DEPARTMENT OF ENVIRONMENTAL BIOTECHNOLOGY

SCHOOL OF ENVIRONMENTAL SCIENCES

BHARATHIDASAN UNIVERSITY

TIRUCHIRAPPALLI - 620 024

From Academic year 2025-2026 onwards

M.Sc., Biotechnology (Environment)

(Program Code: 2PSEBT)

Curriculum (CBCS)

From Academic year 2025-2026 onwards

BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI
DEPARTMENT OF ENVIRONMENTAL BIOTECHNOLOGY
M. Sc. Biotechnology(Environment) Curriculum
(For the students admitted during the academic year 2025 - 26 onwards)

Program's General Objective

PG Graduates are Professionally Competent with characteristic Knowledge-bank, Skill-set, Mind-set and Pragmatic Wisdom in their chosen fields. PG Graduates demonstrate the desired sense of being seasoned and exhibit unequivocal Spiritedness with excellent qualities of productive contribution to society and nation in the arena Science and Technology. PG Graduates are mentored such that they exert Leadership Latitude in their chosen fields with commitment to novelty and distinction. PG Graduates are directed in understanding of ethical principles and responsibilities, moral and social values in day-to-day life thereby attaining Cultural and Civilized personality. PG Graduates are able to collate information from different kinds of sources and gain a coherent understanding of the subject.

Program Outcome (PO)

The M.Sc., program provides all essential components to the transformative learning that prepares our graduates to become alumni who make a significant contribution to the society. The courses build students' abilities to think critically, solve problems, generate new ideas and create knowledge and to make connections between academic disciplines.

PO1	This program is designed to develop comprehensive and deep knowledge of the field(s), in which the "one semester" thesis research is embedded.
PO2	The challenging, student-centered curriculum is research - based and technology - Oriented and provides a foundation for life - long learning.
PO3	The program caters to students' interest in different domains of biology – from classical to modern, including varied specializations.
PO4	Training in specialized domain of biology is intended to prepare students to become qualified graduates to address biology-related issues at national and international levels.

PO5	Biology being evidence-based, the program is grounded with an equal number of laboratory courses in the formal practices of observation, experimentation, testing hypotheses and interpretation.
PO6	Biology relies on applications of quantitative analysis and mathematical reasoning; therefore, the curriculum is designed to train the students to apply descriptive and inferential statistical methods, design and analyse diverse data set and understand the underlying probability in the calculations.
PO7	The program provides training to the students to develop their knowledge and skills to communicate appropriate scientific content, formatting and presentation of data through scientific seminars.
PO8	The program trains the students to understand the relationship between science and society, which enhances their vision to apply their knowledge in health systems, economic growth and sustainable environment.
PO9	The 8-credit research-oriented course engages in rigorous and original research that advances knowledge in their chosen field of study within the discipline.
PO10	Upon successful completion of the M.Sc. Biotechnology (Environment) program with grade 9.0 and above (CGPA), the students shall be able to summarize the major, central tenets in their disciplines; this will provide ample chances for them to qualify for national eligibility tests and professional development gained will lead them to be successful in their careers in academia / industry.

Program Specific Outcome (PSO)

PSO1	**Enrichment:** The course on Environmental Science describes the various types of pollution impact on the environment and the biological approach to control pollution
PSO2	**Environmental Insight:** Understand the causes, effects, and solutions of different environmental problems.
PSO3	**Current overview:** Introduces the concept of bioenergy resources and its scenario in India and at global level
PSO4	**Knowledge in depth:** This course is designed to provide an outline ecotoxicology, including an introduction of the major classes of pollutants, their fate in the environment, their disposition in organisms and their mechanisms of toxicity.
PSO5	**Application of knowledge:** Implement management strategies like bioremediation and bio restoration of contaminated lands
PSO6	**Critical thinking:** Learn the different instrumentation, and how to use as an environmental analytical tool for environmental matrices
PSO7	**Application oriented knowledge gaining:** Identify the role of Genomics and Proteomics in sustainable environment management
PSO8	**Skill acquisition:** Gain an overview of the basic and advanced molecular techniques to apply them in different aspects related to environment.
PSO9	**Advance Proficiency:** Reaching a level where the skills are performed with a high degree of competence and efficiency, often with minimal supervision. This is characterized by a deep understanding of the subject and the ability to handle complex situations.
PSO10	**Career Planning:** Setting career goals and creating a plan to achieve them. This involves assessing one's strengths and weaknesses, exploring career options, and identifying steps to reach desired positions or roles.

BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI - 620 024

DEPARTMENT OF ENVIRONMENTAL BIOTECHNOLOGY

M.Sc., Biotechnology (Environment) (Program Code: 2PSEBT)

Course Structure (CBCS)

From Academic year 2025-2026 onwards

Semester	Sl. No	Course code	Course Title	Hrs/week	Credits	Marks		
						IA	UE	Total
I	1	CC01	Cell and Molecular Biology	4	4	25	75	100
	2	CC02	Environmental Microbiology	5	5	25	75	100
	3	CC03	Environmental Chemistry	5	5	25	75	100
	4	CO01	1.Bio-Energy Resources 2.Industrial Biotechnology	4	4	25	75	100
	5	EC01	A.Ecology and Environmental Sciences B.Biodiversity and Conservation C.Environmental Law & Policy	5	5	25	75	100
	6	LC01	Laboratory course 1- Cell and Molecular Biology and Environmental Microbiology	5	3	40	60	100
			Seminar / Library / Leveraging E- resources	2				
			Total	30	26	165	435	600
II	7	CC04	Biological Macromolecules	5	5	25	75	100
	8	CC05	Immunology	4	4	25	75	100
	9	CC06	Toxicology and Toxicogenomics	4	4	25	75	100
	10	CO02	1.Instrumental Methods of Analysis 2. Nano Biotechnology	4	4	25	75	100
	11	EC02	A.Bioinformatics and Statistics B.Cancer Biology C.Protein Engineering	4	4	25	75	100
	12	LC02	Laboratory course - 2- Biological Macromolecules, Toxicology and Toxicogenomics	4	3	40	60	100
	13	NMEC01	Non-Major Elective**	3	2	25	75	100
			Seminar / Library / Leveraging E- resources	2				
			Total	30	26	190	510	700
III	14	CC07	Genetic Engineering	5	5	25	75	100

	15	CC08	Environmental Biotechnology	4	4	25	75	100
	16	CO03	1.Plant and Animal Biotechnology 2. Medical Biotechnology	4	4	25	75	100
	17	EC03	A.Environmental Genomics B. Biosafety and Bioethics C.Bioprocess Technology	4	4	25	75	100
	18	LC03	Laboratory course 3- Genetic Engineering & Plant and Animal Biotechnology	4	4	25	75	100
	19	EIBC01	Bio Entrepreneurship	4	3	25	75	100
	20	CP01	Project	2				
	21	NMEC02	Non-Major Elective**	3	2	25	75	100
			Total	30	26	190	510	700
IV	22	CP01	Project	30	12	25	75	100
			Grand Total	120	90	610	1590	2100

Non Major Elective

II	NMEC01	Contemporary Environmental Issues	3	2	25	75	100
III	NMEC02	Energy and Environment	3	2	25	75	100

Extra Credit Courses

Course Code	Title of the Course	Credits	Hours / week		Maximum Marks		
			Theory	Practical	CIA	ESE	Total
SEMESTER - I							
VAC1	Ecofriendly Products	2	30	-	25	75	100
SEMESTER - II							
ONC01	SWAYAM/MOOC/NPTEL	2	-	-	-	-	-
FPI01	Field Project / Internship#	-	-	-	-	-	-
SEMESTER - III							
VAC2	Waste to Wealth	2	30	-	25	75	100
FPI02	Field Project / Internship##	-	-	-	-	-	-

*** Optional Core Courses**

**** Value added courses not included for Credit Calculations**

 # Field Project/Internship - To undergo during the semester holidays (End of the semester - II)

Field Project/Internship - To undergo during the semester holidays (End of the semester - III)

*** SWAYAM – MOOC – Online course should be for the duration of at least 4 weeks with minimum of 2 credits. The course is mandatory and should be completed within the third semester (i.e., before the start of the fourth semester).**

Program Summary

Core Credit Courses			Extra Credit Courses	
Total Courses	Total Credits	Total Marks	Total Courses	Total Credits
22	**120**	**2100**	**5**	**6**

For final grading and ranking, only the core credit courses will be accounted. However, for the award of the degree, completion of all the extra-credit courses is mandatory.

SEMESTER - I

CORE I: CELL AND MOLECULAR BIOLOGY

Course Code	CC01	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Basic knowledge regarding Cell and its Organelles								

Course Objectives:

- *This course is designed to provide basic information as well as recent developments in significant areas of cell and molecular biology*
- *This course deals with the important aspects of cell biology at molecular level that includes structure of cell and its organelle and their functional features.*
- *This course emphasizes on cellular responses to environmental signals in plants and animals and highlights the mechanism of signal transduction*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Disseminate knowledge about the basics of cell and its different organelles	**K1**
CO2	Explore the architecture of the cell and its organelle with their role in biological process	**K1, K2**
CO3	Describe the important cellular energy transactions and chromatin packaging	**K3, K4**
CO4	Gain information about the cyclic events of cell division and types of cell division with the cell signaling and processes	**K4, K5**
CO5	Elucidate the Molecular Biology which primarily deals with interactions among various systems of the cell, including those between DNA, RNA and proteins and educated how these are regulated	**K4, K5, K6**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Cells Shape and Diversity***	Diversity of cell size and shape – cell theory, structure of prokaryotic and eukaryotic cells –Cytoskeleton: Dynamic structure of microfilaments, intermediate filaments and microtubules-molecular motors cytoskeleton and cell behavior. Cell wall–structure and function. Plasma membrane; transport of nutrients, ions and macromolecules across the membranes.

Unit II ***Cellular Organelles***	Structural organization and functions of cell organelles– Endoplasmic reticulum, Golgi complex, Peroxisomes and Lysosomes their structural organization, Cellular energy transactions – Role of mitochondria and chloroplast. Nucleus Organization of genomes: History of DNA discovery and Structure of DNA. Genes and chromosomes, structure of chromatin and chromosomes, heterochromatin, euchromatin
Unit III ***Cell Cycle and DNA Replication***	Cell cycle – molecular events and model systems, cellular responses to environmental signals in plants and animals – mechanisms of signal transductions. DNA replication, prokaryotic and eukaryotic DNA replication, enzymes and accessories, proteins involved in DNA replication. DNA repair and recombination.
Unit IV ***mRNA Synthesis and Splicing***	Transcription – prokaryotic and eukaryotic transcription, RNA polymerase, general and specific transcription factors, regulatory elements and mechanisms of transcription regulations, transcriptional and posttranscriptional changes – gene silencing modifications in RNA – 5'-CAP formation, transcription termination, 3' processing and polyadenylation, splicing, editing, nuclear export of mRNA, mRNAstability.
Unit V ***Protein Synthesis and Processing***	Translation – prokaryotic and eukaryotic translation, the translational machinery, mechanisms of initiation, elongation and termination, regulation of translation, co-and post-transcriptional modification of proteins. Protein localization, synthesis of secretory and membrane proteins, import into nucleus, mitochondria, chloroplast and peroxisomes, receptor-mediated endocytosis.
Current Contour	Biology of cancer – oncogenes and tumor suppressor genes with suitable examples. Programmed cell death. Stem cell biology, pluripotent cells, totipotent cells, differentiation, re-differentiation and dedifferentiation. Stem cells in therapeutics

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	M	M	S	M	L
CO2	S	M	M	M	L	S	M	M	L	L
CO3	S	M	S	M	L	M	M	S	L	M
CO4	S	S	S	S	L	S	L	M	M	L
CO5	S	S	M	M	L	M	L	L	L	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Cell biology – organelle structure and function, David E. Sadava. (2009), CBS publishers and distributors.
2. Cell and Molecular biology, E.D.P. De Robertis and E.M.F. De Robertis, Jr.(2001), 8th edition. Wolters Kluwer and Lippincott Williams & Wilkins Publishers, Philadelphia.
3. Gene cloning and DNAanalysis – An introduction, T.A. Brown, (2006),15th edition, Wiley-Blackwell – a John Wiley and sons Ltd., USA.
4. Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter, (2002),5th edition. Garland science publishers. New York.

Related Online Contents:

- https://www.nature.com/nrm/
- https://www.cell.com/cell/video
- https://www.the-scientist.com/tag/cell-molecular-biology
- https://www.cell.com/molecular-cell/home
- https://www.youtube.com/playlist?list=PL3kN4iWWCHdoPPOpcVrwfAbhFc7lMKYRC

******

SEMESTER - I

CORE II: ENVIRONMENTAL MICROBIOLOGY

Course Code	CC02	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				4	1	-	5		
Pre-requisite	Knowledge about microbes of different segments of Biosphere								

Course Objectives:

- *This course provides a general introduction to the diverse roles of microorganisms in natural and artificial environments*
- *It also covers topics including: cellular architecture, energetics, growth, evolution, biogeochemical cycling and microorganisms involved in bioremediation.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Know the types of microbes and their classification	**K1,K2**
CO2	Identify various microbes using advanced tools	**K3**
CO3	Understand the metabolism involved in the microbial system	**K2**
CO4	Comment on the different Bio-remediation concept	**K4**
CO5	Discuss about the advanced molecular tools for the environment restoration and would elaborate on the role of microbes in the Environmental restoration	**K5,K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I *Microbial Taxonomy and Diversity*	Systems of Classification, Numerical Taxonomy, Bacteria, Archaea, Eukaryotes- Fungi, Yeasts, Molds, Protozoa, Algae and Viruses. Molecular Approaches to Microbial Taxonomy-Phylogenetic Lineage of Microbes.
Unit II	Isolation, Cultivation and Preservation (Aerobic and Anaerobic),

Microbial Growth	Nutrient Media, Growth Curve, Mathematical Expression of Exponential Growth Phase, Measurement of Growth and Growth Yields, Synchronous Growth, Continuous Culture, Effect of Environmental Factors on Growth. Control of Microorganisms - Physical, Chemical and Antimicrobial Agents.
Unit III ***Microbial Metabolism***	Energetics - Redox Reactions and Electron Carriers, An Overview of Metabolism – Anabolism / Catabolism, Central Metabolism - Glycolysis, Pentose - Phosphate Pathway, Entner-Docdoroff Pathway, Glyoxalate Pathway, Citric Acid Cycle, Fermentation, Aerobic and Anaerobic Respiration, Photosynthesis, Calvin Cycle. Metabolic Pathways of Contaminant Biodegradation, Metabolic Regulation, Stoichiometry and Bacterial Energetics - Mass Balances, Energy Balances (ΔG) – Growth, Substrate Partitioning and Theoretical Yield, Monod and Halden Kinetics.
Unit IV ***Microbial Degradation and Biotransformation***	Xenobiotics – Recalcitrance and Persistence. Bioremediation – Types (*Insitu and Exsitu*), Advantages & Disadvantages; Biodegradation – Aromatic and Aliphatic Pollutants - Lignin, Pectin, Cellulose, BTEX, Phenols, PCB's, Dyes, Oil, Dioxins, Pesticides, Biotransformation – Heavy Metals (Cr, Ni, Fe).
Unit V ***Microbial Ecology and Applications***	Sedimentary Biogeochemical Cycles – Fe, P and S, Gaseous Cycle – C, N and O, Soil Microorganisms Associated with Vascular Plants, Bioindicators, Biosensors, Biofertilizers, Biopesticides, Bioplastics, Bioleaching and Biomining, Biodeterioration and Biofuels.
UNIT VI ***Advanced topics only for discussion and not for examination***	Microbial Genomics and Microbial Ecology; Genetic Exchange Gene Transfer; Introductory Bioinformatics - Data Analysis, Culture Based and Culture Independent Tools; Molecular Biology Tools - Cloning, Amplification, Sequencing with a Case Study.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	S	S	S
CO2	S	S	S	S	M	S	S	S	M	S
CO3	S	S	M	M	S	S	M	S	M	S
CO4	S	S	M	S	S	S	M	S	M	S
CO5	S	S	M	S	S	S	S	S	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Microbiology, K. J. Pelzer, E. C. S. Chan & N. R.Kreig (2008), Tata Mcgraw.
2. Environmental Microbiology, Raina M. Maier & Lanl. Pepper (2000), Elseiver
3. Environmental Biotechnology Principles andApplications, Bruce. E. Rittmannn (2001), Graw-Hill Book Co
4. Environmental Microbiology, John F. T. Spencer & A. L. R. Spencer (2004), Humana Press.
5. Microbiology An Introduction, Tortara, Funke & Case (2007), Benjamin Publishers.
6. Fundamentals of Microbiology, Jeffrey C. Pommerville (2007), Johns & Bartle.
7. Microbiology, Jacauelyn G. Black (2008), John Wiley & Sons.
8. Environmental Microbiology, Ralph Mitchell & J. I. Dong Gu (2010), Wiley Blackwell.
9. Biochemistry, Geoffrey L. Zubay (1997), McGraw-Hill Higher Education.
10. Principles of Biochemistry, David David Lee Nelson, Albert L. Lehninger, Michael M. Cox (2008), W.
    H. Freeman.
11. Manual of Environmental Microbiology, Christon J. Hurst, Ronald L. Crawford & Guv R. Knudsen (2002), ASM Publishers.
12. Bioremediation, Katherine H. Baker, Diane S. Herson (1994), Tata McGraw- Hill.
13. The Dictionary of Environmental Microbiology, Linda D. Stetzenbach & Martylynn V. Vates (2004), Academic Press.
14. Microbiology, I. E. Dward Alcamo (2009), Tata McGraw- Hill.
15. Brock Biology of Microorganisms, Michael T. Madigen, John M. Martinko & Jack Parker (2000), Prentice-Hall Inc.

Related Online Contents:

- http://www.genomic.org.uk/history-of-genomics.html
- https://www.ncbi.nlm.nih.gov/pubmed/25422435
- https://www.ncbi.nlm.nih.gov/pubmed/20553550https://link.springer.com/chapter/10.1007/978-3-319-16345-1_6
- https://archive.org/details/morphologicvaria00henr

****

SEMESTER - I

CORE I: ENVIRONMENTAL CHEMISTRY

Course Code	CC03	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				4	1	-	5		
Pre-requisite	Basic knowledge regarding Chemical reactions in the Biosphere								

Course Objectives:

- *To study the chemicals and chemical processes within the air, water and soil ecosystems*
- *And to impart the source, route, transformation and the effects of the chemicals on various ecosystems.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Significance of chemistry in the environment	**K1,K2**
CO2	Imparting the source, route, transformation and the effects of the chemicals on various ecosystems	**K4**
CO3	Integration of importance of chemistry with the environment. Study of chemicals and chemical processes within air, water and soil ecosystem	**K5,K6**
CO4	Study the chemicals and chemical processes within the air, water and soil ecosystems	**K2**
CO5	Understand the chemical equations and its synthesis	**K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Fundamental Concepts of General Chemistry***	Concepts and Scope of Environmental Chemistry, Elements and Compounds - Atomic Structure, their Properties, Electronic Configuration, Types of Chemical bonds (ionic, covalent, coordinate and hydrogen bonds). Formation of Molecules, Molecular Weight, Equivalent Weight, Strength of the Solution – Molality, Molarity, Normality, Valency and Oxidation State, Oxidation and Reduction Reactions, Properties of Metals and Nonmetals, Aromatic and Aliphatic Compounds, Saturated and Unsaturated Hydrocarbons, Radionuclides, Polarity of the Functional Groups.
Unit II ***Chemical Equilibrium and Kinetics***	Stoichiometry, Chemical Equilibrium, Gibbs Energy, Chemical Potential, Acids, Bases and Salts, Acid-Base Reactions, pH and pOH, Ionic Product of Water, Solutions and solubility - Common Ion Effect, Buffer Solutions, Solutes and Solvents; Solubility and Solubility Product, Hydrolysis, Oxidation and Reduction, Chemical Speciation. Exothermic and Endothermic Reactions, Spontaneous and Nonspontaneous reactions.
Unit III ***Hydrospheric Chemistry***	Chemistry of Water-Water structure and Properties, Water a s a Solvent- Water Quality Parameters - Physical, Chemical and Biological Properties of Water and their Environmental Significance- Methods of Water Quality Assessment-Distribution of Chemical Species in Water; Gases, Organic Matter and Humic Matter in Water. Heavy metals in Water-Sources, solubility, toxicity and env. Impact of Hg, Cr(VI), Al Metal Solubility, Complexation and Chelation in Natural and Waste Water, Role of Microorganisms in Aquatic Chemical Reactions-Nutrient cycling (N, P), degradation of organic pollutants(PAH,Phthalates)
Unit IV ***Atmospheric Chemistry***	Structure and Composition of Atmosphere, Classification of Elements, Particulate Matter, Ions and Radicals in the Atmosphere- Formation and Role of Free Radicals (OH, NO3, etc.) Ionization Processes in the Atmosphere. Chemical and Photochemical Reactions in the Atmosphere - Formation of Smog, PAN, Aerosols; Chemistry of Acid Rain and its impacts on Soil water bodies and vegetation- Reactions of NO_2 and SO_2. Oxygen and Ozone Chemistry- Ozone Layer and Its Importance,Ozone Depletion Reactions,Role of CFCs and Halogens in Ozone Depletion.
Unit V ***Soil Chemistry***	Soil Profile, Soil Horizons, Physical, Chemical and Biological Characteristics of Soil, Nature of Soil, Soil Structure and Texture. Soil Macro and Micro Nutrients, Soil Water, Soil Air, Soil Temperature, Soil Organic Matter. Soil Colloids, Ion Exchange Capacity. Inorganic and Organic Components of Soil, Anion and Cation Exchange Reactions in Soil, Nitrogen Pathways and NPK in Soils.

Current Contour	Ocean Microplastics Contamination- Sources and Types of Microplastics in the Ocean, Environmental and Ecological Impacts of Microplastics, Microplastic Bioaccumulation in Marine Life, Role of Microbes in Breaking Down Plastics in Oceans, Potential of Biodegradation for Reducing Plastic Pollution Applications of Plastic-Degrading Enzymes in Waste Management-Strategies for Monitoring and Reducing Microplastics Pollution, Arsenic Sensing and Removal Strategies, Toxins in Fracking Fluid.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	M	S	S	S	S	S
CO2	S	S	M	S	M	S	S	S	S	S
CO3	S	S	M	S	S	S	S	M	M	M
CO4	S	S	M	S	S	S	S	S	S	S
CO5	S	S	S	S	S	M	M	M	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Basic Concept of Environmental Chemistry, Des W. Connell (2005), Taylor & Francis Chemisity for Environmental Engineering, C. N. Sawyer & P. L. McCarty (1990), McGraw Hill Kogakusha Ltd.
2. Environmental Chemistry with Green Chemistry. Asim K. Das & Mahua Das (2012), Books & Allied Pvt. Ltd.
3. Environmental Chemistry, A. K. De (2010), New Age International Pvt. Ltd.
4. Environmental Chemistry, Colin Baird & Michael Cann (2008), W. H. Freman & Co.
5. Environmental Chemistry, Peter O' Neil, (2004), Blackie Academic & Professional
6. Environmental Chemistry, Stanley E. Manahan (1999), CRC Press
7. Environmental Science & Technology, Stanley E. Manahan (2007), Tailor & Francis, CRC Press
8. Fundamentals Concepts of Environmental Chemistry, G. S. Sodhi (2011), Narosa Publishing House
9. The Principles of Environmental Chemistry, James E. Girard (2005), Jones & Bartlet
10. Manahan, S. E. (2017). Environmental Chemistry (10th ed.). Boca Raton, FL: CRC Press.
11. VanLoon, G. W., and Duffy, S. J. (2011). Environmental Chemistry: A Global Perspective (3rd ed.). Oxford, UK: Oxford University Press.
12. Baird, C., and Cann, M. (2012). Environmental Chemistry (5th ed.). New York, NY: W.H. Freeman and Company.
13. Connell, D. W. (2005). Basic Concepts of Environmental Chemistry (2nd ed.). Boca Raton, FL: CRC Press.
14. Harrison, R. M. (Ed.). (2007). Principles of Environmental Chemistry (2nd ed.). Cambridge, UK: Royal Society of Chemistry.
15. Spiro, T. G., and Stigliani, W. M. (2003). Chemistry of the Environment (2nd ed.). Sausalito, CA: University Science Books.
16. Rao, C. S. (2007). Environmental Pollution Control Engineering. New Delhi, India: New

Age International Publishers.
17. Alloway, B. J., and Ayres, D. C. (1997). Chemical Principles of Environmental Pollution (2nd ed.). Dordrecht, Netherlands: Springer.

E-BOOKS

- http://base.dnsgb.com.ua/files/book/Agriculture/Soil/The- Chemistry-of-Soils.pdf
- http://www.ncert.nic.in/ncerts/l/kech101.pdf
- Srivastava, S. Environmental Chemistry. https://ndl.iitkgp.ac.in/
- Lancaster, M. Introduction to Green Chemistry. Green Chemistry Network Centre, University of Delhi.: http://www.du.ac.in/du/uploads/centres_institutes/green_chemistry/ebook.pdf
- Saleh, H. E. D. M. (Ed.). Chemistry for Sustainable Development. IntechOpen. https://www.intechopen.com/books/chemistry-for-sustainable-development
- Patnaik, P. Handbook of Environmental Analysis. https://openlibrary.org/

Related Online Contents:

- https://www.khanacademy.org/science/chemistry
- https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics- kinetics-spring-2008/lecture-notes/
- https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-84j-atmospheric-chemistry-fall2013/lecture- notes
- https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-89-environmental-microbiology-fall2004/lecture-notes/
- https://www.rsc.org/journals-books-databases/about-journals/environmental-science/
- American Chemical Society (ACS)
- https://pubs.acs.org/journal/esthag
- https://www.niehs.nih.gov/health/topics/index.cfm
- https://www.epa.gov/
- https://www.sciencedirect.com/journal/environmental-chemistry-and-ecotoxicology

****

SEMESTER - I

CORE OPTIONAL 1: BIOENERGY RESOURCES

Course Code	CO01	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Knowledge about Renewable energy resources								

Course Objectives:

- *The students will be exposed to different types of energy resources and to the global energy budget*
- *Also they will be able to widen their knowledge in different types of wastes material from which energy can be derived and the energy patterns of India and world.*
- *To understand the fundamentals and significance of bioenergy.*
- *To explore different types of bioenergy resources and technologies.*
- *To evaluate the environmental and socio-economic impacts of bioenergy.*
- *To gain knowledge of bioenergy policies and future trends in the bioenergy sector.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand about the bioenergy consumption patterns & its growing need	**K1,K2**
CO2	Know the types of bio energy resources	**K2**
CO3	Acquire knowledge about the biofuels their production & methods of storage	**K4,K5**
CO4	Understand the environmental impacts of bioenergy on the segments of biosphere	**K6,K7**
CO5	Describe the applications of alternative energy resources. Case studies pertaining to bioenergy resources are also listed	**K4,K5**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Introduction to Bioenergy***	Definition and Importance of Bioenergy-Sources of Bioenergy: Biomass, Biogas, Biofuels, Algae, Waste-to-Energy-Properties of Biofuels: Chemical Composition, Energy Content, Combustion Properties-Traditional vs Modern Bioenergy: Traditional Use of Biomass (Firewood, Charcoal), Modern Technologies (Bioethanol, Biodiesel, Biomass Gasification)-Bioenergy Consumption Patterns: Global and Regional Perspectives (with focus on developing countries
Unit II ***Biomass Resources and Feedstocks***	Types of Biomass: Agricultural Residues, Forest Residues, Municipal Solid Waste, Energy Crops (Miscanthus, Switchgrass), Algae-Biomass Harvesting, Collection, and Transportation-Sustainability of Biomass Resources: Land Use, Water Consumption, Biodiversity Impacts-Challenges in Biomass Availability: Seasonal Variations, Logistics, Storage-Case Studies: Biomass Utilization in India, Brazil, and the U.S.

Unit III ***Bioenergy Conversion Technologies***	Thermochemical Conversion: Combustion, Pyrolysis, Gasification, and Torrefaction-Biochemical Conversion: Anaerobic Digestion, Fermentation, Transesterification for Biodiesel Production-Biogas Production: Feedstock, Process Design, Digester Types, and Upgrading Technologies-Biohydrogen Production: Methods, Applications, and Challenges-Bioenergy Systems: Small-Scale and Large-Scale Systems, Co-generation, Bio-refineries
Unit IV ***Environmental Impacts and Benefits of Bioenergy***	Environmental Benefits: Reduced Carbon Emissions, Waste Management, Soil Improvement-Life Cycle Analysis (LCA) of Bioenergy Systems: Carbon Footprint, Energy Payback-Potential Environmental Concerns: Deforestation, Water Use, Pollution from Processing-Bioenergy and Climate Change: Role in Reducing Greenhouse Gas Emissions, Bioenergy with Carbon Capture and Storage (BECCS)-Sustainability Criteria for Bioenergy: Global Standards and Certification
Unit V ***Bioenergy Policy, Economics, and Socio-Economic Impacts***	Global Bioenergy Policies: European Union's Renewable Energy Directive, U.S. Renewable Fuel Standard, and India's National Biofuel Policy-Incentives for Bioenergy: Subsidies, Carbon Credits, Feed-in Tariffs-Bioenergy Economics: Cost of Biofuel Production, Market Dynamics, Financial Viability-Social Impacts of Bioenergy: Energy Access in Rural Areas, Job Creation, Food vs. Fuel Debate-Case Studies of Successful Bioenergy Programs: Brazil's Ethanol Program, India's Biogas and Biomass Energy Initiatives
Current Contour	Improved Biomass Energy Technologies – Benefits and Challenges – The Kenya Ceramic Jiko – Smokeless chulkas – Bagasse-based co-generation - Synthetic Biology for Biofuel Production-Bioenergy with Carbon Capture and Storage (BECCS): Technology Overview and Potential-Decentralized Bioenergy Systems: Mini-grids, Off-grid Bioenergy Solutions for Rural Electrification-Future Challenges and Opportunities: Scaling Up Bioenergy -Emerging Markets for Bioenergy: Trends in Biofuel Trade and International Cooperation

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	L	M	L	S	M	S	S
CO2	M	L	L	L	S	M	M	S	L	L
CO3	S	S	S	M	S	M	S	S	S	M
CO4	L	M	M	L	L	M	S	M	S	L
CO5	S	S	M	L	L	L	S	M	S	L
S-Strong; M-Medium; L-Low										

Recommended References:

1. Renewable Energy Resources, Twidell J, Weir T (2015), Routledge
2. Renewable Energy, Sorensen B. (2010); Fourth Edition, Academic press
3. Introduction to Bioenergy (Energy and the Environment), Vaughn C. Nelson and Kenneth L. Starcher (2016), CRC Press, New Delhi.
4. Biomass to Biofuels, Anju Dahiya (2014), Academic Press,UK
5. Principles and Applications, Yebo Li and Samir Kumar Khanal (2016), Wiley Blackwell Pub.
6. Bioenergy, Judy D. Wall and Caroline S. Harwood, (2008) ASM Press, USA
7. Bioenergy: Sustainable Perspectives, Ted Weyland (Ed), (2016), Callisto Reference Pub.
8. Wood Chemistry and Wood Biotechnology. Monica EK; Goran Gellerstedt; Gunnar Henriksson (2009), Degruyter Pub.
9. Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. Samir K. Khanal. (2008) Wiley-Blackwell Publishing.
10. Energy and Environment Set: Mathematics of Decision Making, Loulou, Richard; Waaub, Jean Philippe; Zaccour, Georges (Eds.), (2005), Springer.
11. Energy and the Environment, 2nd Edition, John Wiley, 2006, ISBN:9780471172482; Authors: Ristinen, Robert A. Kraushaar, Jack J. A Kraushaar, Jack P. Ristinen, Robert A., Publisher: Wiley, New York.
12. Energy and the Challenge of Sustainability, World Energy assessment, UNDP, N York, 2000.
13. Li, Yebo, and Samir Kumar Khanal (2016). Bioenergy: Principles and Applications. John Wiley & Sons.
14. Pimentel, David (2008). Biofuels, Solar and Wind as Renewable Energy Systems: Benefits and Risks. Springer.
15. Demirbas, Ayhan (2008). Biofuels: Securing the Planet's Future Energy Needs. Springer.
16. Kaltschmitt, Martin, and Hermann Hofbauer (eds.) (2010). Biomass Conversion Technology. Springer.
17. Sims, Ralph E.H. (2003). Bioenergy Options for a Cleaner Environment: In Developed and Developing Countries. Elsevier.
18. McKendry, Peter (2002). Energy Production from Biomass (Part 1): Overview of Biomass. Bioresource Technology, 83(1): 37-46.
19. Cherubini, Francesco (2010). The Biorefinery Concept: Using Biomass Instead of Oil for Producing Energy and Chemicals. Energy Conversion and Management, 51(7): 1412-1421.
20. IEA Bioenergy (2017). Sustainable Bioenergy: A Framework for Decision Makers. International Energy Agency.
21. Balat, Mustafa, and Havva Balat (2009). Recent Trends in Global Production and Utilization of Bio-Ethanol Fuel. Applied Energy, 86(11): 2273-2282.
22. Tilman, David, et al. (2009). Beneficial Biofuels—The Food, Energy, and Environment Trilemma. Science, 325(5938): 270-271.

E-Books

- Demirbas, A. (2009). *Biofuels: Securing the Planet's Future Energy Needs*. London, UK: Springer. https://link.springer.com/
- Luque, R., & Clark, J. H. (Eds.). (2010). *Handbook of Biofuels Production: Processes and Technologies*. Oxford, UK: https://www.sciencedirect.com/
- Brown, R. C. (2011). *Thermochemical Processing of Biomass: Conversion into Fuels, Chemicals, and Power*. Hoboken, NJ: John Wiley & Sons. https://onlinelibrary.wiley.com/
- Kreith, F., & Goswami, D. Y. (Eds.). (2007). *Handbook of Energy Efficiency and Renewable Energy*.

Boca Raton, FL: CRC Press.: https://www.taylorfrancis.com/

- Van Loo, S., & Koppejan, J. (Eds.). (2008). *The Handbook of Biomass Combustion and Co-firing*. London, UK: Earthscan. https://www.researchgate.net/
- Kalia, V. C. (Ed.). (2016). *Microbial Applications Vol.1: Biofuels, Waste Treatment, and Nanobiotechnology*. Cham, Switzerland: Springer. https://link.springer.com/

Related Online Contents:

- http://www.eesi.org/
- www.energy.gov
- www.reenergyholdings.com
- http://www.wgbn.wisc.edu/
- http://www.fao.org/
- www.renewableenergyworld.com
- https://bioenergyinternational.com
- https://www.irena.org
- https://www.energy.gov/eere/bioenergy/bioenergy-technologies-office
- https://www.nrel.gov/
- https://bioenergyeurope.org/

****

SEMESTER - I

CORE OPTIONAL 2: INDUSTRIAL BIOTECHNOLOGY

Course Code	CO01	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Knowledge about Industrial bioprocess								

Course Objectives:

- *This course will cover the fundamentals about industrial production using bioprocesses. This includes methods for cultivation in bioreactors and recovery of bio products using separation methods.*
- *Typical industrial bioprocesses such as production of antibiotics, biogas, industrial enzymes, therapeutic proteins, vaccines, and environmental applications are covered.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Fundamental understanding of industrial biotechnology with focus on products such as enzymes, and food will be understood by the students.	**K1, K2**
CO2	The students would acquire knowledge about the metabolites and antibiotics.	**K1**
CO3	The learner will know about the Bio Products in detail.	**K2, K5**
CO4	Understanding of metabolic and cell biological processes from engineering perspectives is also facilitated.	**K2, K4**
CO5	The students would gain enough knowledge regarding the vaccines.	**K5, K6**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Introduction to Industrial Bioprocess***	Fermentation- Bacterial, Fungal and Yeast, Biochemistry of fermentation. Traditional and Modern Biotechnology- A brief survey of organisms, processes, products. Basic concepts of Upstream and Downstream processing in Bioprocess, Process flow sheeting – block diagrams, pictorial representation
Unit II ***Production of Primary Metabolites***	Primary Metabolites- Production of commercially important primary metabolites like organic acids, amino acids and alcohols.

Unit III *Production of Secondary Metabolites*	Secondary Metabolites- Production processes for various classes of secondary metabolites: Antibiotics, Vitamins and Steroids.
Unit IV *Production of Enzymes and other Bio products*	Production of Industrial Enzymes, Biopesticides, Biofertilizers, Bio preservatives, Biopolymers Biodiesel. Cheese, Beer, SCP & Mushroom culture, Bioremediation.
Unit V *Production Modern Biotechnology Products*	Production of recombinant proteins having therapeutic and diagnostic applications, vaccines. Bioprocess strategies in Plant Cell and Animal Cell culture.
Current Contour	Bio- energy: Bio fuels, Bio plastics, Cosmeceuticals and Personal Care, Bio prospecting, Molecular Bio sensing, Bio robotics and Renewable Chemicals

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	S	M	L	S	M	S	S
CO2	M	L	M	L	S	M	S	M	L	L
CO3	S	S	S	M	S	S	L	S	M	S
CO4	L	M	M	L	S	M	L	M	S	L
CO5	S	M	M	M	L	M	S	M	S	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Bioprocess Engineering Basic Concepts Shular and Kargi,(2012) Prentice Hall PTR Upper Saddle River, NJ 07458,2002
2. Lee, S.Y., Nielsen, J. and Stephanopoulos, G., "Industrial Biotechnology: Products and Processes", John Wiley & Sons, 2016.
3. Waites, M.J., Morgan,N.L., Rockey,J.S., Higton, G., "Industrial Microbiology: An Introduction" Blackwell, 2001.
4. Cruger, W., Cruger, A., "A Textbook of Industrial Microbiology", Panima Publishing Corporation, 2nd Edition, 2005.
5. Pandey, A., Negi, S., Soccol, C.R., "Current Developments in Biotechnology and Bioengineering: Production, isolation and purification of industrial products", Elsevier, 2016.
6. Okafor, N., "Modern Industrial Microbiology and Biotechnology", CRC Press, 2007

WEB LINK

- https://www.heraldopenaccess.us/journals/advances-in- industrial-biotechnology

E-BOOK

- Basic industrial biotechnology, S M Reddy; S Ram Reddy G Narendra Babu, (2012), New Age International, New Delhi.

****

SEMESTER - I

Elective A: ECOLOGY AND ENVIRONMENTAL SCIENCES

Course Code	EC01	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				4	1		5		
Pre-requisite	Basic Knowledge about Ecology								

Course Objectives:

- *This course is framed in such a way that the students are exposed to the structure and function of our life-supporting environment*
- *It also provides the understand the causes effects and solutions for different environmental problems*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	The learner will understand the structure and function of our life-supporting environment the fundamentals of ecology	**K1, K2**
CO2	Student would learn the basic concepts of population ecology and the interactions between the species	**K2, K4**
CO3	One can clearly understand the interaction between the communities and the progression of ecological succession	**K2, K4**
CO4	Student gains knowledge on the basic concepts of ecosystems and its components and the concepts of food chain, food web and energy flow in an ecosystem	**K1, K2**
CO5	Student could have a wide knowledge regarding various types of pollution and gets exposure regarding major case studies around the globe related to different environmental issues	**K4,K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Fundamentals of Ecology***	Definition, Principle, Branches and Scope of Ecology. Ecology as an inter-disciplinary Science. Origin of life and speciation and settlement. Ecological Factors: Abiotic – Physical and Chemical Factors: Soil, Air, Water, Temperature, pH, Humidity, Radiation, Wind, Pressure and Precipitation. Biotic – Limiting Factors. Species Interaction: Commensalism, Amensalism, Mutualism, Competition, Parasitism, Prey–Predator Relationship– Sedimentary Cycles (P, S, Fe), Gaseous Cycles (C, N, O) and Hydrological Cycle. Tools and Techniques used in Ecological Research, including GIS, Remote Sensing, and Simulation Models.

Unit II ***Population Ecology and Species interaction***	Population – Definition, Characteristics, Population Density, Natality, Mortality, Age Distribution, Growth Patterns, Population Fluctuation, Population Equilibrium, Biotic Potentials, Population Dispersion, Regulation of Population. Concept of 'r' and 'k' species. Keystone species - Ecological Age Pyramids. Survivorship Curves and its Types. Population Growth Models (Exponential, Logistic), Population Regulation, and Life History Strategies.
Unit III ***Community Ecology and Ecological Succession***	Community – Definition, Characteristics, Dominance, Structure, Stratification, Periodicity, Fluctuation within Community, Types and Interaction - Predation, Herbivory, Parasitism and Allelopathy Biological invasions. Communal Interdependence, Ecotone, Edge Effect, Ecological Niche and Ecological Equivalents, Ecological Succession - Primary and Secondary Succession, Mechanisms, and Stages, Types, Process, Climax and Significance of Succession. .
Unit IV ***Ecosystem***	Definition, Concept, Structure and Function of an Ecosystem: Producers, Consumers and Decomposers. Primary and Secondary Productivity. Food Chain, Food Web, Energy Flow. Ecological Pyramids – Types, Ecosystem Types: Terrestrial – Forest, Mountains, Deserts and Grassland. Aquatic – Freshwater (Lentic and Lotic) and Marine (Estuary, Deep sea) – Mangroves, Corals. Ecosystem stability and factors affecting stability. Ecosystem services. Ecological Niches: Fundamental and Realized Niche, Niche Partitioning, and Niche Construction. Biomes: Concept, classification and distribution. Characteristics of different biomes: Tundra, Taiga, Grassland, Deciduous forest biome, Highland Icy alpine biome, Chaparral, Savanna, Tropical Rain forest.
Unit V ***Introduction to Environmental Sciences***	Definition, Principle and Scope of Environmental Sciences. Earth, Man and Environment Interactions. Geographical Classification and Zones – Torrid, Temperate and Frigid Zones. Significance of Atmosphere, Lithosphere, Hydrosphere and Biosphere. Environmental Pollution: Definition and Types (Air, Water and Soil). Case Studies – London Smog, Minamata Disease, Love Canal, Bhopal Gas Tragedy, Chernobyl Disaster. Torrey Canyon Oil spill. Fukoshima nuclear disaster, Seveso Dioxin Crisis-Biodiversity - Definition, Concept and Types.
Current Contour	Recent scenario of Air and Water Pollution at national and global level – highly polluted cities. Various Ecosystems of Tamil Nadu, Threat to the coral reef, Impact of Tannery industries in and around Tiruchirappalli, Impact of Cement Industries

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	L	S	S	L	M	S	S	M
CO2	S	L	M	M	S	L	M	S	M	M
CO3	S	M	L	M	S	M	L	S	L	M
CO4	S	L	M	M	S	L	M	S	M	M
CO5	S	S	M	S	M	M	S	S	S	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. A Text-Book of Ecology, S. K. Dubey (2006), Dominant Publishers.
2. Ecology Principles and Applications, J. L. Chapman & M. J. Resiss (2010), Cambridge University Press.
3. Ecology, Russell (2008), Cengage Learning.
4. Elements of Ecology, Thomas M. Smith, Robert Leo Smith (2016), Pearson India Education Services.
5. Environment, Peter H. Raven, Berg, David M. Hassenzahl (2010), John Wiley & Sons.
6. Environmental Science Physical Principles and Applications, Egbert Boeker & Rienkvan Grandelle (2001), John Wiley & Sons.
7. Environmental Science, Travis Wagner & Robert Stanford (2005), John Wiley & Sons.
8. Fundamentals of Ecology, Eugene P. Odum, Gary W. Barrett (2012), Cengage Learning
9. Ricklefs, R. E. (2013). Ecology: The Economy of Nature (7th ed.). New York, NY: W.H. Freeman and Company.
10. Smith, T. M., and Smith, R. L. (2015). Elements of Ecology (9th ed.). Boston, MA: Pearson Education.
11. Odum, E. P., and Barrett, G. W. (2004). Fundamentals of Ecology (5th ed.). Belmont, CA: Brooks/Cole, Cengage Learning.
12. Gurevitch, J., Scheiner, S. M., and Fox, G. A. (2006). The Ecology of Plants (2nd ed.). Sunderland, MA: Sinauer Associates.
13. Gotelli, N. J. (2008). A Primer of Ecology (4th ed.). Sunderland, MA: Sinauer Associates.
14. Botkin, D. B., and Keller, E. A. (2014). Environmental Science: Earth as a Living Planet (9th ed.). Hoboken, NJ: Wiley.
15. Cunningham, W. P., and Cunningham, M. A. (2019). Principles of Environmental Science: Inquiry and Applications (9th ed.). New York, NY: McGraw-Hill Education.
16. Wright, R. T., and Boorse, D. F. (2013). Environmental Science (12th ed.). Boston, MA: Pearson Education.
17. Masters, G. M., and Ela, W. P. (2008). Introduction to Environmental Engineering and Science (3rd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.
18. Carson, R. (1962). Silent Spring. Boston, MA: Houghton Mifflin Harcourt.

Related Online Contents:

- http://www.envfor.nic.in
- http://www.ecology.edu

****

SEMESTER – I

Elective B: BIODIVERSITY AND CONSERVATION

Course Code	EC01	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				4	1	-	5		
Pre-requisite	Basic knowledge on importance of flora and fauna of different Ecosystems								

Course Objectives:

- *This course deals with biodiversity conservation which is a major domain of Environmental Science*
- *On completion of the course the student learns about the different aspects of diversified ecosystem, its deterioration, conservation and management strategies to be adopted in changing global scenario.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Students would understand the types of biodiversity	K1, K2
CO2	The learner will know about the economic values of loss of biodiversity and One could obtain the knowledge of sustainable environment	K5
CO3	The importance and threats to biodiversity is taught and One could learn about the methods followed for Biodiversity Conservation.	K4, K7
CO4	Students are taught about the acts, protocols, and conventions regarding the biodiversity conservation	K5
CO5	Students get exposed to the status of endangered, extinct, rare species of India and of the world.	K6, K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

UNIT I

Introduction and Types of Biodiversity

Definition and Scope of Biodiversity - Composition and Scales of Biodiversity: Types of Biodiversity: Genetic Diversity, Species Diversity, Ecosystem Diversity, Landscape/ Pattern Diversity, Importance of Biodiversity, Threats to Biodiversity- Natural and Anthropogenic, Conservation Strategies, Concept and basis of identification of 'Hotspots'; hotspots in India.

UNIT II

Status of Biodiversity

Biogeographical Classification in India. Status of Biodiversity – Global, National and Local Status. Species

Inventory, Hot-spots of Biodiversity. Concept of restoration ecology. Extinct, Rare, Endangered and Threatened flora and fauna of India. Bioprospecting, IUCN Categories – Red Data Book- Biodiversity and Climate Change, Policy and Biodiversity Conservation.

UNIT III

Values of Biodiversity

Ecological Value, Cultural Values, Economic Valuation of Biodiversity, Direct, Indirect/ Non-consumptive Use Value - Tangible Benefits - Food, Fiber, Fodder, Timber, Rattans and Canes, Ornamentals, Medicines and Construction Material. Intangibles - Pollination, Pest Control, Soil Development and Maintenance of Soil Fertility, Soil and Water Conservation. Environmental Ethics. Intrinsic Value; Ethical and Aesthetic, Anthropocentrism, Biocentrism, Ecocentrism and Religions; Intellectual Values.

Major Drivers of Biodiversity Loss - Habitat Alteration, Invasive Species, Pollution, Population Explosion, and Over Exploitation of Bio resources - Factors Causing Loss of Genetic Diversity- Loss of Species Diversity- Processes Responsible for Species Extinction, Current and Future Extinction Rates, IUCN Threatened Categories, Sixth Extinction/Biological Crisis. Loss of Ecosystem Diversity - Factors Affecting Ecosystem Diversity, Loss Diversity of Major Ecosystem - Loss of Agrobiodiversity - Projected Scenario for Biodiversity Loss - Loss of Biodiversity as an Economic Process - Policy and Legislation, Future Directions and Solutions.

UNIT IV

Loss of Biodiversity

Introduction to Biodiversity and Conservation, Protection of Natural Habitats, National and International Protected Area, Current Practices in Conservation - In *Situ* Conservation and *Ex Situ* Conservation of Threatened Species - Cryopreservation, Gene Banks, Gene Pool and Species Conservation. National Parks and Sanctuaries. Economic Aspects of Conservation, Community Based Conservation. The Biological Diversity Act, 2002, Biological Diversity Rules, 2004 – Patent Act - Intellectual Property Rights (IPR). Biodiversity Bill 2002, Agenda 21, Multilateral Treaties, Biodiversity Conventions, Case studies in Biodiversity Conservation.

UNIT V

Biodiversity Conservation

Current Contour	For an assessment of biodiversity, a field visit to BDU campus. Field visit to Butterfly Conservation Park. An observation visits to Pachamalai area, Trichy. To study about marine bio-resources (MFR).

Total Lectures - 40

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	M	S	S	M	M	S
CO2	S	M	S	M	S	M	S	S	M	M
CO3	S	S	M	L	S	M	M	M	S	S
CO4	M	M	S	M	M	M	M	S	M	M
CO5	S	S	M	S	S	S	M	M	M	M
S-Strong; M-Medium; L-Low										

1. Sustaining Life: How Human Health Depends on Biodiversity edited by Eric Chivian and Aaron Bernstein (2008). Oxford Academic Press.
2. Biodiversity and Human Health, Aguirre, A. Alonso (2009), Eco Health, 6 (1), 153-156.
3. Biodiversity and Ecosystem functioning, Michael Lotaceer, Shaheed Naeen & P. Inchausti (2002). Oxford Press.
4. Environmental Biodiversity, P. R. Yadhav, Shudrata. R. Mishra (2004), Discovery Publishers.
5. Valuation and Conservation of Biodiverstiy, M. Markassen, R. Buse & H. Garrelts (2005), Springer.
6. Biodiverstiy, Supriyo Chakraburty (2007), Pointer Publishers.
7. Global Biodiversity and Environmental Conservation, T. I. Khanz (2000) Oxford Press.
8. An Introduction to Conservation Biology (2nd ed., annotated), Sher, A. A., & Primack, R. B. (2020). Oxford University Press.
9. Biodiversity and Health in the Face of Climate Change by Melissa R. Marselle, Jutta Stadler, Horst Korn, Katherine N. Irvine, and Aletta Bonn (2019). Springer.

WEBLINK

- www.biodiversityofindia.org
- www.edu.green.teri.res.in
- www.intelwl.org
- www.glems.com

*****

SEMESTER - I

Elective C: ENVIRONMENTAL LAW AND POLICY

Course Code	EC01	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				4	1	-	5		
Pre-requisite	Knowledge regarding the Legislations								

Course Objectives:

- *To make students aware of Indian as well as International environmental laws and their importance.*
- *To develop an ethical consideration to environment and its components*

Expected Course Outcomes:

On completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Familiar with the laws acts in the field of Environment	**K1**
CO2	Acquire knowledge regarding international environmental treaties	**K2**
CO3	Understand the Policies, regulations work to Environmental protection	**K4**
CO4	Gets on exposure to SDG's the current topic	**K6**
CO5	Can realize the importance of Environmental ethics and its impact. Acquire the ability to know about the laws, policies	**K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Environmental Laws in India***	Environmental Policy and Laws. Constitutional and Statutory laws in India: Doctrine Principles of State Policy, Fundamental duties and Fundamental Rights and Panchayat Raj System, Statutory protection of the Human environment: such as Indian penal court, Factories Act,Motor Vehicle Act, Hazardous waste legislation for pollution abatement. Anti-Pollution Acts: The Water Act, 1974, The Air Act, 1981.The Environment Protection Act 1986.Objectives of the Anti-Pollution Acts.

Unit II ***International Environmental Treaties***	Evolution and Development on International Environmental Laws with references to Stockholm Conference 1972, Nairobi Declaration 1987, Rioconference,1992, Rio+5, Rio+10 Environmental issues and international laws: to control Global warming, Ozone depletion, Acid rain, hazardous waste, CITES Role of UN authorities in Protection of Global Environment, Multinational authorities and agreements, future of international laws.
Unit III ***National Environmental Policy and Regulatory frame work***	National Policy on EIA and Regulatory Framework: Rule & Regulation of Central & Sate Government and Pollution Control Boards for safeguard for Environmental Protection. Wildlife Protection Act, 1972 amended 1991, Forest Conservation Act, 1980; Indian Forests Act revised1982; Air (Prevention and Control of Pollution) Act 1981 as Amended by Amendment Act1987 and rule1982. Scheme of labeling of environmentally friendly products (Ecomark), Public liability Insurance Act, 1991 and Rules 1991.Provision of Constitution of India regarding Environment (Article48Aand 58A).
Unit IV ***Sustainable Development***	Definition and concepts of Sustainable development, Integration of: Economic, Social and Environmental sustainability, Biodiversity and Availability of natural resources in development. Sustainable development scenario-global and national level. Sustainable development Goals
Unit V ***Environmental Ethics***	Concept of environmental ethics; Biocentrism and Ecocentrism; Application of ethics to environmental issues: Ecofeminism
Current Contour	Discussion of prevention control and abatement of Environmental pollution, Brain storming on natural resources conservation and the Judicial response towards Environmental Protection

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	M	S	S	S	S	S
CO2	S	S	M	S	M	S	S	S	S	S
CO3	S	S	M	S	S	S	S	M	M	M
CO4	S	S	M	S	S	S	S	S	S	S
CO5	S	S	S	S	S	M	M	M	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Environmental law Bell, S.,Mc Gillivray, D.,Pedersen, O.,Lees,E., & Stokes, E.(2017), Oxford University
2. Environmental Compliance Handbook, Jacob I. Bregman, Robert D. Edell, (2016), Lewis Publications
3. Environmental law, policy, and economics: Reclaiming the environmental agenda, (2008), Ashford, Nicholas Askounes, and Charles C. Caldart. Mit Press.
4. Environmental Laws: Summaries of Major Statutes Administered by the Environmental Protection Agency(EPA) Fletcher,S.R.(Ed.),(2008)..Nova Publishers.
5. Environmental law in India Leelakrishnan,P.(2016)..LexisNexis.
6. India's Environmental Policies, Programmes and Stewardship, Dwivedi, O.P. (2016). Springer.
7. Environmental Law from the Policy Perspective: understanding how legal frameworks influence environmental problem solving, Mc Guire,C.J.(2014). Routledge.

Related Online Contents:

- https://www.coursera.org/learn/environmental-law
- https://www.esf.edu
- https://indianlegalsolution.com
- https://www.mondaq.com
- http://www.envis.harayana.gov.in

****

SEMESTER - I

Laboratory Course –I - CELL AND MOLECULAR BIOLOGY AND ENVIRONMENTAL MICROBIOLOGY

Course Code	LC01	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
						5	3		
Pre-requisite	Basic knowledge regarding microbes, molecular biology								

Course Objectives:

- *The course will make the students familiar about the isolating, identifying and culturing the microorganisms facilitating their usage for various other studies.*
- *The learner will be exposed to various molecular identification protocols.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	The students get trained to do different molecular biological techniques such as genomic DNA I solation, agarose gel electrophoresis, SDS-PAGE etc	**K4**
CO2	The learner could identify the mitotic cell division.	**K5**
CO3	The student learns the technique of SDS-PAGE electrophoresis.	**K4& K5**
CO4	The practical provides knowledge to the students to learn the role of microbes in the environmental processes	**K6**
CO5	Techniques for characterizing microorganisms and investigating microbial processes is also provided	**K7**
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

1. Introduction to General Microbiology: Laboratory Rules, Microscopy, Sterilization, Preparation of Culture Media, Isolation of Bacteria from Soil, Isolation of fungi from Soil, Ubiquitous nature of Microorganisms.
2. Types of staining techniques: Simple staining, Gram staining, Capsular staining and Endospore staining.
3. Demonstration of motility for bacteria by hanging drop technique
4. List of Biochemical Test: Indole production, Methyl Red, Voges Proskaeur, Citrate Utilization, Triple Sugar-Iron agar, Catalase and Oxidase Test
5. Antibiotic sensitivity test: Disc diffusion method 6. Enzymatic test of Milk by Methylene blue reductase.
7. Most Probable Number (MPN): Presumptive, Confirmatory and complete test
8. Identification of Fungi: Lacto phenol cotton blue test
9. Molecular identification of unknown bacteria: Isolation of genomic DNA, PCR amplification of 16S rRNA and Phylogenetic analysis of 16S r RNA.
10. Molecular identification of unknown fungi: Isolation of genomic DNA, PCR amplification of 18S rRNA and Phylogenetic analysis of 18S r RNA.

1. Introduction to laboratory techniques: pipetting, calculations, Introduction to laboratory equipments and lab safety, sterile techniques
2. Staining for identification of different stages of mitosis and meiosis in *Allium cepa* (Onion)
3. Isolation of bacterial Genomic DNA
4. Agarose gel electrophoresis
5. SDS Polyacrylamide Gel Electrophoresis (SDS-PAGE)
6. Primer Design
7. PCR

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	S	S	M	S	S	L	M
CO2	S	M	M	M	S	L	M	M	L	M
CO3	S	S	L	M	S	M	M	M	L	L
CO4	S	M	M	M	S	L	M	L	L	M
CO5	S	S	L	M	S	L	L	L	L	L
S-Strong; M-Medium; L-Low										

Recommended References:

1. Laboratory Manual in General Microbiology by N Kannan, Panima Publishing Corporation, New Delhi.
2. S. Kannan, M. Krishnan, R. Thirumurugan and S. Achiraman (2011) Methods in Molecular Biology (From Cell to Molecules). UVN Publishing House Pvt. Ltd. Sivakasi.
3. Lab Manual of Industrial Biotechnology by Dr.K. Swaminathan, Dr. J. Angayarkanni, Dr. V. Brindha priyadarishini, Dr. K. Preethi, Department of Microbial Biotechnology, Bharathiyar University, Coimbatore.
4. Practical Microbiology: based on the Hungarian practical notes entitled "Mikrobiológiai Laboratóriumi Gyakorlatok" by English versions: Erika M. Tóth, Andrea K. Borsodi, Tamás Felföldi, Balázs, Vajna, Rita Sipos and Károly Márialigeti (https://ttk.elte.hu/dstore/document/893/book.pdf)

Related Online Contents:

- E.Book: Cell Biology Laboratory Manual by William H.Heidcamp, (https://www.bjcancer.org/Sites_OldFiles/_Library/UserFiles/pdf/Cell_Biology_Laboratory_Manual.pdf)
- Bacterial isolation, identification and storage by Lila Ruangpan, Eleonor A. Tendencia,(https://repository.seafdec.org.ph/bitstream/handle/10862/1616/Chapter1-Bacterial-Isolation-Identification-and Storage.pdf? sequence=1&is Allowed=y).
- https://youtu.be/S7NIkBy38To?si=JkyywRGqoW1iA3Gn
- https://youtu.be/arvRLuLwk9k?si=2Jx4U4L7rEt4pg9N
- https://youtu.be/bm99zrq3ijo?si=2qdFtJiGYtKhOXQX

****

SEMESTER – I

Value Added Course 1: ECO-FRIENDLY PRODUCTS

Course Code	VAC01	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				30		-	2		
Pre-requisite	Idea on Environmental Conservation								

Course Objectives:

- *To understand the importance of reducing waste and to know about the ways to create less toxic waste.*
- *To design and develop eco-friendly products and processes towards accomplishment of the sustainable development goals.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	The students becomes aware of the ill effects of plastics and advantages of plastic of biological origin	**K5,K6**
CO2	The learner acquires knowledge regarding the biofertilizers in terms of production, advantages	**K1,K2**
CO3	The student would highlight the importance of biopesticides	**K5.K6**
CO4	One would know about the possibility of reusing the certain household products	**K2,K3,K4**
CO5	The student is exposed to 3R concept. The learner would know the possible alternatives ensuring sustainability.	**K2,K3,K6**
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit I ***Bioplastics***	Definition of bioplastics, Types of bioplastics, genetically modified bioplastics. Environmental impact of Bioplastics and their biodegradation, Applications and manufacture of Bio Plastics

UNIT II ***Bio fertilizers***	Introduction and types and importance of biofertilizers, History of biofertilizers production, Classification of bio fertilizers, microorganisms used in bio fertilizers production, Quality standard for bio fertilizers.
Unit III ***Biopesticides***	Introduction and types and importance of Bio pesticides and bioagents in agriculture and organic farming System, Different methods of application of biopesticides and bioagents, Strategies of marking and Registration with CIB of bioagents and biopesticides, Quality parameters as per CIB specifications.
Unit IV ***Reusable products***	House hold items in daily use, Day today use of organic products in domestic use. List of organic products, effects of chemical products on environment and human**.**
Unit V ***Sustainability of the environment***	Stages in Product Life Cycle, Eco-efficiency and the importance of the 3Rs, Transitioning to more resource efficient economy, Conventional waste management and its consequences.
Current Contour	Improved Biomass Energy Technologies – Benefits and Challenges – The Kenya Ceramic Jiko – Smokeless chulhas – Bagasse-based co-generation

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	M	M	M	S	S	S
CO2	M	M	S	S	S	S	M	M	M	S
CO3	S	S	S	M	M	M	S	S	S	S
CO4	S	S	M	M	M	S	S	S	M	S
CO5	M	M	S	S	S	S	M	M	M	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Introduction to Soil Microbiology. Alexander M. (1977), John Wiley.
2. Methods for Evaluating Biological Nitrogen Fixation Bergerson FJ. (1980). John Wiley and Sons.
3. Biofertilizer Technology, Marketing and Usage- A Source Book-cum-glossary Motsara, I.M.R., Bhattacharyya, P. and Srivastava, B. (1995). FDCO, New Delhi.
4. Biofertilizers in Agriculture and Forestry. Subba Rao, N.S. (1993). Oxford and IBH. Publ. Co., New Delhi.
5. Formulation of Microbial Biopesticides, Burges, H.D. (1998), Springer Dordrecht
6. Biological Control of Insect Pests, Saxena, A.B. (2003). Anmol Publ. New Delhi.

8. Theory and Practice of Biological control. Huffaker, C.B. and Messenger, P.S. (1976). Academic Press, New York.

****

SEMESTER - II

CORE IV: BIOLOGICAL MACROMOLECULES

Course Code	CC04	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				4	1		5		
Pre-requisite	Basic understanding of biochemistry and molecular biology								

Course Objectives:

- *This course provides the students with the Chemistry which is relevant and applicable to biological systems.*
- *The students will be taught to understand the chemical structure and functions of different biomolecules. The functions and biochemical roles of important biomolecules in life and their relationship is introduced to the students*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	The students will be exposed to different chemical bonds and functional groups of biological macromolecules	**K1,K4**
CO2	The students will be able to identify the principles of Chemistry that integrates to Biology	**K2**
CO3	The students will be able to understand the metabolic pathways involved in the energy production and utilization.	**K2,K7**
CO4	The students are able to understand the role of biomolecules in biological systems	**K2,K3**
CO5	Students will be exposed to the relationship between cellular activities and biological responses	**K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Types of Macromolecules***	Classification, structure and properties of carbohydrates, proteins, lipids including sterols and nucleic acids
Unit II ***Protein Structure and Function & Enzyme Catalysis***	Amino acids, peptides and polypeptides, Determination of amino acid composition of proteins, Determination of amino acid sequence of proteins, chemical synthesis of peptides and polypeptides, Fibrous protein, alpha keratins, collagens, Globular protein, Functional diversity of proteins. Enzyme kinetics, regulation of enzyme activities, vitamins and coenzymes
Unit III ***Metabolism of Carbohydrates***	Glycolysis, Gluconeogenesis, pentose phosphate pathway, tricarboxylic acid cycle, electron transport and oxidative phosphorylation, photosynthesis, metabolism of oligosaccharides and polysaccharides
Unit IV ***Metabolism of Lipids***	Metabolism of fatty acids – fatty acid degradation, Biosynthesis of saturated fatty acids, regulation of fatty acid metabolism, Biosynthesis of membrane lipids – phospholipids, sphingolipids, eicosanoids, Metabolism of cholesterol – Biosynthesis of cholesterol, lipoprotein metabolism, bile acid metabolism, metabolism of steroid hormones
Unit V ***Metabolism of Nitrogen – Containing Compounds***	Amino acid biosynthesis and nitrogen fixation in plants and microorganism, amino acid metabolism in vertebrates, nucleotides – metabolism, synthesis of purine and pyrimindine ribonucleotides, biosynthesis of deoxyribonucleotides, Salvage pathways, Inhibitors of nucleotide synthesis, Catabolism of nucleotides, Regulation of nucleotide metabolism, integration of metabolism and hormone action
Current Contour	Introduction to protein folding and proteosome removal of misfolded proteins; etiology and molecular basis for Alzheimer's, Prion diseases (mad cow), Huntington's Chorea, sickle cell anemia, Thalassemia, Parkinson's.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	M	S	S	S	S	S
CO2	S	S	M	S	M	S	S	S	S	S
CO3	S	S	M	S	S	S	S	M	M	M
CO4	S	S	M	S	S	S	S	S	S	S
CO5	S	S	S	S	S	M	M	M	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Principles of Biochemistry, Geoffrey L. Zubay, Willaim W. Parson, Dennis E. Vance, (1995), Wim C. Brown Communications
2. Biochemistry, Jeremy M. Berg, John L.Tymoczko, Lubert Stryer, (2002), 5th edition, W. H. Freeman and Company.
3. Biochemistry, Voet D, Voet J, (1995), 2nd edition, John Wiley and Sons Inc.
4. Principles of Biochemistry, Lehninger, Nelson D. L, Cox, M. M, (2000), 3rd edition, Mac Millan Worth
   i. Publishers
5. Biochemistry, Campbell M.K, (1999), 3rd edition, Saunders College Publishing/ Harcourt Brace College Publishers.

****

SEMESTER - II

Core V: IMMUNOLOGY

Course Code	CC05	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Fundamental knowledge about Cell and Molecular Biology								

Course Objectives:

- *The objective of this course is to introduce the basics of immunology and immune techniques applicable to biomedical research.*
- *Students will be able to understand the mechanisms behind the functioning of the immune system in defending the infections.*
- *Students also will be exposed to all the concepts of molecular, cellular immunology, autoimmune disease, allergy, etc*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Comprehend basics and molecular mechanism of humoral and cell mediated immunity	**K1,K4**
CO2	Understand the concepts of autoimmunity and different diseases due to interrupting immune system	**K2,K5**
CO3	Gain knowledge in role of immune system in developing different types of vaccines	**K1,K7**
CO4	Learn about genetics of immune haematology	**K3,K5**
CO5	Acquire knowledge on primary and secondary lymphoid organs	**K1,K4**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Overview of the Immune System***	Introduction to Immunology: Historical perspectives and fundamental concepts. Components of Innate and Acquired Immunity: Overview and differences. Cells and Tissues of the Immune System: Hematopoietic stem cells, myeloid and lymphoid lineage. Innate Immunity: Pathogen recognition receptors (PRRs), pathogen-associated molecular patterns (PAMPs), Toll-like receptors (TLRs), and acute phase proteins. Inflammatory Response: Mechanisms and significance. Acquired Immunity: Natural, artificial, active, and passive immunity; primary and secondary immune responses.
Unit II ***Organs and Molecules of the Immune System***	Lymphoid Organs: Structure and function of primary (thymus, bone marrow) and secondary (spleen, lymph nodes, MALT, GALT) lymphoid organs. Major Histocompatibility Complex (MHC): Types, structure, inheritance, role in immune responsiveness and disease susceptibility. Antigen Processing and Presentation: Cytosolic and endocytic pathways, role of professional antigen-presenting cells (APCs).
Unit III ***Humoral Mediated Immunity***	Humoral Immunity: Nature of antigens, immunogenicity vs. antigenicity, epitopes, haptens. Immunoglobulins: Structure, classes, and biological functions. Antibody Diversity: Germline and somatic variations, class switching. Mechanism of Antigen-Antibody Interaction: Affinity, avidity, and Ag-Ab tests (precipitation, agglutination, ELISA, Western blotting).
Unit IV ***Cell Mediated Immunity(CMI)***	T-Cell Receptors (TCRs): Structure, organization, and rearrangements. T-Cell Maturation, Activation, and Differentiation: Positive and negative selection, effector T cells, functional subsets (TH1, TH2, CTLs, Tregs). Mechanisms of CTL and NK Cell Killing: Roles in antiviral and antitumor immunity.
Unit V ***Immune System in Health and Disease***	Viral infection: cell - mediated antiviral mechanisms-influenza; Bacterial infection: contribution of immune response to bacterial pathogenesis-diphtheria and tuberculosis; protozoan infection: malaria and parasitic worms. hypersensitivity reactions-types, causes and mechanism of immediate and delayed type reactions; Immune deficiency diseases –types and causes; Autoimmunity –types and causes autoimmune diseases; Transplantation immunity- mechanism of graft rejection and prevention of graft rejection; Vaccine– active and passive immunization; designing and purification of macromolecules as vaccines; whole organism vaccines; recombinant vaccine and DNA vaccines.

Current Contour

Genetics of Immunohematology – Genetic basis and significance of ABO and other minor blood groups in humans, Bombay blood groups, Secretors and Non-secretors, Rh System and genetic basis of D-antigens. Clinical and forensic relevance of ABO and minor blood groups.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	L	M	S	L	S	M	L
CO2	S	M	L	S	L	M	M	L	S	M
CO3	L	S	M	M	S	S	S	M	M	S
CO4	M	L	S	L	M	M	L	S	S	M
CO5	S	M	L	S	M	L	S	M	M	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Ivan M. Roitt, Peter J. Delves, Seamus J. Martin, Dennis R. Burton (2021), Wiley-Blackwell, USA,
2. John W. Kimball (2021), Jones and Bartlett Publishers, USA
3. Immunology a short course. Benjamin E, Coico R and G. Sunskise (2015), Wiley-Blackwell; 7th edition
4. Immunology IV edn, Goldsby R.A. Kindt T.I and Osborne B.A (2000) Kuby WH Freeman&Co, NY
5. Essential Immunology (Essentials) (Paperback), Peter J. Delves, Seamus J. Martin 13th Edition (2017). Blackwell Sci NY
6. Cellular and Molecular Immunology: Ninth Edition Paperback Abul K. Abbas MBBS, Andrew H, Lichtman, Shiv Pillai (2017) Elsevier publishers.
7. The Immune System, 3rd Edition by Peter Parham, (2009) Garland Science publishers

Related Online Contents:

- Fundamentals of Immunology by Otto G. Bier Wilmar Dias da Silva Dietrich Gotze Ivan Mota springer ISBN: 978-1-4684-0116-5

WEB LINK

- https://www.frontiersin.org/journals/immunology

****

.

SEMESTER - II

CORE VI: TOXICOLOGY AND TOXICOGENOMICS

Course Code	CC06	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Fundamentals of environmental pollutants and its toxic effects								

Course Objectives:

- *This study provides organizational knowledge, capability and research skills in the field of toxicology and how they can apply it in developing areas concerned with health and environment*
- *This course gives understanding of uptake and distribution of environmental pollutants that affects at molecular, gene, cellular and at systemic level*
- *Students will learn to analyze the toxicant, interpret the data and will be able to compile a scientific report to implement policies related to environmental issues*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Realize the core concepts of the science of toxicology, including classification of toxicants, and route of entry of toxicants, hazard identification etc	**K1**
CO2	Gain knowledge and skills regarding risk assessment and to know about environmental monitoring and toxicant identification	**K1 & K2**
CO3	Explore the mode of action of toxicants in different organ systems with their effect causing health issues such as cancer, reproductive toxicity etc	**K3**
CO4	The learners will be trained to bioassay for evaluation of toxicity using different model systems	**K4 , K5**
CO5	Elucidate the molecular mechanism of action in progression of diseases by toxicants through gene expression	**K5, K6, K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Introduction to Toxicology and Toxicants***	Definition of Toxicology, Toxicity and Toxicants. Classification of toxic agents in environment – natural toxins (Phytotoxins, animal and microbial toxins). Classes of environmental toxicants; Inorganic ions (Metals-Hg, Anions-NO_3^-). Organic contaminants (DDT, Parathion and PAHs). Ionizing radiations, Detergents, Pharmaceuticals andPersonal Care Products
Unit II ***Entry, Distribution and Mode of Action***	Routes of Entry – Inhalation, Absorption, Ingestion, Injection. Bio-distribution, Bio-magnification and Biotransformation and excretion nof toxic agents. Types of Toxicity – Acute, Subacute and Chronic effects of Toxicants.Short Term and Long term. Dose-Response Relationship – LC50, LD50, EC50. Definition Mode of Action – Reactions of Toxicants with Target Molecules –Covalent Binding, Non-covalent Binding, Hydrogen Abstraction, Electron Transfer and Enzymatic Reactions.
Unit III ***Systemic Toxicology***	Toxic response of different body system - Toxicants and their effects Dermal, Respiratory, Liver, Kidney, Reproductive Organs. Endocrine disrupting chemicals, Mutagens, Teratogens, Carcinogens and hallucinogens.
Unit IV ***Toxicogenomics and Proteomics***	Introduction to Toxicogenomics, Toxicoproteomics, Modification of DNA, RNA and Protein Metabolism by Toxicants. Gene Expression Changes by Toxicants–Role of Ecotoxicogenomics for Environmental Monitoring and Toxicant Identification.
Unit V ***Protein Synthesis and Processing***	Concept of bioassay. Toxicity evaluation using various tests for genomic (comet assay), plants (seed germination, growth of plemule and radical), aquatic animals (fish and rodent model). OSHA Permissible Exposure Limits (PELS). Threshold limits value, margin of safety, therapeutic index. Risk Assessment, Elements of Risk Assessment – Categories of Risk Assessment – Retroactive and Predictive, Risk Assessor, Risk Manager, Hazard Index, NAS Paradigm and its Components.
Current Contour	Case studies with respect to the toxicants released from Tannery, Fertilizer, Electroplating, Cement and other relevant Industries.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	S	S	L	S	S	S	M	M
CO2	S	L	S	L	S	S	M	M	M	M
CO3	S	M	M	M	L	M	M	M	L	S
CO4	S	M	L	M	S	S	M	L	L	M
CO5	S	S	L	L	L	M	S	L	M	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Essentials of Toxicology, Casarett and Doull's. Second Edn. (2010). Curtis Klaassen and John B.Watkins III. Mc Graw Hill.
2. Environmental Risk Assessment Report, Benjamin, S.L., and Bellurk,D.A.,(2001).
3. Environmental Toxicology – Biological and Health Effects of Pollutants, Ming-Ho Yu, (2004), Second Edition, CRC Press (Taylor &Francis Group).
4. Environmental Toxicology-Engineering Tools for Environmental Risk Management, Katalin Gruiz, Tams Meggyes and Eva Fenves, (2014), CRCPress (Taylor & FrancisGroup).
5. Essentials of Toxicology – KlassenCD,Watkn J.B(2003) 3 rd Ed., Mc Grew Hill, NewYork
6. Fundamentals of Ecotoxicology, MichaelC. Newman, (2001), Lewis Publishers.
7. Handbook of Ecotoxicology, David J. Hojjman, Barnett A. Rattner, G. Allen Burton, Jr., and John Cairns,Jr.,(2000),CRCPress (Taylor & Francis Group).
8. Information Resources inToxicology:Wexler,Philipet al,2000.3rd ed. Academic press, 2000.
9. Introduction to EnvironmentalToxicology-Wayne. G.Landis,MingHo Yu, 3rd Ed. (2002) Lewis Publishers, CRCpress, NY.
10. LU's Basic Toxicology (Fundamentals, Target Organs and Risk Assessment), Sixth Edition, Samkacew and Byung-Mu Lee, (2013), CRCPress (Taylor & Francis Group).

Related Online Contents:

- https://envirotoxinfo.nlm.nih.gov/
- https://ctdbase.org/
- https://www.evotec.com/en/panomics/toxicogenomics
- https://19january2017snapshot.epa.gov/chemical-research/computational-toxicology-communities-practice_.html
- https://onlinelibrary.wiley.com/page/journal/15227278/homepage/video-gallery

****

SEMESTER - II

CORE OPTIONAL 1: INSTRUMENTAL METHODS OF ANALYSIS

Course Code	CO02	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Basic Principle of instrumental analysis								

Course Objectives:

- *Environmental analysis and monitoring is a very demanding and dynamic field, and this course involves instrumental qualitative and quantitative determination of contaminants / chemicals from ppm to very trace levels, and the ever changing requirements for regulatory compliance in monitoring drinking water, wastewater, ambient/emission air, and solid/hazardous wastes.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand the theories and principles of instrumental methods available in analytical chemistry	**K1,K2**
CO2	Develop knowledge pertaining to the appropriate selection of instruments for the successful analysis of complex mixtures	**K2**
CO3	Identify and describe the steps that are included in a complete the analysis as sampling, sample preparation, separation, detection and data evaluation	**K3,K4**
CO4	Gain hands on experience on selected instrumental methods of analysis	**K5**
CO5	Develop deeper understanding about the field of environmental analytical methods	**K6,K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

UNIT I ***Microscopy***	Introduction to Microscopy, Fixation and Staining. Principles and applications of Light, Phase Contrast, Fluorescence, Confocal, Atomic Force, Scanning Electron and Transmission Electron Microscopy (SEM & TEM), Cytophotometry.

UNIT II ***Separation Techniques***	Centrifugation – Differential and Ultracentrifugation. Principles and applications of Gel Filtration, Column, Ion-Exchange, Size Exclusion and Affinity Chromatography. Paper chromatography, TLC, HPLC, GC.
UNIT III ***Analytical Techniques-1***	Titrimetry, Gravimetry, Colourimetry, Turbidimetry, Nephelometry, Flame Photometry, Elemental Analyzer, TOC Analyzer. Spectrophotometers – Fluorescence, UV-Visible and IR. NMR Spectroscopy, AAS, ICP-OES, ICP-MS, Amino Acid analyzer, GC- MS, LC-MS, Tandem Mass spectrometers, SELDI-TOF-MS, MALDI-TOF-MS and Bio-Sensors.
UNIT IV ***Analytical Techniques - 2***	AAS, ICPOES, ICPMS, GC-MS, LC-MS, SELDI-TOF-MS, MALDI-TOF-MS and Bio-Sensors. Principle and Application of Radioactive Isotopes, Autoradiography, Scintillation Counter, Geiger Muller Counter.
UNIT V ***MOLECULAR TECHNIQUES***	Electrophoresis- PAGE, PFGE, SDS-PAGE, Agarose Gel, Immunoelectrophoresis, 2D Electrophoresis and Gel Documentation, Principle and Application of PCR, RT-PCR, RFLP, RAPD, AFLP and DNA Fingerprinting.
Current Contour	X-ray Absorption Fine Structure (EXAFS) and X-ray Absorption Near Edge Structure (XANES), SEM - Back-scattered and secondary electron imaging, Electron Microprobe Analysis (EMA)

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	M	M	S
CO2	S	S	M	S	S	S	S	S	M	S
CO3	S	S	M	M	S	M	S	S	M	S
CO4	S	S	M	M	S	S	S	S	M	S
CO5	S	S	S	S	S	S	S	S	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Biochemistry Laboratory: Modern Theory & Techniques, Rodney F. Boyer (2006), Prentice Hall.

2. Biophysical Chemistry: Principles & Techniques, Avinash Upadhyay, Kakoli Upadhyay, Nirmalendu Nath (2009), Himalaya Publishing House

3. Biophysics and Biophysical Chemistry, Debajyoti Das (2001), Academic Publishers, Kolkata
4. Biosensors, Jon Cooper, Tony Cass (2004), Oxford University Press, USA
5. Biotechniques of Ecology, Ashok Kumar (2006), Discovery Publishing Pvt.Ltd, New Delhi
6. Fundamental Concepts in Biophysics, Thomas Jue (2009), Humana Press
7. Mass Spectrometry for Biotechnology, Gary Siuzdak (2006), Elsevier New Delhi Academic Press
8. Mass Spectrometry of Proteins & Peptides, Lipton Mary S, Paša- TolicLjiljana (2009), Humana Press
9. Principle & Techniques of Biochemistry & Molecular Biology, Keith Wilson, John Walker (2010), Cambridge University Press.

Related Online Contents:

- http://nptel.ac.in/courses/102103044/pdf/mod2.pdf
- Analytical Chemistry https://kanalispolban.files.wordpress.com/2012/04/analytical_chemistry.pdf
- AnalyticalChemistryhttps://www.pdfdrive.com/download.pdf?id=912659&h=c1beb8cca20136a30c73f39f 19c8dd81&u=cache&ext=pdf
- Principles and Practice of Analytical Chemistry http://sci-lib.org/books_1/F/fifield.pdf

WEB LINKS

- https://www.epa.gov/pesticide-analytical-methods/ environmental-chemistry-methods-ecmindex
- https://www.microscopyu.com/microscopy-basics
- http://elte.prompt.hu/sites/default/files/tananyagok/ Introduction To Practical Biochemistry/ch06.html
- http://nptel.ac.in/courses/102103013/module3/lec4/2.html

****

SEMESTER - II

CORE OPTIONAL 2: NANO-BIOTECHNOLOGY

Course Code	CO02	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1		4		
Pre-requisite	To understand about sources and applications of Nanobiotechnology								

Course Objectives:

- *The course aims at providing a general and broad introduction to multi-disciplinary field of Nanotechnology*
- *It will familiarize students with the combination of the top-down approach of microelectronics and micromechanics with the bottom-up approach of Chemistry/Biochemistry; a development that is creating new and exciting cross-disciplinary research fields and technologies*
- *The course will also give an insight into complete systems where Nanotechnology can be used to improve our everyday life*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOME	KNOWLEDGE LEVEL
CO1	Students will be able to describe basic science behind the properties of materials at nanometre scale	**K1, K2**
CO2	The principles behind advanced experimental techniques for studying nanomaterials will be learned	**K1, K2**
CO3	The learner will know about the nano probes with their principle and advantages	**K3**
CO4	The fate of nano particles in the environment will also be understood in detail	**K2, K4**
CO5	The student also gains knowledge regarding the nanogenomics- an emerging area of importance	**K5, K6**
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

UNIT - I ***Introduction to Nanobiotechnology***	Historical Prospective of Nanobiotechnology, Nanomaterials-Clarification, properties and types Nanobiotechnology-application. Scope of Nanobiotechnology.

UNIT – II ***Nanoprobes***	Atomic force microscopy, scanning tunneling microscopy, NMR, Brewster angle microscopy, UV/Vis spectrometry, infrared spectrometry (FTIR), electron microscopy, SEM, TEM, X-RAY spectroscopy and diffraction, bimolecular microarrays, mass spectrometry.
UNIT- III *Environmental Nanobiotechnology*	Environmental fate and transport of nanoparticles: Ecological hazard of nanomaterials – principles, factors affecting the toxicological of nanomaterials, effects on ecosystems; toxicology and risk assessment of nanoparticles; application of nanoparticles in pollution control.
UNIT - IV ***Nanobiology***	Nanogenomics-human T lymphocytes cell cycles, organ transplants, osteogenesis: nanoproteomics-cell cycles, cell transformation and differentiation; cell nanobiosciences nuclesome core; protein stability to heat and radiation-bioinformatics analysis, structural comparision. Nanoparticles, liposomes, diamondoid, nanostructure, nanoshell, nanopores, carbon nanotubes.
UNIT- V ***Nanobiotechnology-Future Prospective***	Research scope in Nanobiotechnology, global status of Nanobiotechnology, IPR and Nanobiotechnology. Developing environmental regulations pertinent in Nanobiotechnology – TSCA, FIFRA, CAA, CWA, RCRA, PPA, FEDCA, NIOSH, CPSE; International development – REACH, OECD.
Current Contour	Nanoprobes - BioPhotonics- Diagnostic Biosensors- Catalyst- Functionalized Metallic Nanoparticles and Their Applications in Colorimetric Sensing- Dip stick Tests- Nanoparticles as Catalysts for Signal Generation and Amplification- Iron Oxide Nanoparticles in Magnetic Resonance Imaging- Optical nanoparticles sensors for quantitative intracellular imaging. Cancer imaging- Nanophotonics

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	S	M	S	M	M	S
CO2	M	M	S	S	M	M	S	S	S	S
CO3	S	M	S	M	M	S	M	M	M	S
CO4	L	M	M	L	M	L	M	M	M	L
CO5	S	S	M	S	L	L	S	S	M	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Gero Decher, Joseph B. Schlenoff, (2003); Wiley- VCH Verlag GmbH & Co. KGaA
2. Bionanotechnology: Lessons from Nature; David S. Goodsell, (2004); Wiley-Liss
3. Biomedical Nanotechnology, Neelina H. Malsch (2005), CRC Press
4. Bioconjugate Techniques, Greg T. Hermanson, (2013); (3rd Edition); Elsevier
5. Nanofabrication: Principles to Laboratory Practice (Optical Sciences and Applications of Light) 1st Edition, Andrew Sarangan, (2016), CRC Press.

SEMESTER - II

Elective A: BIOINFORMATICS AND STATISTICS

Course Code	EC02	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1		4		
Pre-requisite	Understanding about various soft wares applied in Bioinformatics and Biostatistics								

Course Objectives:

- *To familiarize the students with basic Bioinformatics viz. different types of biological databases and data mining etc*
- *To extend their knowledge to address research problems through biological molecules, Sequence alignments, Phylogenetic analysis and protein analysis.*
- *To interconnect the in silico studies and analysis to aid wet lab.*

Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Describe Internet perception, various search engines, an overview of bioinformatics, and the basic molecular structure and properties of nucleic acids and proteins	**K4,K5**
CO2	Learn to design primer and restriction site analysis	**K3,K7**
CO3	Understand the basis for phylogeny construction and Construct and analyze phylogeny tree using various methods	**K2,K6**
CO4	Acquire knowledge on prediction and visualization of the protein secondary and tertiary structure	**K1,K6**
CO5	Resolve problems quantitatively using appropriate statistical measures	**K4,K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

UNIT I

Basics of Bioinformatics

Internet Perception – Internet Service Providers, www, Search Engines, Search Techniques. Definition and History of Bioinformatics. Overview of Bioinformatics, Introduction to data mining, Application of data mining, Physical and chemical properties of protein – molecular weight, theoretical pI (isoelectric point), amino acid composition, atomic composition, extinction coefficient, estimated half-life, instability index, aliphatic index and grand average of hydropathicity *- PROTPARAM, ISOTOPIDENT.

UNIT II ***Database and Data Mining***	Introduction and overview of biological database - Nucleic acid database (primary-NCBI, DDBJ, EMBL and secondary-UNIGENE, EMI Genomes). Protein sequence database-SWISS PROT/ TrEMBL, PIR. Sequence motif database - Pfam, PROSITE. Protein structure database-PDB, SCOP, CATH. Other relevant database-KEGG, PQS. Finding Scientific articles - Pubmed, Highwire, Press, Plos. **Sequence alignments (pairwise alignment) – local, Global, dotplot, dynamic programming. Scoring Matrix – BLOSUM, PAM, GAP PENALTY. Inferring Data relationships (Heuristic method) - BLAST: blastn, blastp, blastx PSI, PHI. Sequence Alignment Score: E-Value, P-Value. Analysis at nucleotide level- restriction mapping, Primer synthesis, ORF prediction
UNIT III ***Sequence Alignment***	Multiple Sequence Alignment: Progressive, Iterative and Block based alignment. ClustalW2, Clustal Omega, MUSCLE, T-COFFEE* Phylogenetic Tree - Phenetics, Cladistics: rooted, unrooted, Bifurcating.Phylogenetic analysis – Neighbor-Joining, Maximum parsimony, minimum livelihood, UPGMA.
UNIT IV ***Analysis at Protein Level***	Signature, profiles and motifs – My Domains, My Hits, PRATT, Scan Prosite. Protein Secondary Structure Prediction: Methods for predicting secondary structure: Chou and Fasman method, GOR method. Protein Tertiary Structure Prediction; Comparative modeling - Modeller, Swiss model Threading – Gen Threader, PR ROSETTA, TOUCHSTONE. Visualization of protein structure: RASMOL, SWISS PDB, CHIMERA, YASARA
UNIT V ***Biostatistics***	Primary and secondary data collection, classification, tabulation. Sampling and sampling methods, Measures of Central tendency – mean (arithmetic, harmonic & geometric) median and mode; Correlation Coefficient*, Simple linear regression; basic idea of Significance Test, hypothesis tests, levels of significance, Student ‘t’, ‘Chi’ square and goodness of fit.
Current Contour	Bio programming and bioinformatics software, big data analysis, pharmaceutical and Health Care Data Management, implementation of Big Data Analysis in Pharmaceuticals and Healthcare Industry, Conditional probability mass function, and probability density.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	L	M	S	M	L	S	S
CO2	M	S	M	L	M	M	S	M	S	M
CO3	S	S	L	M	S	M	L	M	S	M
CO4	M	M	S	M	M	M	S	L	M	L
CO5	S	M	M	S	M	S	M	M	L	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Bioinformatics: Sequence and Genome Analysis: David W. Mount (2019). Cold Spring Harbor Laboratory Press.
2. Introduction to Bioinformatics Terry Attwood and David Parry- Smith (2019) [Longman Higher Education; ISBN 0582327881]
3. Bioinformatics: Sequence Structure and Databanks des Higgins and Willie Taylor (2019), Oxford University Press; ISBN 0199637903.
4. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins Andreas Baxevanis and Francis Ouellette (2019), Wiley-Interscience; ISBN 0471478784
5. Bioinformatics for Dummies, Jean-Michel Claverie and Cedric Notredame (2018) 2nd Edition.
6. Bioinformatics Basics: Applications in Biological Science and Medicine, HH Rashidi & LK Buehler (2002), CRC Press, London
7. Bioinformatics: Sequence, structure and databanks, Des Higgins & Willie Taylor (2002), Oxford University Press
8. Bioinformatics: A practical guide to the analysis of genes and proteins, Baxevanis AD & Ouellette BEF (2001) Wiley Inter science – New York
9. Primer of Biostatistics, Stanton A & Glantz, (2012), McGraw Hill Inc., New York.
10. Essential Bioinformatics, Jin xiong (2007). Cambridge University Press, New York.
11. Introduction to Biostatistics, Gurumani (2005); MJP Publishers
12. Modern statistics for Life Sciences, Alan Graphen Rosie Hails (2002);
13. Introduction to Biostatistics and Research methods, Sundhar Rao., David Clark (2016), 5th Edn, PHI Learning Pvt Ltd.
14. Biostatistics an Introduction, Mariappan (2013), Pearson Education;
15. Bioinformatics Concepts Skills and Applications, Rastogi (2006), 2nd Edn CBS Publications
16. Bioinformatics and Functional Genomics, Jonathan Pevsner (2009), 2nd Edn, Wiley India Ltd
17. Principles of Biostatistics, Marcello Pagano Durubav (2007), 2nd Edn, Thomas Learning

WEBLINK

- http://taz.newffr.com/TAZ/Coding/OReilly-Developing_Bioinformatics_Computer_Skills.pdf
- http://211.69.141.12/upload/fe6a2527-a4b1-4083-8471- 07b31f5e3bfd.pdf
- Guides. Libarary.umass.edu/bioepi/web
- Hsph. Harvard . edu/ biostatistics
- Public-health. Viowa.edu/biostatistics – student – handbook/

E BOOK

- Ebookee.com/Primer – of Biostatistics – 6th edition – 123705 html
- Book authority.org/ book/best- bioinformatics-eBooks
- Courses.cs.ut.ee/NTAT.03.242/2017 – fall/ uploads/ Main/basics-of- bioinformatics. pdf

****

SEMESTER - III

Elective B: CANCER BIOLOGY

Course Code	EC02	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1		4		
Pre-requisite	Basics of cancer biology with diagnosis and therapy								

Course Objectives:

- *To learn about the basic Biology of Cancer cells along with the different forms of cancer.*
- *To understand about the impacts of antibodies against cancer in the human body. To also know about the Enhanced immunology based detection methods and imaging techniques.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	To appreciate the role of immune system in cancer	**K1 & K2**
CO2	To describe self – tolerance machinery and immune surveillance	**K3**
CO3	To understand the cancer microenvironment and its influence on immune cells.	**K4 &K5**
CO4	To have awareness on medical applications of cytokines and immune cells against cancer.	**K6**
CO5	The student gains awareness regarding the therapies available for the treatment of cancer at an early stage.	**K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

UNIT I ***Basic Biology of Cancer***	Regulation of Cell cycle, Mutations that cause changes in signal molecules, effects on receptor, signal switches, tumour suppressor genes, Modulation of cell cycle-in cancer, Different forms of cancers, Diet and cancer.

UNIT II ***Carcinogenesis of Cancer***	Chemical Carcinogenesis, Metabolism of Carcinogenesis, Natural History of Carcinogenesis, Targets of Chemical Carcinogenesis, Principles of Physical Carcinogenesis, X-Ray radiation – Mechanism of radiation Carcinogens
UNIT III ***Oncogenes of Cancer***	Oncogenes, Identification of Oncogenes, Retroviruses and Oncogenes. Growth factor and Growth factor receptors that are Oncogenes. Oncogenes / Proto Oncogenes activity. Growth factors related to transformations
UNIT IV ***Clinical Importance of Cancer***	Clinical significances of invasion, heterogeneity of metastatic phenotype, Metastatic cascade, Basement membrane disruption, Three step theory of invasion, Proteinases and tumor cell invasion.
Unit V ***Cancer Therapy***	Different forms of therapy, Chemotherapy, Radiation Therapy, Detection of Cancers, Prediction of aggressiveness of Cancer, Advances in Cancer detection
Current Contour	Cancer epidemiology, risk factor and Symptoms, imaging, biopsy and laboratory investigations, tumour markers, staging and prognosis of tumours

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	M	L	S	S	M	M
CO2	S	S	M	M	M	L	S	M	M	M
CO3	S	M	S	S	M	M	M	S	L	L
CO4	S	M	M	L	L	S	M	M	L	M
CO5	S	M	M	M	S	L	L	L	L	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. The Biology of Cancer, Weinberg, R.A. (2007), Garland Science.
2. Molecular Biology of Cancer, McDonald, (2004), IInd Edition. Taylor and Francis.
3. Cancer Biology, King, Roger J.B. (1996), Addison Wesley Longman.
4. Cancer Biology, Ruddon, Raymond W. (1995), IIIrd Edition. Oxford University Press.
5. Virology a practical approach, Maly B.W.J, (1987), IRL press, Oxford**.**
6. Introduction to modern Virology, Dunmock.N.J and Primrose S.B, (1988) Blackwell,Scientific Publications Oxford.
7. Cancer Biology, King,R.J.B, Addision,Wesley Longmann, Ltd,U.K.1996.

WEB LINK

- Wcrj. net/ topic/ cancer – biology
- Cancer biomed. org/index. Php/cocr
- Mdpi.com / journal/cancers/ section/ molecular_ cancer biology

E- BOOKS

- Technology networks. Com / advances – in – cancer –research –ebook
- Technology networks. Com/ spotlight –on – oncology
- Technology networks. Com / the – central – role – of – immune – cells – metabolism – in – building – next – generation – cell –therapies.

****

SEMESTER - II

Elective C: PROTEIN ENGINEERING

Course Code	EC02	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Fundamental knowledge on antigen, antibody and immune response								

Course Objectives:

- *To familiarize the basic structure of proteins; to understand the protein characterization through advanced techniques; enhanced knowledge in application of protein engineering, to introduce different methods and strategies commonly used in protein engineering Learning*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understanding the structure and function of proteins is made possible.	**K1,K2.K4**
CO2	Understanding the importance of critical amino acids involved in catalysis, stability and regulation of proteins	**K2,K1,K7**
CO3	The student knows about protein evolution using genetic engineering approaches with improved biochemical properties	**K2,K4**
CO4	To acquire knowledge on computational approaches to protein engineering	**K2,K7**
CO5	To learn about different applications of protein engineering	**K4,K6.K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

UNIT I ***Protein Structures***	Forces stabilizing proteins – Van der Waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study) – affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, etc. Protein engineering with unnatural amino acids and its applications.

UNIT II ***Methods of Measuring Stability of a Protein***	Spectroscopic methods to study physicochemical properties of proteins: UV spectrophotometry; CD spectroscopy; Fluorescence spectroscopy; Hydrodynamic properties–viscosity, Dynamic light scattering; hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy-emphasis on parameters that can be measured/ obtained from NMR and their interpretation
UNIT III ***Computational Approaches to Protein Engineering***	Sequence and 3D structure analysis, Active site residues and modifying agents; Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles, mesophiles and thermophiles.
UNIT IV ***Experimental Methods of Protein Engineering***	Rational and directed evolution; Module shuffling; Guided protein recombination, Basics of optimization and high throughput screening Application to devices with bacteriorhodopsin as an example; Applications to vaccines.
UNIT V ***Applications of Protein Engineering***	Protein Engineering to enhance the solubility and assist folding of expressed proteins. Protein Engineering to assist purification of expressed proteins. Role in Vaccine Development. Engineering blood clotting factors: factor VIII. Engineering enzymes: tyrosyl-tRNA synthase. Engineering therapeutic hormones: insulin. Engineering humanized antibodies
Current Contour	Analyse the DNA Sequence of proteins for factors which can affect the expression and properties of the protein, construct modification to change the proteins properties. Discussion on PCR – based mutagenesis, construct primer for isolation of genes by PCR.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	S	M	M	M	S	S	S
CO2	M	M	S	S	S	S	M	M	M	M
CO3	S	S	M	S	M	M	S	S	S	S
CO4	S	M	M	M	S	S	M	S	M	S
CO5	M	M	S	S	S	S	M	S	M	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Protein-Protein Interactions: Techniques and Applications O'Neill PB, Larsen and Keller, (2018), Education, ISBN: 978-1635496536.
2. Protein Engineering and Design, Torres A, (2017), Syrawood Publishing House, ISBN: 978 1682864029.

3. Protein Engineering Techniques: Gateways to Synthetic Protein Universe 1 st ed., Poluri KM and Gulati K, (2016), Springer; ISBN: 978-9811027314.
4. Handbook of Protein Engineering 2nd ed., Callisto TA, (2015), ISBN: 978-1632394101
5. Protein Engineering (Nucleic Acids and Molecular Biology) Koehrer C and RajBhandary UL, (2010), Springer, ISBN: 978- 3642089923 47
6. Protein Engineering, Principles and Practice Cleland JL and Craik CS, (2006), Vol 7, Springer Netherlands. ISBN: 978-0471103547.
7. Structure in Protein Chemistry 2nd ed. Kyte J, (2006), Garland publishers, ASIN: B013J9NXQ

E BOOK

- news-medical. net / life sciences/ protein – structure – and – function –aspx

****

SEMESTER – II

Laboratory Course II: Biological Macromolecules& Toxicology and Toxicogenomics

Course Code	LC02	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
						4	3		
Pre-requisite	Basics of biochemistry, molecular biology and genetics								

Course Objectives:

- *This course helps the students to understand the significance of various water quality parameters to understand the quality of the water tested.*
- *The soil quality is also known by analyzing the basic parameters. Further to understand the effects toxicants on animal model and it can be used to detect in humans too.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Hands-on experience with macromolecules helps students and researchers grasp fundamental concepts in biochemistry and molecular biology, bridging theoretical knowledge with practical skills	**K4**
CO2	This practical provide essential insights that drive advancements in biotechnology, medicine, and fundamental biological research.	**K4 &K5**
CO3	Understand the biochemical changes happening in rats exposed to toxicants	**K5**
CO4	Could evaluate the histopathological changes due to different toxicants	**K6**
CO5	The toxicity of the specific toxicants could be understood by performing relevant experiments	**K7**
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

1. Paper Chromatography
2. Thin-layer Chromatography
3. Cell fractionation
4. Isolation of DNA from liver tissue
5. Immunoelectrophoresis
6. Determination of pesticides in water samples using liquid extraction
7. Determination of PAH's in air by Soxhlet extraction
8. Determination of PPCP's in water sample by solid phase extraction
9. Isolation and estimation of chlorophyll by UV-spectrophotometry

1. Estimation of Serum Aspartate Aminotransferase (AST) in serum of rats exposed to toxicants.
2. Estimation of Serum Alanine Aminotransferase (ALT) in serum of rats exposed to toxicants.
3. Estimation of urea in serum of rats exposed to toxicants.
4. Estimation of uric acid in serum of rats exposed to toxicants.
5. Evaluation of the antioxidant enzyme Superoxide Dismutase (SOD) in liver tissues of rats exposed to toxicants.
6. Evaluation of lipid peroxidation (MDA) in liver tissues of rats exposed to toxicants.
7. Evaluation of the antioxidant enzyme Superoxide Dismutase (SOD) in kidney tissues of rats exposed to toxicants.
8. Evaluation of lipid peroxidation (MDA) in kidney tissues of rats exposed to toxicants.
9. Histopathology of liver tissue from the rats exposed to toxicants.
10. Histopathology of kidney tissue from the rats exposed to toxicants.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	L	M	S	M	S	L	S
CO2	S	M	M	L	M	L	M	M	L	S
CO3	S	S	M	M	L	M	M	L	L	M
CO4	S	S	M	M	M	L	M	L	L	M
CO5	S	M	L	L	S	L	M	M	L	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Practical Manual of Biochemistry by Dr. G. Sattanathan, Ph.D., Dr. S.S. Padmapriya, Ph.D., Dr. B. Balamuralikrishnan, Ph.D., Skyfox Publishing Group.
2. Instrumental Methods of Chemical Analysis by B.K Sharma
3. Organic spectroscopy by Y.R Sharma
4. Text book of Pharmaceutical Analysis by Kenneth A. Connors
5. Vogel's Text book of Quantitative Chemical Analysis by A.I. Vogel
6. Practical Pharmaceutical Chemistry by A.H. Beckett and J.B. Stenlake
7. Toxicology Laboratory Manual by Prepared by: Bight'08 Toxicology Committee

Related Online Contents:

- https://youtu.be/8wmQ_xWqZbo?si=Py4ZqWasUXghHKD9
- https://youtu.be/ltT8vr5Wmz8?si=KVNd2BFrIIZRidYj
- https://youtu.be/y4mMP8rmp3M?si=oLN859Zj-4FYui-m
- https://youtu.be/ozvaUhGe8GU?si=e9c4eNo0ceuRFHic

****

SEMESTER - III

CORE VII: GENETIC ENGINEERING

Course Code	CC07	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				4	1	-	5		
Pre-requisite	Understanding of Genetic engineering tools and technology								

Course Objectives:

- *This course will instruct the concept of genetic code, discovery of restriction endonucleases, PCR, gene cloning techniques, recent advancements in genetic engineering of plant and animal system and significance of bioethics.*
- *Understand the concept of genetic code and genome*
- *Practice on Genome Engineering tools*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	This course will make the students understand the concept of genetic code and genome	**K1**
CO2	Comprehend the principle of restriction endonucleases and PCR working mechanisms which further emphasize the significance in gene cloning	**K2,K3**
CO3	Theoretically will know the different types of cloning vector and their applications	**K1,K4**
CO4	Aware of recent advancements in genetic engineering and importance of studying bioethics	**K5,K6**
CO5	To know the bioethics related to transgenic organisms	**K5,K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Fundamentals of Recombinant DNA Technology***	Introduction to rDNA Technology: Historical perspective and advancements. DNA Modifying Enzymes: Types and applications of restriction enzymes (Type I, II, III), DNA polymerases, kinases, phosphatases, ligases, and nucleases. Restriction Mapping and Site Elucidation: rare-cutting enzymes, and mapping techniques.
Unit II ***Cloning Vectors and Host Systems***	Overview of Cloning Vectors: Features and applications of plasmids (pBR322, pUC), phage vectors (Lambda, M13), cosmids, BACs, YACs, and HACs. Expression Vectors: Prokaryotic and eukaryotic systems, shuttle vectors, and vectors for protein purification. Competent Cell Preparation: Methods for bacterial, yeast, plant, and animal cell transformation. DNA Transfer Techniques: Transformation, transfection, electroporation, and biolistics.
Unit III ***Gene Isolation, Amplification, and Screening***	DNA Libraries: Construction of genomic and cDNA libraries. Molecular Probes: Design, labelling (radioactive and non-radioactive), and hybridization techniques. PCR Techniques: Standard PCR, RACE, Long PCR, Screening Recombinants: Alpha complementation, blue-white screening, and hybridization strategies. Principles of Blotting: Techniques for Southern, Northern, and Western blotting.
Unit IV ***DNA Sequencing and Genomic Applications***	DNA Sequencing: Maxam-Gilbert, Sanger, and high-throughput methods like next-generation sequencing (NGS). Genomic Techniques: Chromosome jumping, chromosome walking, and positional cloning. Site-Directed Mutagenesis: Techniques and applications in functional genomics. DNA Fingerprinting: Methods and applications in genetics and forensics.
Unit V ***Recombinant Proteins, Safety, and Ethics***	Recombinant Protein Production: Insulin, human growth hormone, and industrial enzymes. Safety and Biosafety: Guidelines for recombinant DNA work, risk assessment, and containment. Ethical Considerations: Environmental impacts of transgenic organisms and societal concerns. Case Studies: Applications and controversies in recombinant DNA technology.
Current Contour	Metabolic pathway engineering, Genome engineering tools – TALEN, Zinc finger and CRSPR-Cas9, biowarfare and bioterrorism, bioethics in Biotechnology.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	L	M	S	L	S	M	L
CO2	S	M	L	S	L	M	M	L	S	M
CO3	L	S	M	M	S	S	S	M	M	S

CO4	M	L	S	L	M	M	L	S	S	M
CO5	S	M	L	S	M	L	S	M	M	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Biotechnology – Applying the genetic revolution. David P. Clark and Nanette J. Pazdernik. (2016). Elsevier publication.
2. Gene cloning and DNA analysis – An introduction. T.A. Brown (2010). 6th edition. Wiley-blackwell – a John Wiley and sons, Ltd, publication.
3. Molecular Biology of the Cell. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter (2007). 5th edition. Garland science publishers.
4. Principles of cloning. Jose Cibeli, Robert P. Lanza, Keith HS. Campbell and Michael D. West (2002). Academic Press-Elsevier science publication.
5. Molecular cell Biology, Lodish, Berk, Zipursky, Matsudira, Baltimore and Darnell. (2005) W.H.Freeman and Company
6. Principles of Gene manipulation and proteomics Primrose, S.B., R.M. Ywyman and R.W. Old. (2006). Seventh edition, Blackwell Science,U.K.

Related Online Contents:

E BOOK

- Genetic Engineering Principles and Methods 2006 by Jane K. Setlow

WEBLINKS

- https://www.britannica.com/science/genetic-engineering

****

SEMESTER - III

CORE VIII: ENVIRONMENTAL BIOTECHNOLOGY

Course Code	CC08	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Basic understanding of microbiology, biotechnology, and environmental science								

Course Objectives:

- *This course aims to introduce fundamentals of Environmental Biotechnology*
- *The course will introduce major groups of microorganisms-tools in biotechnology and their most important environmental applications*
- *The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	To describe suitable methods for characterizing the activity, function, diversity, and composition of microbial communities	K1,K6
CO2	To elucidate the microbial processes	K2, K3
CO3	Understand the growth requirements under laying different treatment techniques of microbes	K1, K4
CO4	To evaluate the potential for biodegradation of organic and inorganic pollutants, taking microbial and physical/chemical environments	K5,K7
CO5	Understand to analyze the chemical structure of the compounds	K4, K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Introduction to Environment***	Introduction to Environment; pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology

Unit II ***Bioremediation***	Bioremediation - fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.), technological aspects of bioremediation (in situ, ex situ))- Biodegradation pathways and microbial enzymes involved in pollutant breakdown- Biosorption and bioaccumulation mechanisms for heavy metals-Role of nanotechnology in enhancing bioremediation processes- Challenges and limitations of bioremediation in extreme environments.
Unit III ***Role of microorganism in bioremediation***	Application of bacteria and fungi in bioremediation: White rot fungi vs specialized degrading bacteria: examples, uses and advantages vs disadvantages -Role of archaea and extremophiles in bioremediation of extreme environments (e.g., high salinity, temperature, pH)-Microbial consortia and synergistic interactions in pollutant degradation-Genetically engineered microorganisms (GEMs) for enhanced bioremediation efficiency-Enzymatic degradation: microbial enzymes involved in breaking down hydrocarbons, plastics, and other persistent pollutants- Microbial bioreactors for wastewater treatment and industrial effluent cleanup-Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltrationphytostabilization)-Phytoremediation and its applications in soil and water cleanup
Unit IV ***Biotechnology and agriculture***	Bioinsecticides: *Bacillus thuringiensis*, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (e.g. *Trichoderma*, *Pseudomonas fluorescens*); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application - Genetic engineering for crop improvement: drought resistance, pest resistance, and nutrient enhancement-Biotechnology in post-harvest management: biopreservation and reducing food wastage- Ethical considerations and biosafety of genetically modified organisms (GMOs) in agriculture
Unit V ***Environmental Bioprocesses***	Wastewater treatment-Microbial treatment processes: aerobic and anaerobic digestion, activated sludge process-Microbial fuel cells for wastewater treatment ( ) -Role of biofilms in wastewater treatment and biofilters-Bioreactors: design and applications in

	wastewater management-Application of biosorbents in heavy metal removal from wastewater-Emerging technologies in decentralized wastewater treatment: membrane bioreactors, constructed wetlands
Current Contour	GM crops of India and other Countries-Statistics - GM crops permitted in India- Pros and Cons of GM Crops-Case studies on Bioremediation - Impact of global warming on microbial ecosystems and biodiversity-Applications of omics technologies in environmental biotechnology.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	L	M	S	L	S	M	L
CO2	S	M	L	S	L	M	M	L	S	M
CO3	L	S	M	M	S	S	S	M	M	S
CO4	M	L	S	L	M	M	L	S	S	M
CO5	S	M	L	S	M	L	S	M	M	S
S-Strong; M-Medium; L-Low										

Percentage of modification-186/29 x 100=78

Recommended References:

1. Environmental Biotechnology: Theory and Applications, G. M. Evans and J. C. Furlong (2003), Wiley Publishers.
2. Environmental Biotechnology: Principle & Applications, B.Ritmann and P. L. McCarty, (2000), 2nd Ed., McGraw Hill Science.
3. Environmental Biotechnology, Scragg A., (2005), Pearson Education Limited.
4. Biofiltration for Air Pollution Control, J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), CRC Press.
5. Biotechnology – A Multi-Volume Comprehensive Treatise, H. J. Rehm and G. Reed, (2001), Vol. 11, 2nd Ed., VCH Publishers Inc.

Related Online Contents:

- https://onlinecourses.nptel.ac.in/
- https://www.nature.com/subjects/environmental-biotechnology
- https://www.biologydiscussion.com/biotechnology

****

SEMESTER - III

CORE OPTIONAL 1: PLANT AND ANIMAL BIOTECHNOLOGY

Course Code	CO03	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Fundamentals of plant and animal cell culture								

Course Objectives:

- *To introduce the students about the fundamentals of plant and animal cell culture techniques*
- *Students will be provided with novel insights about plant breeding along with plant tissue culture to improve food quality and in the discovery of medicinal products*
- *The students will get familiarized with the concept of transfer of new genes in animal cells culture methods and to understand the different phases of the embryo development and associated medical implications basic embryo structure and morphological fundamentals will be imparted to the students*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Deliver practical knowledge on how to do cloning and sequencing	**K1 & K2**
CO2	Deliver both theoretical and practical knowledge on different molecular techniques such PCR, Restriction digestion, ligation and transformation	**K3**
CO3	The student would be able to perform plant tissue culture experiments	**K4 &K5**
CO4	Animal tissue culture will be performed by the students.	**K5 & K6**
CO5	Knowledge regarding Cell passaging and cell viability will be understood.	**K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Tissue Culture***	Totipotency; Tissue culture media; Plant hormones and morphogenesis; embryogenesis; Cell suspension culture; Micropropagation – shoot tip culture, somatic embryos, artificial seeds; Applications of tissue culture; shoot tip culture; Wide hybridization, Anther culture and dihaploids. Production of alkaloids and other secondary metabolites; Protoplast isolation and purification; Protoplast culture; Protoplast fusion; Somatic hybrids; Cybrids

Unit II ***Stress Tolerant and Resistance***	Plant biotechnology for enhancing cold and heat stress tolerance; secondary effects of abiotic stress – production of ROS; genes involved in scavenging of ROS. Stress tolerance - resistance against fungal pathogens; anti-microbial proteins; viral resistance- pathogen derived resistance; coat protein, antisense, SiRNA and ribozyme approaches to enhance resistance for extending shelf life of fruits and flowers (ACC synthase gene and polygalacturonase).
Unit III ***Plant Biotechnology and Environment***	Plant biotechnology in improving fruit ripening and enhancing photosynthesis; Golden rice- nutritionally improved rice through biotechnology; transgenic sweet potato; Modification of taste and appearance- sweetness, starch and preventing discoloration; Bioplastics- biodegradable plastic from plants through biotechnological intervention. *Bacillus thuringiensis*: molecular basis of insecticidal activity. Agriculturally important microorganisms and their application .
Unit IV ***Animal Reproductive Biotechnology***	Animal cell culture. structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and in vitro fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos; applications of transgenic animal technology;
Unit V ***Animal cloning***	Basic concept, cloning for conservation for conservation endangered species; Vaccinology: history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines. DNA fingerprinting-principles and applications;
Current Contour	Molecular markers – hybridization, STS, SSR, AFLP, SNP markers; introduction to mapping of genes/QTLs; marker-assisted selection strategies for Introducing genes of biotic and abiotic stress resistance in plants: genetic basis for disease resistance in animals; molecular diagnostics of pathogens in plants and animals; detection of meat adulteration using DNA based methods.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	M	S	L	S	M	M
CO2	M	S	L	S	L	L	S	S	S	S
CO3	M	S	M	L	M	S	S	M	M	L
CO4	S	M	M	M	S	M	M	S	L	M
CO5	S	L	M	L	L	M	L	M	M	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Experiments in Plant Tissue Culture, J.H. Dodds and L.K. Roberts, (1985) Cambridge University Press
2. Plant Biotechnology and Transgenic Plants, K.M.O. Caldenty, W.H. Barz and H.L. Wills, (2002), Marcel Dekker
3. Plant Biotechnology, J. Hammond, P. McGarvy and V. Yusibov, (2000), Springer Verlag.
4. Plant Cell & Tissue Culture for the Production of Food Ingredients, T-J Fu, G. Singh and W.R. Curtis, (1999), Kluwer Academic/Plenum Press
5. Animal Cell Culture – A Practical approach, J.R.W. Masters, (2000), Oxford.
6. Animal Cell Culture Techniques, M. Clynes, (1998), Springer Verlag.
7. Cell Culture Lab Fax, M. Butler and M. Dawson, (1992), Bios Scientific Publications Ltd.

.

Related Online Contents:

- https://icar.org.in/
- https://www.ccmb.res.in/
- http://www.cdfd.org.in/
- https://www.labroots.com/tag/animal-and-plant-biotechnology
- https://aggie-horticulture.tamu.edu/tisscult/tcintro.html
- https://passel2.unl.edu/

****

SEMESTER - III

CORE OPTIONAL 2: MEDICAL BIOTECHNOLOGY

Course Code	CO03	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Exploring the role of biotechnology in medicine								

Course Objectives:

- *This is a field of study that connects Medical Science with technological aspects*
- *A lot of medical research and development centers are always hiring medical biotechnologists for different purposes ranging from new concepts for a new medicine to the development and production of the new medicine.*
- *. It will equip the students to choose a lot of career options as medical science and technology, is a very vast field.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Students can become entrepreneurs in the most demanding sector of medical biotechnology such as diagnostics, drug designing, and stem cell biology.	**K1**
CO2	Students will gain knowledge on genetic disorder	**K2 & K3**
CO3	Students will develop an ability to identify, organize and answer problems bacterial , fungal and viral diseases	**K4**
CO4	Light is thrown regarding the important protozoan borne diseases too.	**K5**
CO5	Students will develop an ability to use skills and modern technological tools to detect different diseases	**K6 & K7**
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit I ***Introduction***	Normal microflora of human body, nosocomial infections, carriers, septic shock, septicemia, pathogenicity, virulence factors, toxins, biosafety levels.
Unit II ***Genetic disorders***	Genetic disease, type of inheritance, single-gene and multifactorial inheritance, example of genetic diseases. Therapeutic intervention in blood disorder by stem cell transplantation/gene therapy.
Unit III ***Bacterial diseases***	Diseases caused by Gram negative bacteria (*E. coli, N. gonorrhoea, N. meningitidis, P. aeruginosa, S. typhi, S.dysenteriae, Y. pestis, H. influenzae,)* and Gram positive bacteria *(S. aureus, S. pyogenes, B.anthracis, C. perferinges, C. tetani, C. botulinum):-*

	Morphology, pathogenesis symptoms, laboratory diagnosis, preventive measures
Unit IV ***Viral diseases***	Diseases caused by viruses- Picornavirus, Orthomyxoviruses,Paramyxoviruses,Rhabdoviruses,Reoviruses Pox virus, Herpes virus, Papova virus, Retro viruses (including HIV/AIDS) and Hepatitisviruses. Antigenic shift and drift.
Unit V ***Fungal and protozoan diseases***	Fungal and Protozoan infections. Dermatophytoses Subcutaneous infection (Sporothrix, Cryptococcus), systemic infection (Histoplasma, Coccidoides) and opportunistic fungal infections (Candidiasis, Aspergillosis), Gastrointestinal infections (Amoebiasis, Giardiasis), Blood-borne infections (Leishmaniasis, Malaria)
Current Contour	3D visualization and augmented reality for surgery, Targeted Cancer Therapies, 3D Printed Organs, Nerve Regeneration, Brain Signals to Audible Speech, Genome Engineering-CRISPR-Cas9

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	S	M	S	M	S	L	M
CO2	M	S	M	M	L	M	L	M	M	M
CO3	S	S	M	S	M	L	S	S	L	M
CO4	M	L	L	M	L	L	M	L	M	M
CO5	S	M	L	M	L	L	M	M	L	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Medical Microbiology, Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's 24th edition. McGraw Hill Publication.
2. Medical Microbiology, Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' 4th edition. Elsevier.
3. Microbiology, Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's, 7th edition. McGraw Hill Higher Education
4. Murray PR, Baron EJ, Pfaller MA, Tenover PC and Yolken RH (Eds): Manual of Clinical Microbiology 6th Ed. American Society for Microbiology, Washington, DC 2005.
5. Parija SC, Text Book of Medical Microbiology and Immunology, 1st Ed., Elsevier, 2009.

WEBLINK

- Medical Biotechnology Journal https://www.wiley.com/en-us/ Medical+Biotechnology-p-00059307

E BOOK

- Medical Biotechnology E-Book, 1st Edition, 2008 Judit Pongracz & Mary Keen

****

SEMESTER - III

Elective A: ENVIRONMENTAL GENOMICS

Course Code	EC03	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Knowledge on Gene expression								

Course Objectives:

- *This course is to identify the genes and genetic pathways that are responsible for the ecological responses*
- *To determine the extent to which those genes and pathways exhibit functional variation in nature and characterize the ecological and evolutionary consequences of that variation*
- *The vision of this course (environmental genomics) is to outline the gene-environment foundations of human disease in ways that can lead to improved human health*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Gain knowledge to characterize underlying factors, at the genetic level, that contribute to the variability in organisms toxicological responses	**K1**
CO2	Integrate molecular biology, physiology, toxicology with ecology for interdisciplinary research program	**K2, K3**
CO3	Identify appropriated risk estimation, potentially, for the development of effective strategies to protect the environment, and to establish sustainable environment	**K3, K4, K5**
CO4	Use genomic approaches in holistic assessment of biological responses upon environmental pollutants	**K5, K6**
CO5	Discover new biomolecules that may be used as biomarkers in routine environmental monitoring	**K6, K7**
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit I *Genomics and Transcriptomics*	Chromosomes types of RNA. Central dogma: Protein synthesis – transcription and translation The Vocabulary of Genomics; Omics, Genomics, and Transcriptomics. Gene, Genome and Genomics. RNA types, Transcriptome and transcriptomics. DNA damage and repair mechanisms, Genotoxicity: damage to DNA and its consequences, DNA repair in the protection against genotoxic stress, tools of toxicogenomics. Toxicogenomics as an Information Provider.

Unit II ***Proteomics and Metabolomics***	Proteomics: fundamentals, structure and function of protein. Toxicoproteomics in assessing organ specific toxicity, Biomarkers in Toxicology. Types/classes of receptors, receptor-ligand interaction, Receptors mediating toxicity, effect of toxicant on cellular signaling. Metabolomics: Fundamentals of metabolomics, metabolomic profiling for toxicity assessment.
Unit III ***Epigenomics***	Epigenetics–DNA Methylation–Post Translational Modification. Chromatin Remodeling, Histone Modification–SUMOylation, Acetylation, Methylation, Phosphorylation, Ubiquitination, ADP Ribosylation and Deamination. Methods in Epigenomics–ChIP assay– Histone Modification Assay.
Unit IV ***Microbial and Eukaryotic Community Profiling***	PCR, Q-PCR, RAPD, RFLP, Flow Cytometry and Fluorescence *In situ* Hybridization (FISH), Denaturing and Temperature Gradient Electrophoresis (DGGE and TGGE). Metagenomics and its applications in Medicine, Biofuels, Environmental Remediation, Biotechnology, Agriculture and Ecology.
Unit V ***Genomics and Environment (Case Studies)***	Gene Expression in Response to Eutrophic and OliINgotrophic Conditions- Ammonia Oxidizing Bacteria within a Domestic Effluent and Industrial effluents- Endocrine Disruption in Fish with a Focus on Estrogenic Effects - Genomics Approach to Develop a Terrestrial Biomarker for Heavy Metal Contamination - Toxicogenomic Profiling of Bioreactive Particles within Diesel Exhaust
Current Contour	Genome editing and its future application, Next-generation sequencing approaches, Expression of added genes, Artificial and Synthetic Chromosomes, Targeted Epigenetic Modifications, Gene drive, Omic technologies for agricultural development.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	M	S	S	S	L
CO2	S	M	M	S	L	M	S	L	S	S
CO3	S	M	L	M	M	L	M	L	M	M
CO4	S	S	M	L	M	L	S	M	M	L
CO5	S	S	M	S	L	M	M	M	L	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. DNA Microarrays, Ulrike A Nuber (2004), Taylor & Francis
2. Environmental Genomics - An Introduction Environment Agency, Astra Zeneca (2003), Rio House, Waterside Drive, Aztec West, Almondsbury. From genes to clones, Ernst L. Winnacker (1987).
3. Functional Genomics (2nd edition) Springer, Kaufman, Michael, Klinger, Claudia (2012), New York
4. Genes VI, Lewin B (1997), Oxford University Press, USA
5. Molecular biology of the gene, Watson, Baker, Bell, Gann, Levine, Losick (2007),(6th edition) Cold Spring Harbor Laboratory Press
6. RNAi – A guide to gene silencing (1st edition), Hannon J Gregory (2003), Cold Spring Harbor Laboratory Press.

Related Online Contents:

E-BOOKS

- Emerging Technologies in Genetic Engineering and Biological Weapons (2004) Sunshine Project USA and Third World Network, Malaysia.
- An Introduction to Ecological Genomics, Nico M. van Stralen, Dick Roelofs, OUP Oxford, 2011
- Insight on Environmental Genomics: The High-Throughput Sequencing Revolution 1st Edition, Kindle Edition, Denis Faure & Dominique Joly, ISTE Press – Elsevier, 2016

WEBLINK

- https://www.nap.edu/read/23395/chapter/10
- http://www.oxfordbibliographies.com/view/document/ob0-9780199830060/obo-9780199830060-0129.xml
- https://courses.lumenlearning.com/boundless-microbiology/ chapter/environmental-genomics/
- https://nanoporetech.com/resource-centre/london-calling-2023-revolutionizing-biodiversity-research-oxford-nanopore
- https://environmentalchange.nd.edu/news-events/news/category/environmental-genomics/

****

SEMESTER - III

Elective B: BIOSAFETYAND BIOETHICS

Course Code	EC03	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Knowledge regarding the safety measures and basic ethics in biology								

Course Objectives:

- *This course helps the students to follow to the ethical values which are appropriate to impart ethical practices in the industries and field of research*
- *It gives clear idea about the biosafety of hazardous materials.*

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Know about the importance of biosafety	**K1, K2**
CO2	Acquires knowledge regarding risk assessment & management	**K1, K2, K3**
CO3	Understand about the ethics and its importance	**K2, K2**
CO4	Discuss about the principles of various ethical theories	**K1, K2**
CO5	Really know about the impacts of Biotechnology on the environment	**K4, K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Biosafety***	Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India
Unit II ***Definition of GMOs & LMOs***	Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; 7 Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

Unit III ***Bioethics***	Concepts; Philosophical considerations; Epistemology of Science; Ethical Terms; Principles & Theories; Relevance to Biotechnology; Ethics and the Law Issues: Genetic Engineering, Stem Cells, Cloning, Medical techniques, Trans-humanism, Bioweapons; Research concerns - Animal Rights, Ethics of Human Cloning, Reproduction and Stem Cell Research; Emerging issues
Unit IV ***Intellectual Property Rights and Bioethics in Research***	Intellectual Property Rights (IPR): Patents, copyrights, trademarks, and trade secrets in biotechnology. Patenting of Biotechnological Innovations: Issues and challenges (e.g., GMOs, bioinformatics tools). Ethics in Research and Publication: Plagiarism, authorship conflicts, and falsification of data. Importance of ethical review boards. Ethical Issues in Biotechnology Applications: Stem cell research, gene editing (CRISPR), and cloning. Genetic screening and its implications.
Unit V ***Emerging Topics in Biosafety and Bioethics***	Biosafety in Industrial Biotechnology: Fermentation technology, biopharmaceutical production. Bioweapons and Bioterrorism: Ethical and Biosafety Concerns. Synthetic Biology: Risks, ethical concerns, and regulatory challenges. Bioethics and Sustainability: Role in addressing climate change, conservation, and biodiversity. Global Collaboration in Biosafety: Sharing resources, data, and knowledge for global health and safety.
Current Contour	Biosafety Guidelines for Handling and Processing Specimens associated with Corona Virus disease 2019 - Virus mutants-Pandemic and Epidemic

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	M	M	M	S	S	M	M
CO2	L	S	M	L	M	M	S	S	S	M
CO3	L	S	S	S	M	L	S	M	M	L
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	M	M	L	M	M	S	L	M	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Intellectual Property Rights, Brigitte Anderson, (2006) Edward Elgar Publishing,London.
2. Intellectual Property Rights and the Life Sciences Industries, Graham Dutfield, (2016), Routledge.
3. Intellectual Property, Elizabeth Verkey and Jithin Saji Isaac (2021), Eastern Book Company,India
4. Intellectual Property Rights, William Cornish, (200), OUP Oxford Pub.

Related Online Contents:

- WIPO Intellectual Property Handbook- https://www.wipo.int/publications/en/details.jsp?id=275 &plang=EN

****

SEMESTER - III

Elective C: BIOPROCESS TECHNOLOGY

Course Code	EC03	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	4		
Pre-requisite	Basic concepts of Microbiology and biochemistry								

Course Objectives:

- *The course provides the student with the basics of bioreactor technology and focuses on its performance and operation.*
- *Also the course teaches the kinetics related to microbial growth, product formation, function of enzymes and transfer phenomena*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Will understand the importance and role of bioprocess techniques and their position in the scientific tree, including biosystem engineering	**K1.K4,K7**
CO2	Will be able to development of bioprocess engineering to support a bio-based economy	**K2,K6,K7**
CO3	Identify reactors used in industrial bioprocesses. Will be able to develop mathematical models for bioreactors	**K3,K4**
CO4	Will understand suitable process instrumentation for monitoring and control of bioreactors	**K2,K3**
CO5	The student could analyze the problem of selection of suitable bioreactor configuration	**K4,K6,K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Basic principles of Bioprocess Technology***	Introduction to Concepts of Bioprocess Engineering, Overview of Bioprocesses with their Various, Components, Isolation, Screening and Maintenance of Industrially Important Microbes; Strain Improvement for Increased Yield and Other Desirable Characteristics, Microbial Growth and Death Kinetics With Respect to Fermenters, Optimization of Bioprocesses, Yield Coefficient, Doubling Time, Specific Growth Rate, Metabolic and Biomass Productivities, Effect of Temperature, pH and Salt Concentration on Product Formation.
Unit II ***Fermentation Processes***	Bioreactor Designs; Types of Fermenters; Concepts of Basic Modes of Fermentation - Batch, Fed Batch and Continuous; Solid Substrate, Surface and Submerged Fermentation; Fermentation Media; Design and Types of Culture/Production Vessels- Batch, Fed Batch, CSTBR, Airlift, Packed Bed And Bubble Column Fermentor; Impeller, Baffles, Sparger
Unit III ***Upstream and Downstream Processing***	Media Formulation; Inocula Development and Sterilization; Aeration and Agitation in Bioprocess; Measurement and Control of Bioprocess Parameters; Scale Up and Scale Down Process. Bioseparation Techniques; Cell Disruption Methods; Liquid-Liquid Extraction; Purification by Chromatographic Techniques; Reverse Osmosis and Ultrafiltration, Drying, Crystallization, Storage and Packaging; Treatment of Effluent and Its Disposal.
Unit IV ***Commercial Strain Development & Microbial Processes***	Sources of industrial cultures and maintenance. Alcoholic fermentation: Production of Industrial Alcohol – Fermentation mechanism. Recent developments, brewing and malting, manufacture of wine and other distilled liquors. Cellular control regulating production of microbial metabolites – Primary and Secondary metabolite – Induced mutation technique – Analogue resistant mutant – Catabolic derepressed mutants – Genetically engineered strain – Protoplast fusion technique. Basic idea on fermentation process, submerged, stationary, solid and semi-solid – with their merits and demerits.
Unit V ***Microbial Production of nucleosides and nucleotides:***	Production of 5’ IMP and 5’GMP, Vitamins (Vitamin B12, Vitamin C) Antibiotics (Bacitracin and Chloramphenicol), Acids (citric, lactic, Acetic acid, vinegar and gluconic acid), Amino acids (Lysine and glutamic acid)
Current Contour	Microbial homologous and heterologous protein production. Physiological and process related items in the production of selected microbial metabolites. Principles and practices in metabolic engineering. Methods for process intensification. Unit operations in product recovery and purification. R&D

methods in biochemical engineering. Specific features of biorefineries

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	M	M	M	S	S	S
CO2	M	S	S	S	S	S	M	M	M	S
CO3	S	M	S	M	S	M	S	S	S	S
CO4	S	S	M	M	M	S	S	S	M	S
CO5	M	M	S	S	M	S	M	M	M	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition, Panima Publishing Co. New Delhi.
2. Shuler ML and Kargi F., Bioprocess Engineering: Basic concepts, 2nd Edition, Prentice Hall, Engelwood Cliffs, 2002.
3. Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol 1, 2, 3 and 4. Young M.M., Reed Elsevier India Private Ltd, India, 2004.
4. Mansi EMTEL, Bryle CFA. Fermentation Microbiology and Biotechnology, 2nd Edition, Taylor & Francis Ltd, UK, 2007.
5. Microbiology by Tortora, Funke and Case Brock Biology of Microorganisms
6. General Microbiology by Hans G Schlegel, Cambridge
7. Atkinson. B and Marituna. F, Biochemical Engineering and Biotechnology Handbok, The Nature Press, Macmillan Publ.Ltd.
8. James E Bailey, David F., Ollis, Biochemical engineering fundamentals, second edition. McGraw Hill

****

SEMESTER - III

Laboratory Course III: GENETIC ENGINEERING & PLANT AND ANIMAL BIOTECHNOLOGY

Course Code	LC03	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				-	-	4	4		
Pre-requisite	A foundational knowledge of molecular biology, genetics, and cell biology								

Course Objectives:

- *This practical course will give hands on experience in different steps in cloning, how to do cloning and its principle and mechanisms.*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Deliver practical knowledge on how to do cloning and sequencing	**K4**
CO2	Deliver both theoretical and practical knowledge on different molecular techniques such PCR, Restriction digestion, ligation and transformation	**K5**
CO3	The student would be able to perform plant tissue culture experiments	**K5**
CO4	Animal tissue culture will be performed by the students.	**K5&K6**
CO5	Knowledge regarding Cell passaging and cell viability will be understood.	**K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

EXPERIMENTS GENETIC ENGINEERING

1. Isolation of plasmid DNA
2. Restriction Enzyme Digestion of DNA and Cloning Vector
3. Elution of DNA from agarose gels
4. Ligation of DNA into expression vectors
5. Competent Cells Preparation
6. Calcium chloride mediated Transformation
7. Optimisation of inducer concentration for recombinant protein expression
8. Optimisation of time of inducer for recombinant protein expression
9. Western blotting
10. Hybridisation with anti-sera

EXPERIMENTS PLANT AND ANIMAL BIOTECHNOLOGY	1. Basic introduction to cell culture, sterilization, and media preparation. 2. Cells – subculture and seeding on culture plates. 3. Cells – Exposure to toxicants/therapeutics, IC50, and AO/EB staining. 4. Total RNA isolation from the animal tissue using the guanidium isothiocyanate-phenol method. 5. mRNA quantification and cDNA synthesis. 6. Real-time qPCR analysis and Data Interpretation. 7. Protoplast isolation from plants using an enzymatic method. 8. Synthetic seed preparation. 9. MS media preparation. 10. White media preparation.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	S	M	M	S	M	M	M
CO2	S	S	M	M	M	L	S	M	M	L
CO3	S	L	S	S	L	S	M	S	L	L
CO4	S	M	M	L	L	S	M	M	M	M
CO5	S	M	M	M	S	L	L	L	L	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. S. Kannan, M. Krishnan, R. Thirumurugan and S. Achiraman (2011) Methods in Molecular Biology (From Cell to Molecules). UVN Publishing House Pvt. Ltd. Sivakasi.
2. Laboratory manual on Molecular Biology & Genetic Engineering A New Approach, by R. S. Sengar
3. Laboratory Manual for Genetic Engineering by Author Venison and S John
4. A manual of practical zoology: biodiversity, cell biology, genetics & developmental biology Part 1.
5. Advanced Methods in Molecular Biology and Biotechnology - A Practical Lab Manual by Khalid Z. Masoodi, Sameena Maqbool Lone and Rovidha Saba Rasool

Related Online Contents:

- https://www.avit.ac.in/lab/molecular_biology_genetic_engineering_lab/download/481172L1/lab_manual.pdf
- https://youtu.be/c40UudFIlGw?si=dL6dvLr3g0xgoWHZ
- https://youtu.be/yUstng0npaY?si=so_MXJk2EUXKkXzJ
- https://youtu.be/WZbAfQ58eCw?si=OvUuw1mKG1PrhYhB

SEMESTER - III

Elective: BIO ENTREPRENEURSHIP

Course Code	EIBC01	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				4	-	-	3		
Pre-requisite	Knowledge about green products								

Course Objectives:

- *The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Students could gain entrepreneurial skills, understand the various operations involved in venture creation	**K3,K7**
CO2	The learner could identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centers and various agencies	**K2,K1,K7**
CO3	The knowledge regarding green products will be acquired by the learners	**K1**
CO4	The possibility of collaborations & partnerships will be understood by the students	**K2,K6**
CO5	The student will understand about the regulatory compliances too	**K2,K7**

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Innovation and entrepreneurship in bio-business***	Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of biosector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.
Unit II ***Bio markets - business strategy and marketing***	Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills
Unit III ***Green Products***	Definition, Characteristics, Advantages, thinking green - Life cycle analysis, Green home- solar panel, LEED certification, water recycling, solid waste management, Terrace garden-Self sustained life style, Rain water harvesting Systems-Waste to wealth.
Unit IV ***Finance and accounting***	Business plan preparation including statutory and legal requirements, Business feasibility study and financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.
Unit V ***Technology management***	Technology – assessment, development & upgradation, managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).
Current Contour	Technology transfers from lab to land-Patenting, Marketing, Promoting and Sustaining-Case studies.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	S	S	M	S	M	S	S
CO2	S	M	S	M	M	M	S	M	M	S
CO3	M	S	M	M	S	M	M	S	S	M
CO4	M	M	S	M	M	M	M	M	M	M
CO5	S	S	M	S	M	S	M	M	M	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences.Adams, D. J., & Sparrow, J. C. (2008). Bloxham: Scion.
2. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam:Shimasaki, C. D. (2014), Elsevier. Academic Press is an imprint of Elsevier.
3. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge, Onetti, A., & Zucchella, A, (2018),Routledge
4. Innovation, Commercialization, and Start-Ups in Life Sciences. Jordan, J. F. (2014). London: CRC Press
5. The Dynamics of Entrepreneurial Development and Management. Desai,V(2009),New Delhi, Himalaya Pub house.

****

SEMESTER - III

Value added course: ***WASTE TO WEALTH***

Course Code	VAC2	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				30			2		
Pre-requisite	Basic concepts of Environmental Science, Microbiology, and Chemistry								

Course Objectives:

• *To introduce students to the principles of converting waste into valuable products using sustainable technologies.*
• *To provide knowledge on biotechnological, chemical, and physical methods for waste valorization.*
• *To develop skills for designing, evaluating, and optimizing waste-to-wealth processes for environmental and economic benefits.*

Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand the concept of waste as a resource and the importance of circular economy	**K1,K2**
CO2	Evaluate different waste valorization technologies for industrial, agricultural, and municipal wastes	**K2,K4 &K6**
CO3	Apply microbial, enzymatic, and thermochemical approaches for converting waste into energy and useful products	**K3,K4 &K6**
CO4	Analyze and design integrated waste management and valorization systems with sustainability indicators	**K4 ,K5 &K7**
CO5	Critically assess techno-economic feasibility, environmental impact, and policies for waste-to-wealth initiatives	**K6 & K7**
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit I ***Introduction to different wastes***	Concept of waste as a resource – Waste hierarchy and 5Rs (Reduce, Reuse, Recycle, Recover, Redesign) – Circular economy and sustainable development goals (SDGs) – Types and sources of waste: agricultural, municipal solid waste (MSW), industrial, e-waste, biomedical – Environmental, social, and economic impacts of improper waste disposal – Policy framework and national initiatives on waste-to-wealth.

Unit II ***Biological Conversion Technologies***	Composting and vermicomposting – Anaerobic digestion and biomethanation for biogas and biohydrogen production – Microbial fuel cells and bioelectrochemical systems – Conversion of agro-residues into biofertilizers, biopolymers, and enzymes – Case studies: BARC–NISARGUNA biogas plant, community-level composting initiatives.
Unit III ***Thermochemical and Physico-Chemical Methods***	Pyrolysis, gasification and hydrothermal carbonization – Refuse-derived fuel (RDF) and waste-to-energy plants – Chemical recovery processes such as transesterification for biodiesel and acid/alkali hydrolysis for value-added chemicals – Biochar production and applications in agriculture and water treatment – E-waste recycling with focus on metal recovery and safe disposal practices.
Unit IV ***Industrial Applications and Value-Added Products***	Recovery of bio-based products such as organic acids, solvents, pigments and biosurfactants – Production of single-cell proteins, algae-based biofuels and nutraceuticals – Conversion of plastics and polymers into useful chemicals – Waste-derived construction materials including fly ash bricks and geopolymer cement – Case studies of successful waste-to-wealth enterprises in India and other countries.
Unit V ***Sustainability, Economics, and Future Perspectives***	Techno-economic feasibility and life-cycle assessment of waste-to-wealth projects – Carbon credits, green business models and entrepreneurship in waste valorization – Smart technologies including AI, IoT and Industry 4.0 in waste management – Integration of waste-to-wealth in smart cities and rural development – Future scope including biorefineries, circular bioeconomy and global challenges.
Current Contour	Microbial Production of Value-Added Metabolites – Metabolic Engineering and Process Intensification – Reactor Design and Bioreactor Optimization – Product Recovery and Purification Techniques – Biorefineries and Circular Bioeconomy Models

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	M	M	S	S	S	M
CO2	M	S	S	S	S	S	M	S	M	M
CO3	S	M	S	S	M	S	S	M	S	M
CO4	S	S	M	S	M	S	S	M	S	M
CO5	M	M	S	S	S	M	M	S	S	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Bhatia, S.C. (2018). *Waste to Wealth: Energy from Waste*. CRC Press, Boca Raton.
2. Satyanarayana, T., Johri, B.N. and A. Prakash. (2012). *Microorganisms in Sustainable Agriculture and Biotechnology*. Springer, New York.
3. Sridhar, M.K.C. and G.O. Adeoye. (2003). *Waste to Wealth: Value Recovery from Wastes*. Pan African University Press, Ibadan.
4. Singh, R.P. and P. Singh. (2022). *Global Waste to Resource: Waste-to-Wealth Approaches*. Springer, Singapore.
5. Rhyner, C.R., Schwartz, L.J., Wenger, R.B. and T.J. Kohrell. (1995). *Waste Management and Resource Recovery*. CRC Press, Boca Raton.

Related Online Contents:

https://ilsr.org/articles/transforming-communitys-waste-to-wealth/ ¬
https://link.springer.com/article/10.1007/s43615-022-00225-2 ¬
https://www.sciencedirect.com/science/article/pii/S2666845924001417 ¬
https://www.sciencedirect.com/science/article/pii/S2665972725001874
https://www.e3s-conferences.org/articles/e3sconf/abs/2023/90/e3sconf_icsdg2023_01035/e3sconf_icsdg2023_01035.html "

E- Books

- https://library.oapen.org/bitstream/20.500.12657/86407/1/9781800084650.pdf
- https://shop.elsevier.com/books/waste-valorization-for-bioenergy-and-bioproducts/ong/978-0-443-19171-8
- https://link.springer.com/book/10.1007/978-1-0716-4646-5
- https://library.oapen.org/handle/20.500.12657/94012
- https://link.springer.com/book/10.1007/978-1-0716-4490-4
- https://archive.org/details/wastetowealthcir0000lacy
- https://library.oapen.org/bitstream/20.500.12657/86407/1/9781800084650.pdf
- https://direct.mit.edu/books/oa-monograph/chapter-pdf/2246871/c001000_9780262369503.pdf
- https://library.oapen.org/bitstream/20.500.12657/95754/1/9781003433729_10.4324_9781003433729-1.pdf
- https://api.developmentaid.org/api/frontend/cms/file/2019/08/WTEfull-compressed.pdf

****

SEMESTER – IV

PROJECT WORK

Course	Course Code	Course Type	Hours	Credits	Syllabusversion
22	CP01	Core - Research	30	12	2025-2026

SEMESTER - II

Non Major Elective I: CONTEMPORARY ENVIRONMENTAL ISSUES

Course Code	NMEC01	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	1	-	2		
Pre-requisite	Knowledge on issues related to Environment								

Course Objectives:

- *The students will be exposed to different important issues of environment and about their impact on the environment*
- *They will be able to widen their knowledge regarding various environmental issues and could spread awareness about the same to the readers*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Describe the sources and effects of various pollutants with respect to water including both fresh water and marine water.	K1, K2
CO2	Review the established methods employed for controlling different types of pollution. Assess the environmental impacts of noise, thermal and radioactive pollution.	K2, K7
CO3	Evaluate the scientific basis underlying in controlling of all pollutants and to take suitable measures for all pollution control.	K7
CO4	Improve the Knowledge on the case studies, which could highlight the real danger of pollution. Propose ideas to control environmental pollution with respects professionalism, ethics and moral.	K6
CO5	Would get an awareness regarding various pollution and understand about their ill effects. Can really come out with research ideas to facilitate sustainability.	K6, K5

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Environmental issues related to Water Pollution***	Water Pollution – Definition – Fresh water and Marine - Sources (Natural and Anthropogenic), Pollutants (anions, cations, microbiological, Persistant Organic Pollutants) , Effects – Control of water Pollution- Primary, secondary and Tertiary treatment – Eutrophication, Oxygen sag curve, Biomagnification- Minamata and Itai- Itai disease, Exxon Valdez and Torrey canyon oil tanker accidents

Unit II ***Environmental issues related to Air Pollution***	Air Pollution – Definition, Sources (Natural and Anthropogenic), Pollutants (Particulate and gaseous) Effects – Control of Air Pollution- Electrostatic precipitator, Cyclones, Bag filter, Scrubbers – Ozone layer depletion, Acid Rain, Global warming, Greenhouse effect, Photochemical smog- Bhopal Gas Tragedy, Chernobyl Disaster
Unit III ***Environmental issues related to Solid Waste Pollution***	Solid waste Pollution – Definition, Sources (Domestic, Municipal, agricultural, Commercial and Industrial), Pollutants (Organic waste, E-waste, biomedical wastes, fertilizers, pesticides) Method of disposal- Open dumping, Sanitary landfills, Incineration, Pyrolysis, Composting and Vermicomposting-Love canal episode
Unit IV ***Environmental issues related to Biodiversity Conservation***	Biodiversity- Definition, types (Genetic, species) – Values of Bodiversity (Direct and indirect) loss of biodiversity –reasons, effects - Conservation of biodiversity- Insitu and exsitu, Ramsar sites in India. Forest Conservation – Chipko movement, Appiko movement, Project tiger, Project Elephant.
Unit V ***Environmental issues related to Thermal, Noise and Radioactive Pollution***	Thermal, Noise and Radioactive Pollution – Definition, Sources and Types of Pollutants - Effects - Fukusima Daiichi nuclear disaster
Current Contour	United Nations SDGs - 17 goals and themes – Environmental awareness levels-1,2,3 and 4 – Laws and Policies for Environmental Management – EIA – Energy auditing

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	M	M	M	S	M	M	S
CO2	S	M	S	M	M	M	M	S	M	M
CO3	M	S	M	S	S	S	S	S	S	M
CO4	M	M	S	M	M	M	M	M	M	M
CO5	S	M	M	S	L	S	M	M	M	S
S-Strong; M-Medium; L-Low										

Recommended References:

1.Environmental pollution and its control, Abbasi. S. A (1998) . Cogent publications (P) Limited. Delhi.

2.Managing Environmental Pollution, Andrew former (2003) Routledge Publisher, London.

3. Environmental pollution and its control, Bhatia H.S (1998) Golgotia publications (P) Limited, New Delhi.

4. Environmental Science, Cunningham, W.P. and W.B. Saigo (2005) McGraw Hill, New York.

5. Environmental Chemistry and pollution control, Dara SS (1998) Textbook of Chanthan company
6. Environmental Chemistry, De A.K (1987) Wiley Eastern Ltd, New Delhi.
7. Environmental Science and Engineering, Dr.Suresh K. Dhamaja (2005)
8. Agroclimoitic approach to water management, Geetha lakshmi V, Jagannathan R, Thavaprakash N (2007) Coimbatore.
9. Fundamentals of Environmental Pollution, Kannan K (1991) S Chand Co, New Delhi.
10. Environmental Chemistry, Manahan (2000) CRC press, U.S
11. Air Pollution, Rao M.N and H.V.N Rao (1989) Tata Mcgraw Hill Publishing Co. Ltd, New Delhi.
12. Chemistry for Environmental Engineering and Science, Sawyer C.N., Mc Carty P.L., and Parkin,G.F (2003) Tata McGraw-Hill Publishing Company Ltd., New Delhi.
13. Soil and Noise Pollution, Sharma, B.K. and H.Kaur (1994) Goel Publishing House.
14. Water Pollution, Sharma, B.K. and H.Kaur (1994) Goel Publishing House.

Related Online Contents

- https://books.google.co.in/books/about/Environmental_ Pollution.html?id=GQftLn 7u8igC& redirges=y
- https://books.google.co.in/books/about/Air_Pollution. html?id=hDoN0SPgLksC
- http://www.naturefirstusa.org/environmental pollution/ Environmental Pollution - Health and Toxicology - Google Books.htm#PPR11,M1
- https://authors.library.caltech.edu/25069/1/AirPollution88.pdf
- http://payesh.saba.org.ir/saba_content/media/image/2016/11/ _orig.pdf

****

SEMESTER - III

Non Major Elective II: ENERGYAND ENVIRONMENT

Course Code	NMEC02	Course Type	Core	L	T	P	C	Syllabus version	2025-2026
				3	-	-	2		
Pre-requisite	Basic idea regarding different energy resources								

Course Objectives:

- *The students will be exposed to different types of energy resources and also their significance*
- *The students will be able to widen their knowledge about the advantages and limitations regarding the usage of different energy resources.*
- *Students also will be exposed to all the concepts of Environment, Renewable and Non-renewable Energy, etc*

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOME	KNOWLEDGE LEVEL
CO1	Describe basic energy concepts and throws light on conventional and renewable energy technologies and their applications	K1, K2
CO2	Reflect and evaluate the environmental impact of energy production and the relationship between energy production, consumption, and climate change and reflect on energy costs	K2
CO3	Analyze the consequences of today's energy consumption	K4, K7
CO4	Understand the need for alternate energy resources	K2, K6
CO5	Promote and advice the use of green energy in all possible places	K1, K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I ***Energy Availability and Usage***	Earth's energy source - Earth's energy balance – Energy reserves and usage – determinants of growth in energy use – Energy Security -Energy usage pattern of the world and India.

Unit II ***Non Renewable Energy Resources***	Fossil fuels- The three kings- Coal, Oil and Natural gas – Formation, Calorific value, Physico-chemical properties of fuel and energy content of fuel- Advantages and limitations – Greenhouse gases and Global warming – Nuclear energy – availability and limitations
Unit III ***Renewable Energy Resources***	Non-conventional energy resources- Principle of energy production and selected appliances - Principles of generation of hydro-power, tidal energy, ocean thermal energy conversion, wind power, geothermal energy, solar energy (solar collectors, photo-voltaic modules, solar ponds)– Advantages- Economic and Environmental considerations.
Unit IV ***Alternative Fuels***	Ethanol as a fuel, Biobutanol, Biodiesel, Lignocellulosic fuels, Dimethyl ether, sustainable aviation fuel, methanol– Production, benefits, Future possibilities, energy efficiency
Unit V **Waste to Energy**	Biomass Energy Source- Microbial Fuel Cells- Fundamentals and their types (algal, Fungal, animal waste, organic waste, wastewater based)- Cost benefit analysis- Future perspectives.
Current Contour	Electric driven cars, two wheelers – Green buildings- Energy auditing- sustainable energy consumption – Sustainable Development Goals

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	S	M	M	M	M	M	S	M
CO2	M	M	M	S	M	M	M	S	S	S
CO3	S	S	M	M	S	S	M	M	M	S
CO4	M	M	S	M	S	M	S	M	M	M
CO5	M	M	M	S	M	L	S	M	M	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Environmental chemistry, Colin Baird and Michael Cann (2008), W. HFreeman and company, England.
2. Environmental Science- towards a sustainable future, Wright, R. T and D.F.Boorse (2011), PHI learning pvt ltd., New Delhi.
3. Advances in Solar Energy Technology, Garg, H.P. (1990), D. Reid Publishing Company, Tokyo.
4. Alternative liquid fuels, Desai, A.V. (1990), New Age International (p) Ltd.,
5. Biomass for Energy in the Developing Countries, Current Roles, Potential, Problems, Prospects, D.O.
   Hall, G.W. Barnard, and P.A. Moss (1982), Pergamon Press Ltd.,
6. Biomass- Regenerable Energy, D.O. Hall & R.P. Overend (1987), John Wiley.
7. Biotechnology and other Alternative Technologies, Chakraverty, A. (1998.). Oxford and IBH Publishing Co. Pvt. Ltd.,
8. Critical Reflections on Nuclear and Renewable Energy, Way Kuo (2014), Scrivener Publishers Wiley.
9. Non-Conventional Energy Sources, Rai, G.D. (2001), Khanna Publishers, New Delhi.
10. Solar Energy, Sukhatme, S.P. (1996), Tata Mc Graw Hill Publishing Company.
11. Wind Energy Conversion Systems, FrerisL.L. (1990) Prentice Hall.
12. Energy and the Environment" by James A. Fay and Dan S. Golomb.
13. Environmental Science- towards a sustainable future, Wright, R.T and D.F.Boorse (2011), PHI learning pvt ltd., New Delhi.
14. Robert A. Ristinen, Jack J. Kraushaar, Jeffrey Brack, Energy and the Environment, wiley Publication
15. Energy at the Crossroads: Global Perspectives and Uncertainties , Vaclav Smil (2024).
16. Renewable Energy: Power for a Sustainable Future ,Godfrey Boyle (2023).

Related Online Contents:

- http://www.ener-supply.eu/downloads/ENER_ andbook _en.pdf
- http://bieap.gov.in/Pdf/Nonconventionalenergysourses.pdf
- https://afdc.energy.gov/fuels/

****