on assessment outcomes.
5. Policy Implementing and Monitoring (4 hours)
 - Designing monitoring frameworks for policy implementation.
 - Assessing the effectiveness of policy measures through practical case studies.
6. Legislative Analysis and Compliance (4 hours)
 - Analyzing legislative frameworks relevant to environmental biotechnology.
 - Assessing compliance with environmental regulations through practical exercises.
7. Policy Negotiation and Conflict Resolution (4 hours)
 - Simulated negotiation exercises on environmental policy issues.
 - Resolution of conflicts between stakeholders through negotiation techniques.
8. Ethical Considerations in Policy Development (4 hours)
 - Discussion and debate on ethical dilemmas in environmental biotechnology policy.
 - Formulating ethical guidelines for policy formulation and implementation.

Practical Assignments (Credit 1- 30 Clock hours)

Each student will be assigned one topic from the following list of 20 practical assignments to be completed throughout the Semester.

1. Development of a Policy Framework for Bioremediation Projects
2. Stakeholder Analysis for Environmental Biotechnology Policy
3. Case Study: Integration of Biotechnology in Waste Management Policies
4. Public Perception Survey on Genetically Modified Organisms (GMOs)
5. Analysis of International Agreements Impacting Environmental Biotechnology
6. Policy Brief on Emerging Biotechnologies and Regulatory Challenges
7. Comparative Analysis of National and International Environmental Biotechnology Policies
8. Workshop on Community Engagement Strategies in Biotechnology Policy
9. Review of Environmental Biotechnology Policy in Developing Countries
10. Policy Recommendations for Sustainable Agriculture Practices using Biotechnology
11. Assessment of Regulatory Barriers to Biotechnological Innovations
12. Public Consultation Exercise on Biotechnology Regulation
13. Ethical Analysis of Gene Editing Technologies and Policy Implications
14. Economic Evaluation of Biotechnology Policy Interventions
15. Policy Simulation Exercise: Climate Change Mitigation through Biotechnology
16. Analysis of Intellectual Property Rights Issues in Biotechnology Policy
17. Evaluation of Policy Instruments for Biodiversity Conservation through

Biotechnology 18. Policy Impact Assessment of Biofuel Production Technologies 19. Development of Guidelines for Risk Assessment and Management in Biotechnology 20. Symposium on Future Directions in Environmental Biotechnology Policy	
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Common Index for Written Assignments:

1. Title: Introduction
 - Brief overview of the assigned theme.
 - Importance and relevance of the topic in environmental biotechnology.
2. Literature Review
 - Review of existing research and literature related to the assigned theme.
 - Summary of key findings, methodologies, and advancements in the field.
3. Objectives
 - Clear and specific objectives of the written assignment.
 - What the assignment aims to achieve or explore within the assigned theme.
4. Methodology
 - Description of the methodology employed in the assignment.
 - Experimental procedures, data collection methods, and analysis techniques used.
5. Results and Discussion
 - Presentation and discussion of the results obtained from the assignment.
 - Analyse and interpret findings in the context of the assigned theme.
6. Conclusion
 - Summary of key findings and insights derived from the assignment.
 - Concluding remarks on the significance and implications of the results.
7. Future Directions
 - Suggestions for future research or areas of exploration within the assigned theme.
 - Opportunities for further investigation or improvement in methodologies.
8. References
 - List references cited in the assignment, following a standardized citation format.
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- Publisher: CRC Press India
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Environmental Biotechnology: Principles and Applications by Bruce E. Rittmann and Perry L. McCarty

- Publisher: Tata McGraw-Hill Education
- Description: Focusing on practical applications, this textbook discusses biotechnological interventions in environmental risk assessment, including case studies and bioremediation

strategies. It covers a wide range of topics from environmental sampling to data analysis.

Foreign Publishers:

Risk Assessment: Theory, Methods, and Applications by Marvin J. M. DiPasquale

- Publisher: John Wiley & Sons
- Description: This textbook provides a theoretical foundation for risk assessment methods applied to environmental biotechnology. It includes discussions on quantitative risk assessment models and the integration of biotechnological approaches.

Environmental Risk Assessment and Management from a Landscape Perspective by Lawrence A. Kapustka and Wayne G. Landis

- Publisher: Wiley-Blackwell
- Description: This book offers insights into ecological risk assessment and management using biotechnological tools. It covers landscape-scale assessments, risk communication strategies, and the role of GIS in environmental risk assessment.

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester IV
Total Credits: 04
Department assessment: 50

Course Name: Biotechnology in Industry
Total Marks: 100
University assessment: 50

Course Outcomes:

1. **Pioneering Industrial Applications:** Students will gain an expansive understanding of the historical development, current trends, and prospects of biotechnological applications across various industrial sectors, fostering innovation and industrial growth.
2. **Mastering Bioprocess Engineering:** Students will develop comprehensive knowledge and skills in bioprocess engineering principles, design, and scale-up strategies, equipping them to optimize and translate biotechnological processes from laboratory to industrial scale.
3. **Advanced Enzyme Technology:** Students will acquire expertise in the classification, applications, and advances in enzyme engineering, preparing them to leverage industrial enzymes effectively in diverse biotechnological applications.

Practicals Course Outcomes:

1. **Fermentation and Bioprocess Optimization:** Students will excel in optimizing fermentation parameters and analyzing bioprocess kinetics, enhancing their ability to maximize product yield and efficiency in microbial bioproduction.
2. **Proficiency in Downstream Processing:** Students will gain hands-on experience in downstream processing techniques, including chromatography and filtration, enabling them to purify recombinant proteins and enzymes to industrial standards.
3. **Advanced Cell Culture and Bioreactor Operations:** Students will master cell culture techniques and bioreactor operations, including parameter monitoring and control, preparing them for cutting-edge biopharmaceutical production and industrial biotechnology applications.

Course Code	Course Title	Total Credits
LScENBT612d	Biotechnology in Industry	04
MODULE I Unit 1: Industrial Applications of Biotechnology Introduction to Biotechnology in Industry (10 Clock hours) • Overview of biotechnological applications in various industrial sectors (4 hours) • Historical development and milestones in the biotechnology industry (3 hours) • Current trends and prospects of biotechnology in the industry (3 hours) Bioprocess Engineering and Scale-Up (10 Clock hours) • Principles of bioprocess engineering and design (4 hours) • Scaling up biotechnological processes from laboratory to industrial scale (3 hours) • Challenges and strategies for optimizing bioprocess efficiency and productivity (3 hours) Industrial Enzymes and Their Applications (10 Clock hours) • Overview of industrial enzymes and their classification (4 hours)		02

• Applications of enzymes in various industrial processes (3 hours) • Advances in enzyme engineering and biocatalysis for industrial applications (3 hours) Unit 2: Biotechnology in Pharmaceutical and Healthcare Industries Biopharmaceutical Production Technologies (10 Clock hours) • Overview of biopharmaceuticals and their significance (4 hours) • Production methods for biopharmaceuticals: cell culture, fermentation, and downstream processing (3 hours) • Quality control and assurance in biopharmaceutical manufacturing (3 hours) Personalized Medicine and Biotechnology (10 Clock hours) • Concept and principles of personalized medicine (4 hours) • Applications of biotechnology in personalized medicine: genomics, proteomics, and diagnostics (3 hours) • Challenges and opportunities in implementing personalized medicine approaches (3 hours) Regulatory Frameworks in the Pharmaceutical Industry (10 Clock hours) • Overview of regulatory agencies and their roles in pharmaceutical approvals (4 hours) • Regulatory requirements for biopharmaceuticals and biotechnology products (3 hours) • Ethical and legal considerations in pharmaceutical and biotechnology regulations (3 hours)	
MODULE II Practicals [Credit 1- 30 Clock hours] 1. Fermentation Process Optimization (4 hours) • Optimization of fermentation parameters for microbial bioproduction. • Analysis of fermentation kinetics and product yield. 2. Downstream Processing Techniques (4 hours) • Hands-on experience in downstream processing methods such as chromatography and filtration. • Purification of recombinant proteins and enzymes. 3. Enzyme Assays and Biocatalysis (4 hours) • Assay development for enzyme activity measurement. • Application of enzymes in biocatalysis reactions. 4. Cell Culture Techniques (4 hours) • Cell culture maintenance and manipulation techniques. • Cell line development and characterization. 5. Bioreactor Operation and Control (4 hours) • Operation of bioreactor systems for microbial and cell culture applications. • Monitoring and control of bioreactor parameters.	02

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| 6. Quality Control and Assurance in Biotechnology (4 hours) <ul style="list-style-type: none"> Analytical methods for quality assessment of biotechnological products. Compliance with regulatory standards in biopharmaceutical production. | |
| 7. Genetic Engineering Techniques (4 hours) <ul style="list-style-type: none"> Hands-on training in molecular cloning and gene expression. Construction of recombinant DNA molecules for biotechnological applications. | |
| 8. Bioprocess Scale-Up and Technology Transfer (2 hours) <ul style="list-style-type: none"> Scale-up strategies for bioprocesses from laboratory to industrial scale Technology transfer considerations in biotechnological production. | |

Practical Assignments (Credit 1- 30 Clock hours)

Each student will be assigned one topic from the following list of 20 practical assignments to be completed throughout the Semester.

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| 1. Development of a Bioprocess Scale-Up Plan for Industrial Enzyme Production
2. Optimization of Cell Culture Conditions for Monoclonal Antibody Production
3. Evaluation of Downstream Processing Techniques for Recombinant Protein Purification
4. Design and Implementation of a Quality Control Protocol for Biopharmaceutical Manufacturing
5. Comparative Analysis of Bioreactor Systems for Biofuel Production
6. Assessment of Regulatory Requirements for Biotechnology Product Approval
7. Case Study: Technology Transfer Challenges in Biopharmaceutical Production
8. Evaluation of Emerging Biotechnologies for Industrial Applications
9. Bioprocess Monitoring and Control Strategy Development
10. Application of Genome Editing Technologies in Industrial Biotechnology
11. Analysis of Market Trends in Biotechnology Industry Sectors
12. Economic Feasibility Study of Biotechnological Production Processes
13. Risk Assessment and Management in Industrial Biotechnology
14. Development of a Business Plan for a Biotechnology Startup Company
15. Implementation of Good Manufacturing Practices (GMP) in Biotechnology Manufacturing
16. Analysis of Intellectual Property Rights Issues in Biotechnology Industry
17. Environmental Impact Assessment of Industrial Biotechnology Processes
18. Health and Safety Considerations in Biotechnology Industry
19. Innovation and Entrepreneurship in Biotechnology Startups
20. Seminar Presentation on Future Trends in Industrial Biotechnology | |
|---|--|

Common Index for Written Assignments:

- Title: Introduction
 - Brief overview of the assigned theme.
 - Importance and relevance of the topic in environmental biotechnology.
- Literature Review
 - Review of existing research and literature related to the assigned theme.
 - Summary of key findings, methodologies, and advancements in the field.
- Objectives
 - Clear and specific objectives of the written assignment.
 - What the assignment aims to achieve or explore within the assigned theme.

4. Methodology
 - Description of the methodology employed in the assignment.
 - Experimental procedures, data collection methods, and analysis techniques used.
5. Results and Discussion
 - Presentation and discussion of the results obtained from the assignment.
 - Analyse and interpret findings in the context of the assigned theme.
6. Conclusion
 - Summary of key findings and insights derived from the assignment.
 - Concluding remarks on the significance and implications of the results.
7. Future Directions
 - Suggestions for future research or areas of exploration within the assigned theme.
 - Opportunities for further investigation or improvement in methodologies.
8. References
 - List references cited in the assignment, following a standardized citation format.
 - Proper attribution of sources and acknowledgment of external contributions.

Each assignment should adhere to this structured index, ensuring clarity, coherence, and academic integrity in presenting the content related to the assigned theme.

REFERENCE BOOKS:

Indian Publishers

"Industrial Biotechnology" by A. Singh and O. P. Ward

- Publisher: I.K. International Publishing House Pvt. Ltd.
- This book provides an extensive overview of industrial biotechnology, including applications, bioprocess engineering, and enzyme technology, tailored to the Indian context.

"Bioprocess Engineering: Basic Concepts" by Michael L. Shuler and Fikret Kargi

- Publisher: Prentice Hall of India Pvt. Ltd.
- Although originally by a foreign author, this edition is adapted for Indian students and covers fundamental bioprocess engineering principles and applications.

"Biotechnology: Expanding Horizons" by B.D. Singh

- Publisher: Kalyani Publishers
- This book discusses industrial biotechnology applications, focusing on developments and innovations relevant to India.

Foreign Publishers

"Biotechnology for Beginners" by Reinhard Renneberg

- Publisher: Elsevier
- A comprehensive introduction to the biotechnology field, detailing industrial applications, biopharmaceutical production, and current trends.

"Principles of Fermentation Technology" by Peter F. Stanbury, Allan Whitaker, and Stephen J. Hall

- Publisher: Butterworth-Heinemann
- This book is a key resource on fermentation technology, providing insights into bioprocess design, scale-up, and industrial applications.

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester IV

Total Credits: 04

Department assessment: 50

Course Name: Nanotechnology in Environmental Applications

Total Marks: 100

University assessment: 50

Course Outcomes:

1. **Fundamental Understanding of Nanotechnology:** Develop a comprehensive understanding of nanoscience and nanotechnology, including its interdisciplinary nature and historical development, enabling students to grasp its significance in modern scientific and technological advancements.
2. **Mastering Nanomaterials Properties:** Gain in-depth knowledge of nanomaterials' size-dependent properties, surface phenomena, and quantum effects, fostering an appreciation of their unique characteristics that drive their applications in environmental remediation.
3. **Proficiency in Nanofabrication and Characterization:** Acquire expertise in various nanofabrication techniques and characterization methods, equipping students with the skills to synthesize and analyze nanomaterials using advanced microscopy, spectroscopy, and diffraction techniques.
4. **Application in Environmental Remediation:** Understand the application of nanotechnology in environmental remediation, including using nanomaterials for water purification, soil remediation, and air pollution control, preparing students to innovate sustainable solutions for pressing environmental challenges.

Practicals [Credit 1- 30 Clock hours]

Course Outcomes

5. **Hands-On Synthesis and Characterization:** Achieve proficiency in synthesizing and characterizing nanomaterials using both bottom-up and top-down approaches and mastering techniques such as TEM, SEM, and XRD, essential for practical nanotechnology applications.
6. **Nanomaterials Application in Environmental Solutions:** Develop practical skills in applying nanomaterials for water treatment, soil remediation, and air filtration, enabling students to assess and enhance the efficiency of nanotechnology-based environmental interventions.
7. **Evaluation of Nanoparticle Stability and Toxicity:** Learn to prepare stable nanoparticle suspensions, evaluate their environmental stability, and assess the potential risks and toxicity of nanomaterials, ensuring the safe and responsible use of nanotechnology in environmental contexts.
8. **Development of Nanosensors and Monitoring Tools:** Gain hands-on experience in developing nanosensors for environmental monitoring and detecting pollutants, equipping students with innovative tools for real-time environmental assessment and management.

Course Code	Course Title	Total Credits
LScENBT612e	Nanotechnology in Environmental Applications	04

MODULE I Unit 1: Fundamentals of Nanotechnology Introduction to Nanoscience and Nanotechnology (10 Clock hours) • Overview of nanoscience and its interdisciplinary nature (4 hours) • Introduction to nanotechnology and its applications (3 hours) • Historical development and milestones in nanotechnology (3 hours) Properties of Nanomaterials and Nanoparticles (10 Clock hours) • Size-dependent properties of nanomaterials (4 hours) • Chemical, physical, and mechanical properties of nanoparticles (3 hours) • Surface phenomena and quantum effects in nanomaterials (3 hours) Nanofabrication Techniques and Characterization Methods (10 Clock hours) • Overview of nanofabrication techniques: top-down and bottom-up approaches (4 hours) • Techniques for nanoparticle synthesis and assembly (3 hours) • Methods for characterizing nanomaterials: microscopy, spectroscopy, and diffraction (3 hours) Unit 2: Nanotechnology in Environmental Remediation Nanomaterials for Water Purification (10 Clock hours) • Introduction to nanotechnology applications in water treatment (3 hours) • Types of nanomaterials used for water purification: nanoparticles, nanocomposites, nanotubes, etc. (4 hours) • Mechanisms of contaminant removal by nanomaterials: adsorption, catalysis, filtration, etc. (3 hours) Nanoparticles for Soil Remediation (10 Clock hours) • Overview of nanotechnology applications in soil remediation (3 hours) • Types of nanoparticles used for soil remediation: zero-valent iron nanoparticles, carbon-based nanomaterials, etc. (4 hours) • Mechanisms of contaminant immobilization and degradation using nanoparticles (3 hours) Nanotechnology-based Air Pollution Control (10 Clock hours) • Introduction to nanotechnology approaches for air pollution mitigation (3 hours) • Types of nanomaterials used for air pollution control: photocatalysts, adsorbents, membranes, etc. (4 hours) • Mechanisms of pollutant removal and degradation using nanotechnology-based solutions (3 hours)	02
MODULE II Practicals [Credit 1- 30 Clock hours] 1. Synthesis of Nanomaterials (4 hours) • Synthesis of nanoparticles using bottom-up and top-down approaches. • Characterization of nanomaterials using techniques such as TEM, SEM, and XRD. 2. Nanomaterials Characterization (4 hours) • Size and morphology analysis of nanoparticles using microscopy techniques. • Surface area and porosity measurements of nanomaterials.	02

3. Nanoparticles Dispersion and Stability
 - Preparation of nanoparticle suspensions and dispersions.
 - Evaluation of nanoparticle stability in different environmental conditions.
4. Nanomaterials for Water Treatment (4 hours)
 - Assessment of the efficiency of nanomaterials in water purification.
 - Remove contaminants such as heavy metals and organic pollutants using nanotechnology.
5. Nanotechnology for Soil Remediation (4 hours)
 - Application of nanoparticles in soil stabilization and remediation.
 - Evaluation of nanoparticle interactions with soil components.
6. Nanoparticles in Air Filtration (4 hours)
 - Fabrication of nanofiber membranes for air filtration applications.
 - Testing the performance of nanomaterial-based filters for air pollution control.
7. Nanotoxicity Assessment (4 hours)
 - Evaluation of the environmental impact and toxicity of nanomaterials.
 - Assessment of the potential risks associated with releasing nanoparticles into the environment.
8. Nanotechnology-based Sensing (2 hours)
 - Development of nanosensors for environmental monitoring.
 - Detection of pollutants and contaminants using nanomaterial-based sensing platforms.

Practical Assignments (Credit 1- 30 Clock hours)

Each student will be assigned one topic from the following list of 20 practical assignments to be completed throughout the Semester.

1. Synthesis and Characterization of Silver Nanoparticles for Water Purification
2. Evaluation of the Effectiveness of Carbon Nanotubes in Soil Remediation
3. Fabrication of Nanocomposite Membranes for Desalination Applications
4. Assessment of Nanoparticle Toxicity on Aquatic Organism
5. Development of a Nanomaterial-based Sensor for Detection of Heavy Metals in Water
6. Application of Nanostructured Catalysts for Air Pollution Control
7. Analysis of Nanoparticle Transport and Fate in Environmental System
8. Design of Nanomaterial-based Adsorbents for Removal of Organic Pollutants from Wastewater
9. Investigation of the Role of Nanoparticles in Bioremediation Processes
10. Study of the Influence of Nanoparticle Size on Environmental Remediation Efficiency
11. Development of Nanotechnology-based Solutions for Oil Spill Cleanup
12. Fabrication and Testing of Nanoparticle-coated Filters for Indoor Air Quality Improvement
13. Assessment of the Stability and Reactivity of Nanomaterials in Different Environmental Matrices

14. Evaluation of Nanoparticle-mediated Plant Growth Enhancement in Contaminated Soils	
15. Design and Optimization of Nanoparticle-based Photocatalysts for Water Purification	
16. Investigation of the Mechanisms of Nanoparticle Interaction with Environmental Pollutants	
17. Development of Nanomaterial-based Smart Coatings for Environmental Applications	
18. Application of Nanotechnology in Sustainable Agriculture and Crop Protection	
19. Study of Nanoparticle Transport in Groundwater Systems for Remediation Strategies	
20. Nanotechnology-enabled Solutions for Environmental Monitoring and Surveillance	

Common Index for Written Assignments:

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 - Concluding remarks on the significance and implications of the results.
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 - Suggestions for future research or areas of exploration within the assigned theme.
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8. References
 - List references cited in the assignment, following a standardized citation format.
 - Proper attribution of sources and acknowledgment of external contributions.

Each assignment should adhere to this structured index, ensuring clarity, coherence, and academic integrity in presenting the content related to the assigned theme.

REFERENCE BOOKS:

Indian Publishers:

Nanotechnology: Principles and Practices by Sulabha K. Kulkarni

- Publisher: Springer India
- Description: This comprehensive textbook covers the fundamental principles of nanotechnology, including synthesis and characterization techniques, properties of nanomaterials, and their various applications, making it ideal for students studying environmental applications of nanotechnology.

Nanomaterials and Environmental Biotechnology, edited by Ritu Singh, Sanjeev Kumar, and R. K. Kotnala

- Publisher: Springer India
- Description: This book explores the intersection of nanomaterials and environmental biotechnology, discussing various applications of nanotechnology in environmental remediation, water treatment, and pollution control.

Textbook of Nanoscience and Nanotechnology by B.S. Murty, P. Shankar, Baldev Raj, B.B. Rath, and James Murday

- Publisher: Universities Press (India) Pvt. Ltd.
- Description: This textbook provides a detailed introduction to nanoscience and nanotechnology, covering key concepts, fabrication techniques, and applications in various fields, including environmental science.

Foreign Publishers:

Nanotechnology: Environmental Implications and Solutions by Louis Theodore and Robert G. Kunz

- Publisher: John Wiley & Sons
- Description: This book addresses the environmental implications of nanotechnology and provides solutions for using nanomaterials in environmental remediation. It covers the impact of nanoparticles on the environment and strategies for mitigating potential risks.

Environmental Nanotechnology: Applications and Impacts of Nanomaterials by Mark R. Wiesner and Jean-Yves Bottero

- Publisher: McGraw-Hill Education
- Description: This textbook focuses on nanotechnology's environmental applications, discussing the use of nanomaterials in water and soil remediation, air pollution control, and sustainable environmental practices. It also examines nanotechnology's potential impacts and regulatory aspects.

Programme Name: M.Sc. (Life Sciences-Environmental Biotechnology) Semester IV

Total Credits: 06

Department assessment: 50

Course Name: Research Project II

Total Marks: 100

University assessment: 50

Course Code	Course Title	Total Credits
LScENBT613	Research Project	06
MODULE I		
This task must be carried out concurrently with other academic responsibilities by the student, encompassing the following elements:		
• Conducting an independent research project under the supervision of a faculty mentor. • Reviewing literature, devising experiments, gathering data, analyzing and interpreting results. • Writing the thesis and delivering presentations on research findings. • Having the chance to publish in peer-reviewed journals or present findings at conferences.		
Detailed guidelines for the effective conduct of dissertation/thesis research are provided below:		
1. Selecting a Research Topic: Choose a research topic that aligns with your academic interests, addresses a gap in existing literature, and has practical relevance in environmental biotechnology. 2. Literature Review: Conduct a thorough literature review to understand the current state of research, identify key concepts, methodologies, and findings, and establish the theoretical framework for your study. 3. Experimental Design: Collaborate closely with your faculty mentor to develop a robust experimental design. Clearly define your research objectives, hypotheses, variables, and methods to ensure the validity and reliability of your results. 4. Data Collection: Implement your experimental design meticulously, collecting relevant data using appropriate techniques and instrumentation. Maintain detailed records of your observations and experimental procedures for future reference and analysis. 5. Data Analysis and Interpretation: Analyze your data rigorously using statistical or qualitative analysis methods, depending on the nature of your research. Interpret the results within the context of your research question and theoretical framework, highlighting key findings and insights. 6. Thesis Writing: Prepare a well-structured and coherent thesis document that presents your research methodology, results, discussion, and conclusions in a logical and concise manner. Adhere to academic writing conventions and formatting guidelines, ensuring clarity, coherence, and accuracy throughout the document. 7. Presentation of Findings: Effectively communicate your research findings through oral		

06

presentations to faculty members and peers. Use visual aids, such as slides or posters, to enhance clarity and engagement during your presentation.

8. Peer Review and Feedback: Seek feedback from your faculty mentor and peers at various stages of your research project, incorporating constructive criticism and suggestions to improve the quality and rigor of your work.
9. Publication and Presentation Opportunities: Explore opportunities for publication in peer-reviewed journals or presentation at academic conferences to disseminate your research findings to the scientific community and contribute to the advancement of knowledge in environmental biotechnology.
10. Time Management and Persistence: Manage your time effectively, allocating sufficient dedicated hours each week to research activities while balancing other academic commitments. Stay motivated and resilient, embracing challenges and setbacks as opportunities for growth and learning in your research journey.

These guidelines provide a comprehensive framework for conducting dissertation/thesis research in environmental biotechnology. By diligently following these principles, students can navigate the research process successfully and make meaningful contributions to the field.

EVALUATION SCHEME

Evaluation: SEMESTER III

Paper Code	Theory		Practical		Total
	Internal	External	Internal	External	
LSc601	50	50			100
LSc602			25	25	50
LSc603	50	50			100
LSc604			25	25	50
LSc605	25	25			50
LSc606 (Electives: a to e)	25	25	25	25	100
LSc607 (ResearchProject I)	Evaluation scheme at the end of the Document				100

Evaluation: SEMESTER IV

Paper Code	Theory		Practical		Total
	Internal	External	Internal	External	
LSc608	50	50			100
LSc609			25	25	50
LSc6010	50	50			100
LSc611	25	25			50
LSc612 (Electives: a to e)	25	25	25	25	100
LSc613 (ResearchProject II)	Evaluation scheme at the end of the Document				100

A. Evaluation for Mandatory Theory Courses (4 Credit Courses)

I. Internal Evaluation for Mandatory Theory Courses: 50 Marks

The internal evaluation for mandatory theory courses comprises two components, each carrying a specific weightage. Students can choose between the following options to fulfil the evaluation requirements:

Option 1: (i) The course teacher will have the liberty to choose the assessment tools/ methods (class test/assignment/record book/tutorials/seminars/case study/ field work/ project work/ quiz/ etc.) – 50 marks.

Option 2: (i) Completion of SWAYAM (Advanced Course) of minimum 2 credits and certification exam - 50 Marks

Option 3: (i) Completion of NPTEL (Advanced Course) of minimum 2 credits and certification exam - 50 Marks

Option 4: (i) Possession of valid International Certifications from recognized providers such as Prometric, Pearson, Certiport, Coursera, Udemy, or similar platforms - 50 Marks

Note: It's important to note that each certification will be awarded marks for only one course. For example, if a student completes four courses, they will need to obtain four different certifications to fulfil the certification marks requirement for each course.

II. External Examination for Mandatory Theory Courses- 50 Marks

- Duration: **2.0 Hours**
- Theory question paper pattern:

Question	All questions are compulsory.		
	Based on	Options	Marks
Q.1	Unit I	Any 1 out of 2 (1 or 1 a, b)	10
Q.2	Unit II	Any 1 out of 2 (2 or 2 a, b)	10
Q.3	Unit III	Any 1 out of 2 (3 or 3 a, b)	10
Q.4	Unit IV	Any 1 out of 2 (4 or 4 a, b)	10
Q.5	Unit I, II, III& IV	Any 4 out of 8 (short notes)	10

B. Evaluation for Elective Theory Courses (4 Credit Courses)

Evaluation for Elective Theory Courses (2 Credit Courses)

I. Internal Evaluation for Elective Theory Courses: 25 Marks

The internal evaluation for elective theory courses consists of two components, each carrying a specific weightage. These components are as follows:

The course teacher will have the liberty to choose the assessment tools/ methods (class test/assignment/record book/tutorials/seminars/case study/ field work/ project work/ quiz/ etc.) – 50 marks.

II. External Examination for Elective Theory Courses- 25 Marks

- Duration: **1 Hour**
- Theory question paper pattern:

All questions are compulsory.			
Question	Based on	Options	Marks
Q.1	Unit I	Any 1 out of 2 (1 or 1 a, b)	10
Q.2	Unit II	Any 1 out of 2 (2 or 2 a, b)	10
Q.3	Unit I & II	Any 2 out of 4 (short notes)	5

C. Evaluation for Mandatory & Elective Practical Courses (2 Credit Courses)

The evaluation for both mandatory and elective practical courses is conducted according to the following criteria:

- Each practical course carries a **total of 50 Marks**, distributed as follows:
 - University Assessment: 25 Marks for practical performance (1 question of 15 marks, spot tests for 5 marks and viva for 5 marks)
 - Departmental Assessment: 5 Marks for the journal, 5 marks for attendance, 5 marks for participation and 10 marks for viva – total 25 marks.
 - The duration of each practical course is 6 to 8 hours.
- To be eligible for evaluation, students must complete a minimum of 80% of the practical work assigned in each core subject.
- It is mandatory for students to submit a certified journal at the time of the practical examination. The journal serves as a record of their practical work and is an essential component of the evaluation process.

Evaluation of Research Project Work I (4 Credit Course):

(Proforma for the Evaluation of the learner by the industry mentor /to whom the learner was reporting in the organization)

Internal Evaluation (by the institution/ at place of Internship by Mentor): 50 Marks

N o	Particular	Excell ent	Very Good	Goo d	Moderat e	Satisfacto ry
1	Attendance & Punctuality					
2	Ability to work in a team					
3	Written and oral communication skills					
4	Problem solving skills					
5	Ability to grasp new concepts					
6	Technical skill in terms of technology, programming, etc					
7	Ability to complete tasks					
8	Quality of overall work done					
9	Time management*					
10	Critical thinking*					

- **Time Management:** Evaluating the ability to effectively manage time and meet deadlines.
- **Critical Thinking:** Assessing the ability to analyze information, evaluate options, and make reasoned decisions.
- **Patterns of Marks: out of 50 as per marks obtained in each of the 10 categories**

Excell ent	Very Good	Go od	Modera te	Satisfacto ry
5	4	3	2	1

Comments: _____

Signature: _____

Name: _____

Designation: _____

Contact details: _____

Email: _____

(Seal of the organization)

Research Project (I): Total Marks = 100.

Internal Assessment: 50 mks.

Thesis submission and evaluation along with Feedback From the organization: 25 mks

Viva: by an Internal Committee (2 members): 25 mks.

External Assessment: 50 mks.

Draft Paper submission: 25 mks

Presentation: 25 mks.

D. Evaluation of Research Project Work II (6 Credit Course):

(Proforma for the Evaluation of the learner by the industry mentor /to whom the learner was reporting in the organization)

Internal Evaluation (by the institution/ at place of Internship by Mentor): 50 Marks

N o	Particular	Excell ent	Very Good	Go od	Moderat e	Satisfacto ry
1	Attendance & Punctuality					
2	Ability to work in a team					
3	Written and oral communication skills					
4	Problem solving skills					
5	Ability to grasp new concepts					
6	Technical skill in terms of technology, programming, etc					
7	Ability to complete tasks					
8	Quality of overall work done					
9	Time management*					
10	Critical thinking*					

- **Time Management:** Evaluating the ability to effectively manage time and meet deadlines.
- **Critical Thinking:** Assessing the ability to analyze information, evaluate options, and make reasoned decisions.

- **Patterns of Marks: out of 50 as per marks obtained in each of the 10 categories**

Excell ent	Very Good	Go od	Modera te	Satisfacto ry
5	4	3	2	1

Comments: _____

Signature: _____

Name: _____

Designation: _____

Contact
details: _____

Email: _____

(Seal of the organization)

Research Project (II): Total Marks = 150.

Internal Assessment: 75 mks

- Research Proposal: 25 mks
- Progress evaluation by internal committee or along with Feedback from the organization: 25
- Attendance: 25

External Assessment: 75 mks.

- Thesis submission and evaluation: 25
- Draft paper/ Presentation: 25
- Viva: 25

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result
9.00 - 10.00	90.0 - 100	O (Outstanding)
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)
5.00 - < 5.50	50.0 - < 55.0	C (Average)
4.00 - < 5.00	40.0 - < 50.0	P (Pass)
Below 4.00	Below 40.0	F (Fail)
Ab (Absent)	-	Absent

Appendix-I

Maintain the weekly online diary for each week in the following format.

	D ay	Date	Name of the Topic/Module Completed	Remarks
1 st WE EK	Monday			
	Tuesday			
	Wednesday			
	Thursday			
	Friday			
	Saturday			

Signature of the Faculty mentor: _____

**Seal of the University
Department**

Appendix-II

(Proforma for the certificate for internship in official letter head)

This is to certify that Mr. /Ms. of University Dept of Life Sciences worked as an intern as part of his/her M.Sc. course in Life Sciences of University of Mumbai. The particulars of internship are given below:

Internship starting date: _____

Internship ending date: _____

Actual number of days worked: _____

Tentative number of hours worked: _____ Hours

Broad area of work: _____

A small description of work done by the intern during the period:

.
.

Signature: _____

Name:

Designation:

Contact
details:

Email:

(Seal of the organization)

Appendix-III

*(Proforma for the certificate for Project Work in official
letter head)*

This is to certify that Mr. /Ms. of University Dept of Life Sciences worked as an Project Student as part of his/her M.Sc. course in Life Sciences of University of Mumbai. The particulars of internship are given below:

Project Work starting date: _____

Project Work ending date: _____

Actual number of days worked: _____

Tentative number of hours worked: _____ Hours

Broad area of work: _____

A small description of work done by the Project Student during the period:

.
.

Signature: _____

Name:

Designation:

Contact
details:

Email:

(Seal of the organization)

Team for Creation of Syllabus (M. Sc. Life Sciences – Environmental Biotechnology)

Name	College Name	Sign
Prof. Indu Anna George	Department of Life Sciences, University of Mumbai	
Dr. Tejashree Shanbag	Principal, K.C. College, HSNC University	
Dr. Prashant Ratnaparkhi	Head, Department of Life Science, St. Xaviers College	
Prof. Priya Sundarrajan	Department of Life Science, St. Xaviers College	
Dr. Nilima Gajbhiye	Department of Life Science, Ramnarain Ruia College	
Dr. Kanchan Chitnis	Department of Life Science, Ramnarain Ruia College	
Prof. Sanjay Deshmukh	Head, Department of Life Sciences, University of Mumbai	
Dr. Ahmad Ali	Department of Life Sciences, University of Mumbai	
Dr. Suruchi Jamkhedkar	Department of Life Sciences, University of Mumbai	
Dr. Nisha Shah	Department of Life Sciences, University of Mumbai	
Dr. Hina Alim	Department of Life Sciences, University of Mumbai	

Indu Anna George
9/7/2024

Sign of BOS Chairperson
Prof. Indu Anna George
Department of Life Sciences
Ad-hoc BOS in Life Sciences

Sign of Offg. Assoc. Dean
Dr. Madhav Rajvade
Offg. Assoc. Dean
Science and Technology
University of Mumbai

Sign of Offg. Dean
Prof. Shivram Garje
Dean Science and Technology
University of Mumbai