SISTER NIVEDITA UNIVERSITY

Undergraduate course structure for Microbiology

As per NEP 2020 regulation and according to UGC-CBCS

Course structure for

B.Sc. in Microbiology

And

B.Sc. Honours in Microbiology / B.Sc. Honours with Research in Microbiology

This curriculum is duly approved by the Board of Studies, Department of Microbiology

SISTER NIVEDITA UNIVERSITY

Undergraduate course structure for Microbiology

As per NEP 2020 regulation and according to UGC-CBCS

Course structure for

B.Sc. in Microbiology

And

B.Sc. Honours in Microbiology / B.Sc. Honours with Research in Microbiology

Category definition with credit breakup

Semester	Credits										Credits /Semester
	MC/ME	ME		Non-Major		MDC	AEC	SEC	VAC	INT	
		Course	Project	NM	NV						
I	10			2	1+1		2	3	2		21
II	10				1+1	3	2	3	2		22
III	10			4	1+1	3	2				21
IV	10			4	1+1	3	2				21
V	15				1+1			3	2		22
VI	15			4	1+1					3	24
VII	19			4							23
VIII		8/20	12/0	2							22
Credits/Course	109			32		9	8	9	6	3	
Total Credit											176

Major – Major Program Specific Course – Compulsory (MC); Major Program Specific Course – Elective (ME); NM – Non-Major Specific Subject Course; NV – Non-Major vocational education and training; MDC – Multidisciplinary courses; AEC – Ability Enhancement Courses; SEC – Skill Enhancement Courses; VAC – Value Added Courses; INT – Internship; Project – Project.

Category	Course name	Credit	Teaching Scheme		
			L	T	P
Semester I					
MC 1	Biochemistry	3	3	0	0
	Biochemistry Lab	2	0	0	4
MC 2	Bacteriology	3	3	0	0
	Bacteriology Lab	2	0	0	4
NM 1	Introduction to Microbiology	2	2	0	0
NV 1	Vocational - EAA I (Yoga/ Sports/ NCC/ NSS)	1	0	0	2
NV 2	Vocational – Soft Skill Development I	1	1	0	0
AEC 1	Communicative English I	2	2	0	0
VAC1	Environmental Science I	2	2	0	0
SEC1	Computer Application	3	3	0	0
Total Credit = 21			Teaching Hour = 26		
Semester II					
MC 3	Bioenergetics and Metabolism	3	3	0	0
	Bioenergetics and Metabolism Lab	2	0	0	4
MC 4	Cell Biology and Cell Signalling	3	3	0	0
	Cell Biology and Cell Signalling Lab	2	0	0	4
NV 3	Vocational - EAA II (Yoga/ Sports/ NCC/ NSS)	1	0	0	2
NV4	Vocational – Soft Skill Development II	1	1	0	0
MDC 1	Selected by the candidate (Elective)	3	3	0	0
AEC 2	Communicative English II	2	2	0	0
VAC 2	Environmental Science II	2	2	0	0
SEC 2	Selected by the candidate (Elective)	3	3	0	0
Total Credit = 22			Teaching Hour = 27		
Semester III					
MC 5	Fundamentals of Molecular Biology	3	3	0	0
	Fundamentals of Molecular Biology Lab	2	0	0	4
MC 6	Eukaryotic Microbiology	3	3	0	0
	Eukaryotic Microbiology Lab	2	0	0	4
NM 2	Minor I – Selected by the candidate	3	3	0	0
	Minor I – Lab Selected by the candidate	1	0	0	2
NV 5	Vocational - Mentored Seminar I	1	1	0	0
NV 6	Vocational – Soft Skill Development III	1	1	0	0
MDC2	Selected by the candidate (Elective)	3	3	0	0
AEC3	Logical Ability I / Foreign Language I	2	2	0	0
Total Credit = 21			Teaching Hour = 26		
Semester IV					
MC 7	Immunology	3	3	0	0
	Immunology Lab	2	0	0	4
MC 8	Microbial Genetics	3	3	0	0
	Microbial Genetics Lab	2	0	0	4
NM 3	Minor II – Selected by the candidate	3	3	0	0
	Minor II – Lab Selected by the candidate	1	0	0	2
NV 7	Vocational - Mentored Seminar II	1	1	0	0
NV8	Vocational – Soft Skill Development IV	1	1	0	0
MDC3	Selected by the candidate (Elective)	3	3	0	0
AEC4	Logical Ability II / Foreign Language II	2	2	0	0
Total Credit = 21			Teaching Hour = 26		

Category	Course name	Credit	Teaching Scheme		
			L	T	P
Semester V					
MC 9	Biophysical Chemistry and Instrumentation	3	3	0	0
	Biophysical Chemistry and Instrumentation Lab	2	0	0	4
MC 10	Recombinant DNA Technology	3	3	0	0
	Recombinant DNA Technology Lab	2	0	0	4
MC 11	Microbial Diversity and Metabolism	3	3	0	0
	Microbial Diversity and Metabolism Lab	2	0	0	4
NV 9	Vocational - Mentored Seminar III	1	1	0	0
NV10	Vocational – Soft Skill Development V	1	1	0	0
SEC 3	Selected by the candidate (Elective)	3	3	0	0
VAC 3	Ethics Study and IPR / elective	2	2	0	0
Total Credit = 22			Teaching Hour = 28		
Semester VI					
MC 12	Biostatistics and Bioinformatics	3	3	0	0
	Biostatistics and Bioinformatics Lab	2	0	0	4
MC 13	Agricultural Microbiology	3	3	0	0
	Agricultural Microbiology Lab	2	0	0	4
MC 14	Industrial and Food Microbiology	3	3	0	0
	Industrial and Food Microbiology Lab	2	0	0	4
NM4	Minor III – Selected by the candidate	3	3	0	0
	Minor III – Lab Selected by the candidate	1	0	0	2
NV 11	Vocational - Mentored Seminar IV	1	1	0	0
NV12	Vocational – Soft Skill Development VI	1	1	0	0
INT1	Internship	3	0	0	6
Total Credit = 24			Teaching Hour = 34		
Semester VII					
MC 15	Data Science and Structural Biology	3	3	0	0
	Data Science and Structural Biology Lab	2	0	0	4
MC 16	Medical Microbiology and Cancer Biology	3	3	0	0
	Medical Microbiology and Cancer Biology Lab	2	0	0	4
MC 17	Environmental Microbiology and Ecology	3	3	0	0
	Environmental Microbiology and Ecology Project	2	0	0	4
MC 18	Genomics, Proteomics and Metabolomics	2	2	0	0
MC 19	Molecular Nanomachines	2	2	0	0
NM 5	Minor IV – Selected by the candidate	3	3	0	0
	Minor IV – Lab Selected by the candidate	1	0	0	2
Total Credit = 23			Teaching Hour = 30		
Semester VIII					
MC 20	Microbial Quality control in Industries	4	4	0	0
MC 21	Emerging Techniques and Trends in Microbiology	2	2	0	0
MC 22	Microbiology Epilogue	2	2	0	0
NM6	Evolutionary Biology	2	2	0	0
ME - Project / Courses	Project/ Research Design and Communication (Mandatory), [Pharmacovigilance, Bio-entrepreneurship, Molecular Diagnostics, Biosafety and Public health (Any 2)]	12/(4 +4+4)	0/12	0	24/0
Total Credit = 22			Teaching Hour = 22/34		

Objectives and outcomes of the program and every courses

Program Educational Objective

PEO 1: **Professional Development:** To develop the ability to acquire knowledge of Biology, Chemistry, Physics, Mathematics & Engineering in the students so that they may apply it professionally within the realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability with due ethical responsibility.

PEO 2: **Core Proficiency:** To provide the ability to identify, formulate, comprehend, analyse, design and solve biotechnological problems with hands-on experience in various technologies as well as using modern tools necessary for good laboratory practices to satisfy the needs of society and the industry.

PEO 3: **Technical Accomplishments:** To equip the students with the ability to design, simulate, experiment, analyse, optimise and interpret multidisciplinary concepts and contemporary learning so that they fit right into industrial set up.

PEO 4: **Professionalism:** To provide training, exposure and awareness on importance of soft skills for better career and holistic personality development as well as professional attitude towards ethical issues, team work, responsibility, accountability, multidisciplinary approach and capability to relate biotechnological issues to broader social context.

PEO 5: **Learning Environment:** To provide students with an academic environment and make them aware of excellence, develop the urge of discovery, creativity, inventiveness, leadership, written ethical codes and guidelines as well as the life-long learning to become a successful professional in the field of microbiology.

Program Outcomes:

PO1: Comprehending the foundational principles of microbiology with the aid of basic knowledge from school-level biology, chemistry, and physics.

PO2: Develop aptitude to appreciate the microbial diversity and explain the processes used by different microorganisms for their survival and reproduction.

PO3: Identify and analyse problems in the area of microbiology considering public health and safety, as well as environmental aspects focusing on sustainable development.

PO4: Understand the safety issues and ethical responsibility in the field of microbiology while conducting experiments, analysing and interpreting results by selecting and applying various analytical tools.

PO5: Function effectively as an individual as well as a member or a leader in diverse teams while undertaking microbiological projects using acquired knowledge.

PO6: Acquire skill in utilizing contemporary laboratory methods, apparatus, and technology for the purpose of performing experiments and conducting research in the field of microbiology.

PO7: Acquire good written and verbal communication skills for delivering basic concepts and applications effectively to individuals and groups from diverse educational as well as social background.

PO8: Stand as a knowledgeable citizen and pursue a wide range of academic, research or industrial careers, as well as entrepreneurship leveraging on public and global health issues.

Program Specific Outcome:

PSO 1: Apply acquired biotechnological knowledge to understand trans disciplinary scientific studies and relevant research areas as well as decide suitable scientific approach to solve complex biological problems.

PSO 2: Adapt to rapid changes in tools and technology in the industry but also understanding societal and ecological issues relevant to professional and technical practice through life-long learning.

PSO 3: Function effectively in multi-disciplinary work environment with good interpersonal skills required to be a leader or as team member who is aware of professional ethics and societal responsibilities.

Semester – I
MC-1: Biochemistry
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 36**

Course Outcomes:

CO 1	Understand the significance of Biochemistry in the biological system.
CO 2	Understand the chemistry of water.
CO 3	Describe the chemistry behind the structures of carbohydrates, lipids, proteins and nucleic acids.
CO 4	Describe the different structural organization of proteins.
CO 5	Describe the mechanism of enzyme action and different classes of enzymes and factors affecting their function.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	1	3	3	3	3
CO 2	3	3	3	1	3	3	3	3
CO 3	3	3	3	1	3	3	3	3
CO 4	3	3	3	1	3	3	3	3
CO 5	3	3	3	1	3	3	3	3
Average CO	3	3	3	1	3	3	3	3

Teaching Topics

Unit 1: **Organization in Nature**: **[2 L]**

Origins of Life; Structure and Properties of water, Introduction of Biomolecules, Concept of solvent and solution; Acid Base Theory, pH, buffer, ionization behavior;

Unit 2: Forces in Biomolecules: **[3 L]**

Types of interaction between atoms, van der Waals interactions, Coulombic, dipole-dipole, hydrophobic interaction, hydrogen bond.

Unit 3: Carbohydrates: **[7 L]**

Definition, classification and structural concept of: Monosaccharides: Hexoses, Pentoses, Stereochemistry of sugars and different nomenclature. Isomerization of sugar molecules, hemiacetal, acetal, hemeketal and ketal. Disaccharides; Amino Sugars: Glucosamine, Muramic Acid, Different chemical reactions of monosaccharides. Principle of chemical estimation of sugar. Anomeric effect, Polysaccharides: Chemical structure of Starch (αamylose, amylopectin), glycogen & cellulose.

Unit 4: Amino Acids: **[7 L]**

Definition, classification, structure, stereochemistry of amino acids; Physico-chemical properties (Ionization & Biuret reaction) of amino acids. Amphoteric molecule, Amino acid titration; Zwitterion, pK values; Isoelectric point, Peptides: peptide bond, biologically important peptides (glutathione, oxytocin-important functions).

Unit 5: Proteins: **[7 L]**

Protein structure (Primary, Secondary, Tertiary, Quaternary). Ramchandran plot. Types of proteins: i) Fibrous (α -helix, β - sheet): definition and structure. ii) Globular: definition & examples. iii) Simple proteins and conjugated protein: definition & examples—physical denaturation and renaturation, Protein folding.

Unit 6: Lipids: **[6 L]**

Definition, nomenclature, classification - (simple, complex, derived lipids - structure & example) phospholipids, glycolipids, - (structure, composition); Soap, surfactants, fatty acid. hydrolysis, saponification, saponification number, I_2 number, acetylation, acetyl number, volatile fatty acid number - definition and related problems, Isomerism - cis-trans isomerism. Fatty acids: Saturated and unsaturated: Structure of free fatty acids. General chemical reaction of fatty acids - esterification. Hydrogenation and halogenations.

Unit 7: Nucleic acid: **[4L]**

Purine, pyrimidine - definition and structure. Nucleoside, nucleotide: definition and structure. DNA double helical structure; Effect of pH, temperature and enzymes; General structure and types of RNA (tRNA, mRNA, rRNA). Denaturation and renaturation.

Course Component: Practical

Course Outcomes:

CO 1	Through this course the students are exposed to the importance of biological macromolecules.
CO 2	They acquire knowledge in the quantitative and qualitative estimation of biomolecules.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	1	1	2	1	3	3	3
CO 2	3	1	1	2	1	3	3	3
Average CO	3	1	1	2	1	3	3	3

Practicals:

1. Maintenance and use of micropipette and balance machine
2. Preparation of buffers
3. pH measurements
4. Identification of amino acid
5. Identification of reducing and non-reducing sugar
6. Molish Test
7. Lipid Solubility Test

Suggested Books:

1. Principles of Biochemistry., A Lehninger.
2. Textbook of Biochemistry., MD Rafi
3. Biochemistry., L Stryer.
4. Harper's Biochemistry., R. K. Murray
5. Biochemistry., Voet and Voet

MC-2: Bacteriology
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 36**

Course Outcomes:

CO 1	Comprehend the basic structure of prokaryotic cells and their functions
CO 2	Apply basic microscopy and staining techniques in microbiology
CO 3	Explain bacterial growth patterns and factors affecting growth
CO 4	Classify microbes based on nutrition and describe culture methods
CO 5	Study the various physical methods for microbial control
CO 6	Study chemical agents and antibiotics used against microbes along with the mechanisms of resistance

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	2	1	2	3	3	3	3
CO 2	3	2	1	3	3	3	3	3
CO 3	3	2	1	3	3	3	3	3
CO 4	3	2	1	3	3	3	3	3
CO 5	3	2	1	3	2	2	3	3
CO 6	3	2	1	3	3	3	3	3
Average CO	3	2	1	3	3	3	3	3

Teaching Topics:

Unit 1: Bacterial cell structures and functions: **[6L]**
Size and shape of bacteria, cell wall study of Gram-positive and Gram-negative bacteria, outer membrane, contents of the cytoplasmic matrix (nucleoid, ribosomes and inclusion bodies), cytoskeleton, plasmids and their classification, components external to the cell wall (capsule, slime layer, pili, fimbriae, flagella), chemotaxis, endospores.

Unit 2: Basic Techniques in Microbiology: **[4L]**
Microscopy- concepts of magnifying power and resolution, numerical aperture, working distance. Principles of staining, simple staining, negative staining, differential staining, Gram and acid-fast staining, flagella staining, capsule and endospore staining.

Unit 3: Bacterial Growth: **[8L]**
Binary fission, bacterial growth curve, bacterial growth kinetics, generation time and growth rate constant. Continuous culture, utility of chemostat and turbidostat. Measurement of microbial growth. Measurement of cell numbers by direct counting methods. Viable cell counting methods
Measurement of cell mass. Influence of environmental factors on microbial growth.

Unit 4: Bacterial Nutrition: **[4L]**

Types of nutrients (macronutrients and micronutrients), nutritional classification of microorganisms based on sources of carbon, energy and electrons (photolithoautotrophs, photoorganoheterotrophs, chemolithoautotrophs, chemolithoheterotrophs, chemoorganoheterotrophs). Types of culture media (selective, enriched and differential media, defined and complex media). Methods for isolation of pure cultures (Streak plate, pour plate, spread plate).

Unit 5: Physical Control of microbes: **[6L]**

Introduction to the concepts of sterilization, disinfection and sanitization. Physical methods of controlling microbes (heat, low temperature, filtration and radiation). Heat – Moist heat (boiling, autoclaving, Pasteurization and its types), dry heat sterilization (incineration and hot air oven). Measurement of heat-killing efficiency. Filtration (depth filter and membrane filter, HEPA filter). Radiation (UV and ionizing radiations).

Unit 6: Chemical Control of microbes: **[8L]**

Introduction to the concepts of antisepsis and chemotherapy. Chemical agents used in control of microbes – phenolic compounds, alcohols, halogens, heavy metals, quaternary ammonium compounds, aldehydes, sterilizing gases, antibiotics. Discovery of antibiotics. General properties of antibiotics (selective toxicity, toxic dose and therapeutic dose). Classification of antibiotics based on their mode of action, activity spectrum and source. Determination of minimal inhibitory concentration (MIC) and Minimum Lethal Concentration (MLC) of an antibiotic. Kirby-Bauer test. E-test. Mode of action of antibiotics. Cell wall synthesis inhibitors, protein synthesis inhibitors, metabolic antagonists and nucleic acid synthesis inhibitors. Antifungal drugs, antiviral drugs and anti-protozoan drugs. Mechanisms of drug resistance.

Component: Practical

Course Outcomes:

CO 1	Know the different staining procedure for different microorganism.
CO 2	Know the morphology of different types of microorganism under microscope.
CO 3	Know the different use of different types of culture media.
CO 4	Know the different nutritional requirements of bacteria
CO 5	Find how bacteria can be cultured in the laboratory condition.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	1	1	2	1	3	3
CO 2	3	3	2	1	2	1	3	3
CO 3	3	3	1	1	2	1	3	3
CO 4	3	3	2	1	2	1	3	3
CO 5	3	3	2	1	2	1	3	3
Average CO	3	3	2	1	2	1	3	3

Practicals:

1. Preparation of different media: Synthetic Media, Complex media (Nutrient Agar, McConkey agar).
2. Simple staining and Gram-staining.
3. Capsule staining and endospore staining.
4. Isolation of pure cultures of bacteria by streaking method.
5. Serial dilution Estimation of CFU count by spread plate method/pour plate method.
6. Cultivation, maintenance and preservation of cultures
7. Biochemical Characterization of Bacteria
8. Oxidation/Fermentation Test Catalase, Oxidase and Urease Tests IMViC test Hydrogen Sulfide Test and Nitrate Reduction Test. Casein and Starch Hydrolysis.

Suggested Books:

1. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9 th edition. Mc Graw Hill Higher Education.

2. Atlas RM. (1997). Principles of Microbiology. 2 nd edition. WMT. Brown Publishers.
3. PelczarJr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition Tata McGraw Hill.
4. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5 th edition McMillan.

5. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited.

6. Madigan MT, and Martinko JM. (2014). Brock Biology of Micro-organisms. 14th edition. Parker J. Prentice Hall International, Inc.

7. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. Prentice Hall.

NM 1: Introduction to Microbiology
Credit: 2 (2L-0T-0P)

Course Component: Theory **Lecture Hour: 24**

Course Outcomes:

CO 1	Explain the origin of life, biological classification, and taxonomy principles.
CO 2	Summarize the historical development of microbiology and key scientific contributions.
CO 3	Describe the nature, classification, and cultivation methods of viruses.
CO 4	Compare lytic and lysogenic phage cycles, and explain phage-host interactions and gene regulation.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	1	1	2	1	3	3
CO 2	3	3	2	1	2	1	3	3
CO 3	3	3	1	1	2	1	3	3
CO 4	3	3	2	1	2	1	3	3
Average CO	3	3	2	1	2	1	3	3

Teaching Topics:

Unit 1: Origin of life and the Science of Classification **[4L]**

Biology as a scientific discipline, definition and characteristics of living organisms, levels of biological organization – definition of population, species, community and ecosystem. Origin of life –Pre-Darwinian concepts of life's origin, Oparin and Haldane hypothesis, Miller's experiment (1953). Geological time scale, Discovery of microorganisms. Five-kingdom classification and Carl Woese's three kingdom classification. Taxonomy - Linnaean hierarchical classification till Phylum and binomial nomenclature. Methods of classification – homology and convergence.

Unit 2: History and Development of Microbiology **[4L]**

Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming. Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A.Waksman. Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner.

Unit 3: Nature and Properties of Viruses **[8L]**

Discovery of viruses. Nature and general properties of viruses. Classification of viruses based on capsid symmetry (helical, icosahedral, complex), presence and absence of envelope, nucleic acid characteristics and reproductive strategy. Virus cultivation in embryonated eggs, cultivation of plant and animal viruses, cytopathic effect. Propagation of bacteriophages. Virus purification by differential and density gradient centrifugation, virus precipitation (ammonium sulfate and polyethylene glycol).

Virus assays – Direct counting, indirect methods (hemagglutination assay), plaque assay. Baltimore classification of viruses. Basic concept of viroids, virusoids, satellite viruses and Prions. Viral taxonomy: Classification and nomenclature of different groups of viruses.

Unit 4: Lytic and Lysogenic bacteriophages [8L]

Introduction to lytic phages. The One-step growth experiment. Multiplicity of infection and burst size Life cycle of the T4 bacteriophage, Replication strategy of double stranded DNA phages. Concept of terminal redundancy and circular permutation. Reproduction of single stranded DNA phages and RNA phages. Concepts of lysogeny, prophage, lysogen and induction of lytic cycle. Early and late proteins and regulation of transcription in lambda phage Lysogenic conversion. Roles of the regulatory proteins cro and cI in phage lambda. Decision making process for lysis or lysogeny in phage lambda, immunity to superinfection.

Suggested Books

1. Microbiology., M. Pelczar
2. Prescott's Microbiology: J.M Willey
3. Fundamental Principles of Bacteriology., A.J Salle
4. General Microbiology., R. Stanier

Semester – II
MC 3: Bioenergetics and Metabolism
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 42**

Course Outcomes:

CO 1	Comprehend the concept of bioenergetics and thermodynamic principles in biology.
CO 2	Understand and evaluating free energy and redox potential in relation to metabolism.
CO 3	Understand how enzymes and cofactors function in bioenergetics reactions.
CO 4	Understand the mechanisms and regulation of anabolic and catabolic processes of macromolecules like carbohydrates, protein, lipid and nucleic acids.
CO 5	Describe the central role of ATP.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	2	-	2	2	3	3
CO 2	3	3	2	-	2	2	3	3
CO 3	3	3	2	-	2	2	3	3
CO 4	3	3	2	-	2	2	3	3
CO 5	3	3	2	-	2	2	3	3
Average CO	3	3	2	-	2	2	3	3

Teaching Topics:

Module 1:

Unit 1: Thermodynamics: **[6 L]**

Zero-th law, 1st law & 2nd law of thermodynamics: application in biological systems, Concept of free energy, standard free energy change. Equilibrium constant; enthalpy; entropy; entropy: open vs. dead cells, dissociation constant, protein unfolding, DNA denaturation, 1^{st} order and second order kinetics.

Unit 2: Enzymes: **[6 L]**

General properties, Nomenclature and classification; Co-factors definition and function with special reference to the representative substances - a) Co-enzymes (NAD+, NADP+, Co-enzyme-A, TPP, Pyridoxal phosphate); b) Prosthetic groups (FAD+ - Succinic dehydrogenase); c) Metal ions: Zn^{2+}, Mg^{2+}, Fe^{2+}, Fe^{3+}, Mn^{2+} - required for enzyme action Enzyme Kinetics - Michaelis-Menten equation; Enzyme Inhibition - Competitive-cite succinate on Malonate dehydrogenase as example, Non- competitive - Cite lodoacetamide on triose phospate dehydrogenase and EDTA as example; Suicide inactivation-action of penicillin on bacterial cell wall biosynthesis as an example; Regulatory enzymes-Allosteric - Cite CTP on aspartate transcarbamylase as example; Feedback inhibition - Cite Threonine to Isoleucine as example; Ribozyme (catalytic RNA) and Abzyme (use of antibody as enzyme) - definition only.

Module 2:

Unit 1: Carbohydrate metabolism: **[8 L]**

Aerobic Respiration-Glycolysis (EMP-pathway) with energy production: entry of galactose & fructose in EMP-path; TCA-cycle with energy production: pentose-phosphate pathway: Electron Transport Chain (in brief) & ATP generation sites; ATP & ADP cycle (oxidationreduction potential and electromotive force). Photophosphorylation, oxidative phosphorylation (chemiosmotic theory); Anaerobic respiration - Utilizing NO2, Sulfur (SO4), CO2 as electron acceptors; Stickland-reaction; Entner-Doudoroff pathway Fermentation - Glucose metabolism in anaerobic condition general concept only Bacterial photosynthesis (Cyanobacteria and Green-sulphur bacteria); Difference with eukaryotic photosynthesis.

Unit 2: Amino acid metabolism: **[8 L]**

Transamination, deamination, transmethylation and decarboxylation. Glucogenic and ketogenic amino acids, Outline of Urea Cycle; Microbial metabolism of glycine, phenylalanine and lysine.

Unit 3: Purine and Pyrimidine metabolism: **[8 L]**

Synthesis of purines: elementary concept, source of the precursors of purines, ribose 5- phosphate; synthesis of AMP and GMP from IMP-only preliminary idea; Importance of folic acid and target of sulfonamides; Microbial reduction of purines to deoxy-purines: thioredoxine; Biosynthesis of pyrimidines: Aspartate transcarbamoylase (ATCase); Origin of Thymine: importance of folic acid (conceptual); Degradation of nucleotides: xanthines, uric acid; catabolites of pyrimidines: NAD and Coenzyme A.

Unit 4: Lipid metabolism: **[6 L]**

Detailed account for oxidation of even-and odd-carbon numbered, saturated and unsaturated fatty acids; Brief idea of fatty acid biosynthesis; Metabolism of Triglycerides and phospholipids.

Component: Practical

Course Outcomes:

CO 1	Gain understanding on growth of microorganisms and acquire skills on how these organisms can be controlled and its proliferation predicted in a specific situation.
CO 2	Gain understanding and acquire skills on the culturing the microorganisms in proper nutrient media and environmental conditions that helps grow them under in vitro conditions.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	1	3	3	2	2
CO 2	3	2	3	2	3	3	2	2
Average CO	3	3	3	2	3	3	2	2

Practicals:

1. Study and plot the growth curve of *E. coli* by turbidometric method.
2. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data.
3. Effect of temperature on growth of *E. coli*.
4. Effect of pH on growth of *E. coli.*
5. Effect of salt concentration on growth of E. coli.
6. Effect of aeration on growth of E. coli.
7. Saponification number of oil.

Suggested Books:

1. Principles of Biochemistry., A Lehninger.
2. Textbook of Biochemistry., MD Rafi
3. Biochemistry., L Stryer.
4. Harper's Biochemistry., R. K. Murray
5. Biochemistry., Voet and Voet

MC 4: Cell Biology and Cell Signalling
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 42**

Course Outcomes:

CO 1	The knowledge of how basic structural and functional unit of life came into existence and diversified into five major taxonomic groups.
CO 2	The knowledge about microscopy and cell fractionation techniques that led to understanding about different cell organelles, their structure and functions.
CO 3	The knowledge of how cells act as self-replicating units through nuclear and cell division and the phases between two events of cell division.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	1	1	1	1	3	3
CO 2	3	3	2	1	1	1	3	3
CO 3	3	3	1	1	1	1	3	3
Average CO	3	3	1	1	1	1	3	3

Teaching Topics:

Module 1:

Unit 1: Introduction to cell biology, discovery of cell, classification of living system, Landmarks in cell biology research. **[2 L]**

Unit 2: Membrane structure and function (Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes). **[4 L]**

Unit 3: Structural organization and function of intracellular organelles (Cell wall, nucleus, mitochondria, Golgi bodies, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility), cellular motility. **[4 L]**

Unit 4: Protein modifications and intracellular transport, glycosylation, vesicular transport, receptor mediated endocytosis, lysosomes, organelle biogenesis. **[2 L]**

Unit 5: Organization of genes and chromosomes (Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons). **[4 L]**

Unit 6: Cell division and cell cycle (Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle), cell control check points, programmed cell death. **[4 L]**

Module 2:

Unit 1: Host parasite interaction Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens,

virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells. **[8 L]**

Unit 2: Cell signaling Hormones and their receptors, cell surface receptor, signaling through G- protein coupled receptors, signal transduction pathways (IP3-DAG pathway, mTOR pathway, JAK- STAT pathway, MAPKinase pathway), second messengers, regulation of signaling pathways, bacterial and plant two component systems, light signaling in plants, bacterial chemotaxis and quorum sensing. **[10 L]**

Unit 3: Cellular communication Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. **[4 L]**

Component: Practical

Course Outcomes:

CO 1	Practical knowledge of how cells from different classification groups appear in reality.
CO 2	Knowledge about the utility of using red blood cells in cytology in general and studies on cell membrane.
CO 3	Observations on important cell organelles like mitochondria and plastids.
CO 4	In depth knowledge about forms of nuclear materials occurring in animal cells and eukaryotic cell cycle, including nuclear division and cytokinesis.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	1	1	2	1	3	3
CO 2	3	3	2	1	2	1	3	3
CO 3	3	3	1	1	2	1	3	3
CO 4	3	3	2	1	2	1	3	3
Average CO	3	3	2	1	2	1	3	3

Practical:

1. Epithelial cell staining and Barr Body identification.
2. Effect of hypotonic solution on blood cells.
3. Effect of hypertonic solution on blood cells.
4. General staining of bacterial cell.
5. Blood smear preparation, staining and identification of different types of WBCs.
6. Cell cycle slide identification.
7. Mammalian tissue section identification.
8. Plant tissue section identification.

Suggested Books:

1. Molecular Biology of the Cell, B Alberts.
2. Cells, Lewin.
3. The Cell: A molecular approach, G. Cooper.
4. The Cell, Kemper Vol 1 and Vol 2.

Semester – III
MC 5: Fundamentals of Molecular Biology
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 36**

Course Outcomes:

CO 1	Understand the structure and types of DNA, RNA, and genetic material in various organisms.
CO 2	Explain DNA replication mechanisms and the role of key enzymes in prokaryotes and eukaryotes.
CO 3	Analyze causes of DNA damage and describe major DNA repair pathways.
CO 4	Compare transcription and post-transcriptional processes in prokaryotes and eukaryotes.
CO 5	Describe translation and post-translational modifications, and assess protein synthesis regulation.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	2	3	3	3	3
CO 2	3	3	3	2	3	3	3	3
CO 3	3	3	3	2	3	3	3	3
CO 4	3	3	3	2	3	3	3	3
CO 5	3	3	3	2	3	3	3	3
Average CO	3	3	3	2	3	3	3	3

Teaching Topics:

Unit 1: Structures of DNA and RNA / Genetic Material **[4L]**

DNA Structure: Miescher to Watson and Crick – historical perspective, DNA structure, salient features of the double helix, types of DNA, types of genetic material, denaturation and renaturation, Cot curves. DNA topology – linking number, topoisomerases; organization of DNA in prokaryotes, viruses, and eukaryotes. RNA structure, mitochondrial and chloroplast DNA, siRNA, miRNA.

Unit 2: Replication of DNA (Prokaryotes and Eukaryotes) **[8L]**

Bidirectional and unidirectional replication, semi-conservative and semi-discontinuous replication. Mechanism of DNA replication: enzymes and proteins involved in DNA replication – DNA polymerases, DNA ligase, primase, telomerase (for replication of linear ends). Various models of DNA replication

Unit 3: DNA Damage and Repair **[4L]**

Mutation and its causes, types of mutations, Ames test, isolation of mutants. Base excision and nucleotide excision repair.

Unit 4: Transcription in Prokaryotes and Eukaryotes **[6L]**

Transcription: definition, difference from replication, promoter – concept and strength of promoter. RNA polymerase and the transcription unit. Transcription in eukaryotes: RNA polymerases, general transcription factors.

Unit 5: Post-Transcriptional Processing **[6L]**

Split genes, concept of introns and exons, RNA splicing, spliceosome machinery, concept of alternative splicing,

polyadenylation and capping, processing of rRNA. RNA interference: siRNA, miRNA and its significance.

Unit 6: Genetic Code and Translation (Prokaryotes and Eukaryotes) [6L]

Genetic code and its properties, codon bias, wobble hypothesis. Translational machinery, charging of tRNA, aminoacyl-tRNA synthetases. Mechanisms of initiation, elongation, and termination of polypeptides in both prokaryotes and eukaryotes. Fidelity of translation. Inhibitors of protein synthesis in prokaryotes and eukaryotes.

Unit 7: Translation and Post-Translational Mechanisms (Prokaryotes and Eukaryotes) [2L]

Introduction to post-translational modifications. Protein folding.

Component: Practical

Course Outcomes:

CO 1	To provide students with hands-on laboratory experience in handling and analyzing genetic material in cellular systems.
CO 2	To teach students various techniques for the isolation and estimation of DNA, RNA, and proteins.
CO 3	To equip students with practical skills relevant to careers in biotechnology, genetic engineering, and pharmaceutical R&D laboratories.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	2	3	3	3	3	3	3
CO 2	3	2	3	3	3	3	3	3
CO 3	3	2	3	3	3	3	3	3
Average CO	3	2	3	3	3	3	3	3

Practicals:

1. Isolation of genomic DNA from *E. coli*.
2. Estimation of DNA using colorimeter or spectrophotometer.
3. Estimation of RNA using colorimeter or spectrophotometer.
4. Visualization of DNA by agarose gel electrophoresis.
5. Protein extraction and estimation.

Suggested Books:

1. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R. (2013). Molecular Biology of the Gene (7th ed.). Pearson.
2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., & Matsudaira, P. (2016). Molecular Cell Biology (9th ed.). W.H. Freeman and Company.
3. Krebs, J.E., Goldstein, E.S., & Kilpatrick, S.T. (2017). Lewin's Genes XII (12th ed.). Jones & Bartlett Learning.
4. Snustad, D.P., & Simmons, M.J. (2015). Principles of Genetics (7th ed.). Wiley.
5. Weaver, R.F. (2012). Molecular Biology (5th ed.). McGraw-Hill Education.

MC 6: Eukaryotic microbiology
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 36**

Course Outcome:

CO 1	Understand the microbial world.
CO 2	Know how fungi, algae and protists have been classified.
CO 3	Know the different habitat of different eukaryotes.
CO 4	Compare the different nutrition types among different eukaryotes.
CO 5	Explain the ecological and economical importance of algae, fungi and protists.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	2	1	1	3	3
CO 2	3	2	3	2	2	3	3
CO 3	3	3	1	2	3	3	3
CO 4	3	3	2	3	2	3	3
CO 5	3	2	3	3	3	2	3
Average CO	3	2	2	2	2	3	3

Teaching topics

Unit 1: Eukaryotic Cell Biology: **[3 L]**

Eukaryotic Cell Structure and the Nucleus; Mitochondrion & Hydrogenosome; Chloroplast; Endosymbiosis; Assembly of Eukaryotic Cell

Unit 2: Algal Cell Structure & Significance: **[4 L]**

Distribution, morphology and classification of Algae; Isolation from soil and water; algal ecology, Media and methods used for culturing algae, measurement of algal growth, strain selection and large-scale cultivation, Symbiotic algae: Lichens.

Unit 3: Algal Ecosystem: **[4 L]**

Introduction structure & their environmental significance; Dinoflagellates, Diatoms, Euglenoids, Red algae, Green algae, Brown algae. Coral reef and sea sponges. Structure and reproduction of *Spirogyra*, *Euglena*, *Exuviaella*, Diatoms, *Sargassam* and *Porphyra*. Biofuel production.

Unit 4: Fungal Cell Structure: **[4 L]**

An introduction to Fungi: General features of Fungi, Classification of Fungi, Life cycle of

selected Fungi (*Aspergillus*, *Penicillium*, Yeast). Structure of Fungal cells. Hyphae and nonmotile unicellulas, motile cells, spores, dormancy, growth of population and colonies, effect of environment on growth, prevention of fungal growth.

Unit 5: Fungal Cell Behaviour: **[5 L]**

Structure of Fungal cells and growth; Hyphae and non-motile unicells, motile cells, spores, dormancy, growth of population and colonies, Mechanism of growth in Fungi, Measurement and kinetics of growth, nutritional and environmental requirements; Prevention of fungal growth. Heterothallism, parasexuality, sex hormones in fungi; physiological specialization, phylogeny of fungi. Thigmotropism and Chemotropism in Fungal cells.

Unit 6: Fungal Cell Interaction: **[4 L]**

Fungi and ecosystem: Saprophyte, substrate groups and nutritional strategies, substrate successions, fungi and bioremediation, parasitism, mutualism and symbiosis with plants and animals, fungal--microbe interaction. Industrial applications of fungal cells.

Unit 7: Protozoa in General: **[4 L]**

Introduction, structure and significance. Protozoans characteristics, classifications and general account. Pathogenic protozoans and parasitism in protozoans. *Leishmania*, *Trichomonas*, *Entamoeba*, *Plasmodium*, cultivation of protozoa.

Unit 8: Plasmodium Infection: **[4 L]**

Ultrastructure and life cycle of Plasmodium in invertebrate and vertebrate hosts. Comparative account of various human species of Malaria pathogens, symptom, treatment and control.

Unit 9: Protozoan Infection: **[4 L]**

Trypansoma: Structure and Life cycle, polymorphism in human and invertebrates host pathogens and therapy, *Leishmania*, systematic position, morphology, kalazar, symptoms and pathogen. *Entamoeba histolytica* as monogen parasite, pathogenesis, host parasite interactions.

Component: Practical

CO 1	Students will have a practical knowledge about the morphology of unicellular eukaryotes.
CO 2	Students will have an overall idea about culturing techniques of the phytoplanktons and zooplanktons.
CO 3	Students will have practical knowledge about the diversity of unicellular eukaryotic world.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	1	3	3	3	3
CO 2	3	3	3	1	3	3	3	3
CO 3	3	3	3	1	3	3	3	3
Average CO	3	3	3	1	3	3	3	3

Practicals:

1. Identification of phytoplanktons.
2. Isolation of pure strain of microalgae from water sample.
3. Morphology, motility and nutrition of free-living protists.
4. Culturing *Paramoecium* under laboratory condition.
5. Isolation of fungus.
6. Identification of different classes of fungi through microscopic observation.

Suggested Books:

1. Microbiology: An Introduction., G.J. Tortora
2. Prescott's Microbiology: J.M Willey
3. Brock Biology of Microorganisms., M.T. Madigan
4. Atlas RM. (1997). Principles of Microbiology. 2 nd edition. WMT. Brown Publishers.
5. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson
6. Education Limited.

Semester IV
MC 7: Immunology
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 42**

Course Outcomes:

CO 1	Gain basic understanding of the mammalian immune system including knowledge about immune cells & organs and the importance of humoral, cell-mediated and innate immune responses in combating pathogens.
CO 2	Understand the difference between antigen & immunogen, role of various physical, chemical and biological factors determining immunogenicity.
CO 3	Learn the structure, functions and production of different classes of immunoglobulins, clonal selection theory.
CO 4	Able to understand the principle of antigen-antibody interaction and to get acquainted with the importance of antigen- antibody interaction in disease diagnosis.
CO 5	Comprehend Histocompatibility, structure of MHC and their mode of antigen presentation, Complement system and activation, mechanisms involved in hypersensitivity reactions.
CO 6	Understand Passive and Active immunization, Types of Vaccines: Inactivated, Attenuated, Recombinant and DNA Vaccines.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	2	3	3	3	2	-	3	3
CO 2	2	3	3	3	-	-	-	3
CO 3	2	3	3	-	-	-	3	3
CO 4	3	-	3	3	3	-	3	3
CO 5	2	2	3	2	-	-	2	2

CO 6	3	2	3	3	-	-	3	3
Average CO	2	3	3	3	-	-	3	3

Teaching Topics:

Unit 1: Basic concept of immunology **[3 L]**
History of Immunology, humoral and cell-mediated immune response, Innate immunity, acquired immunity, B-cell and T-cell.

Unit 2: Cells and Organs: **[4 L]**
Lymphoids cells, mononuclear cells, granulocytic cells, mast cells, dendritic cells, primary lymphoid organs, lymphatic system, secondary lymphoid organs.

Unit 3: Antigens: **[4 L]**
Antigenicity and immunogenicity, Epitopes, properties of B-cell and T-cell epitopes, haptens and mitogens.

Unit 4: Immunoglobulins: **[4 L]**
Basic structure of immunoglobulin, sequencing study, immunoglobulin fine structure, antigenic determinants: isotypic, allotypic, idiotypic. Immunoglobulin classes, monoclonal antibodies.

Unit 5: Immunological techniques: **[4 L]**
Antibody affinity, antibody avidity, cross- reactivity, precipitation reaction, agglutination reaction, radioimmunoassay, ELISA, RIA, immunofluorescence.

Unit 6: Genetic recombination of immunoglobulin genes: **[6 L]**
Genetic model, multigene organization of immunoglobulin genes, variable region gene rearrangements, class switching, regulation of immunoglobulin gene transcription.

Unit 7: Antigen processing and presentation: **[6 L]**
MHC molecules, antigen presenting cells, t-cell receptor, T-cell maturation, T-cell activation, T- cell differentiation. Cytokines.

Unit 8: Compliment system: **[3 L]**
Components of compliment system, activation pathways: classical and alternative and lectin pathways.

Unit 9: Immunological disorders: **[4L]**
Hypersensitivity, types of hypersensitivity reactions. Autoimmune diseases, Hashimoto's thyroiditis, autoimmune anaemia, Goodpasture's syndrome, Insulin dependent diabetes mellitus.

Unit 10: Vaccines: **[4 L]**
Active and passive immunization, whole-organism vaccines, recombinant vector vaccines, DNA vaccines.

Component: Practical

Course Outcomes:

CO 1	Perform and analyse human blood grouping.
CO 2	Perform isolation of serum from freshly collected blood.
CO 3	Perform and analyse Total and differential leucocyte count.

CO 4	Perform radial immunodiffusion, Ouchterlouny Double diffusion, immunoelectrophoresis and ELISA assay.
CO 5	Isolate serum IgG.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	2	-	3	3	3	-	3	3
CO 2	2	-	3	3	3	-	3	3
CO 3	2	-	3	3	3	-	3	3
CO 4	3	-	3	3	3	-	3	3
CO 5	2	-	3	2	3	-	2	2
Average CO	2	-	3	3	3	-	3	3

Practicals:

1. Antigen-Antibody reactions – Agglutination: Determination of blood group and Rh factor of an individual.
2. Total and differential leukocyte count of the given blood sample.
3. Isolation of serum from goat/chicken blood sample (demonstration).
4. Antigen-Antibody reactions – Radial immunodiffusion and Double immunodiffusion
5. Antibody titration (Ouchterlony Double Diffusion).
6. Antigen-Antibody reactions ELISA (Direct, indirect and Sandwich) method.
7. Widal test (slide and Tube agglutination method)
8. Antigen-Antibody reactions: Immunoelectrophoresis, Rocket immunoelectrophoresis.
9. IgG digestion by papain/ pepsin
10. Separation of mononuclear cells by Ficoll-Hypaque

Suggested Books:

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman.
2. Abbas AK, Lichtman, AH, Pillai Shiv. Cellular & Molecular Immunology. Elsevier.
3. Delves PJ, Martin SJ, Burton DR, Roitt IM. Roitt's essential Immunology. Wiley Blackwell
4. Murphy K, Travers P, Walport M. Janeway's Immunobiology. Garland Science Publishers
5. Paul, W. E. Fundamental Immunology. Raven Press.

MC 8: Microbial Genetics
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 42**

Course Outcomes:

CO 1	Explain the processes behind mutations and other genetic changes.
CO 2	Identify and distinguish genetic regulatory mechanisms at different levels.
CO 3	Understand plasmid and application of bacterial and eukaryotic plasmids in research.
CO 4	Understand bacterial recombination system including transformation, conjugation and transduction.
CO 5	Explain viral genetics and genetic regulation for interchange between lysogenic and lytic cycle.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	2	3	3	3	3	3	3	3
CO 2	2	3	3	3	3	3	3	3
CO 3	2	3	3	3	3	3	3	3
CO 4	3	3	3	3	3	3	3	3
CO 5	2	2	3	2	3	3	2	2
Average CO	2	3	3	3	3	3	3	3

Teaching Topics:

Unit 1: Prokaryotic Genome: **[8]**

Transposons Structure of prokaryotics genome, Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Mu transposon Eukaryotic transposable elements - Yeast (Ty retrotransposon), Drosophila (P elements), Maize (Ac/Ds) Uses of transposons and transposition. **Plasmids:**

Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, yeast- 2 µ plasmid, plasmid copy number and its regulation, plasmid replication and partitioning, Host range, plasmid-incompatibility, plasmid amplification, curing of plasmids, Application of Plasmid in genetic engineering

Unit 2: Bacterial Recombination **[5]**

Mechanisms of Genetic Exchange, Transformation - Discovery, mechanism of natural competence, Conjugation - Discovery, mechanism, Hfr and F' strains, Interrupted mating technique and time of entry mapping, Transduction - Generalized transduction, specialized transduction, mathematical problems related to conjugation, transduction, LFT & HFT lysates, Mapping by recombination and co-transduction of markers

Unit3: Operon system: **[8]**

Gene regulation and operon theory in prokaryotes, **repressible operons**, Inducible Operon, lac operon, gal operon, trp operon.

Unit4: Mutation and Repair: **[6]**

Spontaenous (Spontaneous mutation Luria - Delbruck's Fluctuation Test) and induced mutations, Mutagenic agents - Physical, Chemical and Biological (Phage-mu). Genetic Techniques to detect mutations in bacteria and fungi (isolation and characterization of nutritional auxotrophic mutation); Different forms of mutations and how they arise (tautomeric shift, base analog, alkylating agent, apurinic lesions, UV radiation and thymine dimers, replicational error), Ames test is used the assess the mutagenecity of compounds. Repair: reversal of UV damage in prokaryotes: photoreactivation, base excision and nucleotide excision repair, post replicational repair, mismatch repair, SOS repair, error prone repair.

Unit 5: Inheritance biology **[15]**

Mendelian inheritance: Gene, Allele, Allomorphs, Locus, Mendel and his experiments: Law of Segregation, Law of Independent Assortment, Monohybrid cross, Dihybrid cross, Back cross and Test cross, **Non mendelian inheritance:** Multiple Alleles with example, Mathematical problems related to multiple allele. inheritance and co-dominance, Gene interaction, Pleiotropy, Genomic imprinting, Penetrance and Expressivity, Epistasis, **Basic concept of inheritance pathway:** Basic concept of cell division, Mitosis and meiosis. Recombination: Homologous and non- homologous recombination, Linkage, Crossing over: Molecular mechanism of crossing over, Crossing over at four strand stage, Gene mapping, Mathematical problem related to gene mapping. Mutation: Definition and types of mutations, causes of mutations, Ames test for mutagenic agents, Screening procedures for isolation of mutants and uses of mutants. Problem solve related to mutation.

Component: Practical

Course Outcomes:

CO 1	Study the effect of chemical (HNO_2) and physical (UV) mutagens on bacterial cells.
CO 2	Isolate plasmid DNA from *E.coli* and study different conformations of plasmid DNA through Agarose gel electrophoresis.
CO 3	Demonstrate bacterial conjugation

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	-	-	3	3	-	3	3
CO 2	3	-	-	3	3	-	3	3
CO 3	3	-	-	3	3	-	3	3
Average CO	3	-	-	3	3	-	3	3

Practicals:

1. Preparation of Master and Replica Plates.
2. Isolation of Plasmid DNA from *E.coli*.
3. Study different conformations of plasmid DNA through Agaraose gel electrophoresis.
4. Demonstration of Bacterial Conjugation.
5. Demonstration of bacterial transformation
6. Study the effect of chemical (HNO_2) and physical (UV) mutagens on bacterial cells.
7. Study survival curve of bacteria after exposure to ultraviolet (UV) light.

Suggested Books:

1. Principles of genetics by Snustad and Simmons
2. Genetics by Russel
3. Microbial Genetics by Bainbridge.

MC 9: Biophysical Chemistry and Instrumentation
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 36**

Course outcomes:

CO 1	Understand the basic biophysical principles including pH, buffers, viscosity, surface tension, and radioactivity.
CO 2	Explain and apply various chromatographic and electrophoretic techniques for the separation of biomolecules.
CO 3	Understand the principles and applications of centrifugation techniques and analyze sedimentation behavior.
CO 4	Describe the principles and types of microscopy used in biological research, including light, fluorescence, and electron microscopy.
CO 5	Explain the theoretical and instrumental aspects of major spectroscopic techniques used in biomolecular analysis.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	2	3	3	3	2	3	3
CO 2	3	2	3	3	3	2	3	3
CO 3	3	1	3	3	3	2	3	3
CO 4	3	1	2	3	3	2	3	3
CO 5	3	1	3	3	3	2	3	3
Average CO	3	1	3	3	3	2	3	3

Teaching Topics:

Unit 1: General Biophysical methods: **[4 L]**
pH and Buffer. Viscosity, Surface tension, Radioactivity, Autoradiograph.

Unit 2: Separation techniques of Biomolecules: Chromatography **[8 L]**
Concept of Chromatography, Different chromatographic techniques: Partition Chromatography, Paper Chromatography, Adsorption Chromatography, Thin Layer Chromatography, Gas Liquid Chromatography, Ion Exchange Chromatography, Gel Chromatography, Affinity Chromatography, High performance Liquid chromatography); Electrophoresis (Agarose and PAGE)

Unit 3: Separation techniques of Biomolecules: Centrifugation **[6 L]**
Basic Principle of Centrifugation, Instrumentation of Ultracentrifuge (Preparative, Analytical), Factors affecting

Sedimentation velocity, Standard Sedimentation Coefficient, Types of centrifugation

Unit 4: Microscopy: **[8 L]**

Principles of light. General construction of Microscope, Light microscopy, Bright & Dark Field microscopy, Fluorescence microscopy, Phase Contrast microscopy, Electron Microscopy, Atomic Force Microscopy.

Unit 5: Spectroscopy: **[10 L]**

Basic concepts of electromagnetic wave

Absorption spectroscopy (theory and Instrumentation): Uv-Vis Spectroscopy, Infrared Spectroscopy (IR), Raman Spectroscopy, Optical rotatory dispersion (ORD) and Circular Dichroism (CD), Nuclear Magnetic resonance spectrpscopy (NMR) Emission Spectroscopy (theory and Instrumentation: Fluorescence Spectroscopy

Component: Practical

Course Outcomes

CO 1	Master chemical and mechanical cell disruption methods for accurate intracellular product assay.
CO 2	Develop skills in separating insolubles using filtration, sedimentation, and centrifugation techniques.
CO 3	Acquire proficiency in protein purification through methods like ammonium sulfate precipitation, dialysis, ion exchange chromatography, and gel electrophoresis for precise analysis.
CO 4	Learn activity gel assay techniques for assessing enzyme activity, providing insights into protein function.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	3	3	1	3	3
CO 2	3	2	3	3	3	1	3	3
CO 3	3	3	3	3	3	1	3	3
CO 4	1	1	1	3	3	1	3	3
Average CO	3	2	3	3	3	1	3	3

Practicals:

1. Chemical and cell disruption and Protein estimation of different fractions obtained by differential centrifugation.
2. Isolation of different dyes by Paper chromatographic technique and calculation of Rf value.
3. Isolation of different amino acids by Thin layer chromatographic technique and calculation of Rf value.
4. Separation of Chlorophyll by Silica gel Column chromatography technique
5. Ion Exchange chromatography
6. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.

Suggested Books:

1. Instrumental methods of analysis by Willard, Merit Dean and Settle Edition 1986. CBS publishers and distributors.
2.Physical Biochemistry, applications to Biochemistry and Molecular Biology D, Freifelder.W.H.Freeman and company, edition 2, 1982.
3. General Biophysics, vol. I & II – H.V. Volkones.
4. Molecular Biophysics – B. Pullmann & M. Voino.
5. Biophysical chemistry – Upadhyay, 6. Himalaya Publication,edition 3, 2005.
7. Biophysics. S. Mahes, (2003), New Age International (P), Ltd

MC 10: Recombinant DNA technology
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 36**

Course Outcomes:

CO 1	Understand and describe the major tools and strategies used in molecular cloning process.
CO 2	Identify and acquire skills on methods for molecular cloning, including, introduction of rDNA into host cells, methods, and techniques for selection of transgenic organism.
CO 3	Acquire skills on techniques for expression analysis of genes by PCR based techniques as well as identification and analysis of genes by sequencing methods.
CO 4	Apply the techniques in rDNA to construct genomic and cDNA library and learn various applications of rDNA technology to build better solution to biological problems, including, production of pharmaceuticals, growth hormones, generating transgenic crop with enhanced adaptability to changing environmental conditions.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	3	2	3	2	2
CO 2	3	3	3	3	3	3	3	3
CO 3	3	2	3	3	2	3	3	3
CO 4	3	3	3	3	3	3	3	3
Average CO	3	3	3	3	3	3	3	

Teaching Topics

Unit 1: Tools and Strategies: **[8 L]**

Cloning Tools; Restriction modification systems: Types I, II and III. Mode of action, nomenclature, applications of Type II restriction enzymes in genetic engineering DNA modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyl transferase, kinases and phosphatases, and DNA ligases. Cloning Vectors: Properties and Applications. Use of linkers and adaptors. Expression vectors.

Unit 2: Methods in Molecular Cloning: **[8 L]**

Transformation of DNA: Chemical method, Electroporation, Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral mediated delivery, Agrobacterium - mediated delivery DNA, RNA and Protein analysis: Electrophoresis, Southern - and Northern - blotting techniques, dot blot, DNA microarray analysis, SDS-PAGE and Western blotting.

Unit 3: DNA Amplification and DNA sequencing: **[8 L]**

PCR: Basics of PCR, RT-PCR, Real-Time PCR Sanger's DNA Sequencing, Maxim Gilbert DNA sequencing. Traditional and automated sequencing. Primer walking and Shotgun sequencing

Unit 4: Construction and Screening of Genomic and cDNA libraries: **[6 L]**

Genomic and cDNA libraries: Preparation and uses, screening of libraries: Colony hybridization and colony PCR, Chromosome walking and chromosome jumping.

Unit 5: Applications of Recombinant DNA Technology: **[6 L]**

Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, Gene therapy, recombinant vaccines, protein engineering and site directed mutagenesis. Development and application of CRISPR Cas-9.

Component: Practical

Course Outcomes:

CO 1	Competent Cell Preparation: Master the preparation of competent cells for genetic transformation.
CO 2	Bacterial Transformation Proficiency: Demonstrate expertise in bacterial transformation and transformation efficiency calculation.
CO 3	DNA Manipulation Skills: Display proficiency in DNA digestion using restriction enzymes and analysis via gel electrophoresis.
CO 4	Molecular Cloning Competence: Exhibit competence in DNA fragment ligation and understanding of cloning techniques, including screening for recombinants.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	1	1	2	1	3	3
CO 2	3	3	2	1	2	1	3	3
CO 3	3	3	1	1	2	1	3	3
CO 4	3	3	2	1	2	1	3	3
Average CO	3	3	2	1	2	1	3	3

Practicals:

1. Isolation of genomic DNA from bacterial and/or plant samples.
2. DNA Plasmid Isolation Using Alkaline Lysis Method.
3. Determination of the concentration and assess the quality of DNA samples using a UV-spectrophotometer and a NanoDrop.
4. Application of Agarose Gel Electrophoresis for observation of genomic DNA and plasmid DNA.
5. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis.
6. Designing of primers for DNA amplification.
7. Amplification of DNA by PCR.
8. Cloning of DNA insert and blue white screening of recombinant.
9. Interpretation of sequencing gel electropherograms.

Suggested Books:

1. Primrose, S. B., & Twyman, R. (2013). Principles of Gene Manipulation and Genomics. (7th edition) John Wiley & Sons.
2. Brown, T.A. (2012). Genetics: A Molecular Approach. Garland Science.
3. Berk, A., Kaiser, C. A., Lodish, H., & Amon, A. (2016). Molecular Cell Biology. (8th Edition)W. H. Freeman.
4. Sambrook, J., Russell, D. W., & Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual (4th ed.). Cold Spring Harbor Laboratory Press.
5. Nelson, D. L., & Cox, M. M. (2017). Lehninger Principles of Biochemistry (7th ed.). W. H. Freeman
6. Chawla, 2003. Introduction to Plant Biotechnology (2ndedn) Oxford and IBH Publishers
7. R.C. Dubey, A Text Book of Biotechnology. S. Chand & Co Ltd, New Delhi.

MC 11: Microbial Diversity and Metabolism
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 36**

Course Outcomes:

CO 1	Understand and have a general idea about the microbial world.
CO 2	Know how the bacterial, viral, fungal and algal world have been classified.
CO 3	Know the different habitat of different microorganism.
CO 4	Compare the different metabolism types among bacteria.
CO 5	Explain the ecological and economical importance of different microorganism.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	3	2	2	2	2
CO 2	2	3	3	3	3	3	3	3
CO 3	3	2	3	3	3	2	3	3
CO 4	2	3	3	3	3	3	3	3
Average CO	3	3	3	3	3	3	3	3

Teaching Topics:

Unit 1: The classification of bacteria **[5L]**

The units of classifications, new approaches to bacterial taxonomy, comparison of bacterial genotypes by genetic analysis, main outline of bacterial classification.

Unit 2: Gram positive and negative bacteria **[6L]**

Aerobic, microaerophilic, facultative aerobic Gram-negative bacteria, dissimilatory sulfur reducing bacteria, Aerobic, aerotolerant, facultative anaerobic, anaerobic endospore forming, non-spore forming Gram positive bacteria.

Unit 3: Microbes with unusual properties **[6L]**

Rickettsia, Chlamydia, Actinomycetes, Gliding, fruiting, sheathed bacteria, filamentous bacteria, mollicutes, Archaebacteria (Thermoacidophiles, Methanogens and Halophiles).

Unit 4: Introduction to microbial metabolism **[6L]**

Structure and classification of enzyme, Mechanism of Enzyme reactions: Lock and key model, induced fit theory, Michaelis -Menten Kinetics, Enzyme inhibition, Regulation of enzyme activity, Factors affecting rates of enzyme mediated reactions.

Unit 5: Unique metabolism of microbes **[6L]**

Mechanism of nitrogen fixation, Symbiotic and non-symbiotic nitrogen fixation, denitrification, nitrification, Sulfur utilization, iron utilization, methane production and utilization, endosymbiosis, biofilm formation, quorum sensing.

Unit 6: Pathways of ATP generation **[7L]**

Oxygenic photosynthesis in relation to cyanobacteria, anoxygenic photosynthesis in relation to green and purple sulfur bacteria, electron transport chain in anaerobic respiration, fermentation (homo fermentative and hetero fermentative pathways).

Component: Practical

Course Outcomes:

CO 1	Students will learn the estimation of biomolecules (Protein and carbohydrate)
CO 2	Students will have an overall idea about the physiological types of bacteria.
CO 3	Students will learn about diversity of microbial metabolism.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	1	3	2	3	3	3
CO 2	3	3	2	3	2	3	3	3
CO 3	3	3	1	3	2	3	3	3
Average CO	3	3	2	3	2	3	3	3

Practicals

1. Isolation and characterization of anaerobes from environmental samples
2. Isolation and growth of chemolithotrophs in laboratory condition.
3. Isolation and characterization of nitrate reducing bacteria.
4. Screening of sulfate, reducing bacteria.
5. Screening of phosphate solubilizing bacteria.
6. Chlorophyll estimation from cyanobacteria.

Suggested Books

1. General Microbiology., R.Stanier
2. Brock Biology of Microorganisms
3. Prescott's Microbiology., J. M Willey
4. Microbiology., Tortora
5. Microbiology., M . Pelczar
6. Atlas RM. (1997). Principles of Microbiology. 2 nd edition. WMT. Brown Publishers.
7. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited.

Semester VI
MC 12: Biostatistics and Bioinformatics
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 42**

Course Outcomes:

CO 1	Grasp basic C programming concepts including syntax, data types, variables, operators, and decision-making constructs.
CO 2	Understand biological databases, sequence analysis principles, and the significance of scoring matrices in bioinformatics.
CO 3	To understand sequence analysis techniques like identification of sequences, sequence alignment and algorithmic approaches like Needleman-Wunsch and Smith-Waterman.
CO 4	Learn essential statistical concepts including measures of central tendency, hypothesis testing, and significance tests like t-test, F-statistics, and Chi-square test.
CO 5	Understand regression, correlation, and multiple regression analysis techniques, including fitting regression lines and interpreting correlation coefficients.
CO 6	Explore advanced statistical methods such as analysis of variance (ANOVA), statistical optimization, and ANOVA post hoc tests for experimental design and analysis.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	2	3	3	3	3	3	3	3
CO 2	2	3	3	3	3	3	3	3
CO 3	2	3	3	3	3	3	3	3
CO 4	3	3	3	3	3	3	3	3
CO 5	2	2	3	2	3	3	2	2
CO 6	3	2	3	3	3	3	3	3
Average CO	2	3	3	3	3	3	3	3

Teaching Topics:

Unit 1: **[4L]**
Introduction to C programming language, Setting up development environment, Basic syntax, Data types: Data types in C, Type conversions and Constants, Declaring variables, Operators, Decision making: if-else statements, Looping constructs: while, for, do loops.

Unit 2: **[8L]**
Introduction and scope of bioinformatics, Introduction to Biological database: Introduction to sequence data banks, protein sequence data bank - Uniprot-KB, NBRF-PIR, SWISSPORT, Nucleic Acid sequence data bank - GenBank, EMBL, DDBJ. Structural database - PDB, NDB, PubChem, ChemBank; Genome data bank - Metabolic pathway data. Brief idea of Scoring/Substitution matrices: PAM and BLOSUM series and its significance.

Unit 3: **[5L]**
Biological background for sequence analysis, Identification of protein sequence from DNA sequence; Basic concepts of sequence similarity, the dot matrix for comparing sequences, Basic concepts of sequence alignment, Use of pairwise alignments and Multiple sequence alignment for analysis of Nucleic acid and protein sequences and interpretation of results., Use of Needleman Wunsch algorithm & Smith–Waterman algorithm for pair-wise alignment. Use of CLUSTALW and CLUSTALX for multiple sequence alignment.

Unit 4: **[8 L]**
Measures of Central tendency and Dispersion; Properties of Standard Normal Distribution, Normal Approximation to the Binomial Distribution, Normal Approximation to the Poisson Distribution, Permutations and Combinations, Hypothesis testing, Tests of significance: Student's t test, F- statistics, Chi square test.

Unit 5: **[8 L]**
Regression and Correlation Methods: General Concepts, Fitting Regression Lines— The Method of Least Squares, Inferences About Parameters from Regression Lines, Assessing the Goodness of Fit of Regression Lines, The Correlation Coefficient, Statistical Inference for Correlation Coefficients, Multiple Regression.

Unit 6: **[9 L]**
Introduction to the One-Way Analysis of Variance: One-Way ANOVA—Fixed- Effects Model, Hypothesis Testing in One-Way ANOVA, Comparisons of Specific Groups in One-Way ANOVA, Two Way ANOVA, The Kruskal-Wallis Test; Statistical optimization of process parameters: Factors in Biological Systems, Steps in Designing an Experiment, Response Surface methods; ANOVA Post Hoc Tests.

Component: Practical

Course Outcomes:

CO 1	Master Perl programming and BioPerl for bioinformatics applications, and utilize essential databases like NCBI, Uniprot, and PDB for data retrieval and analysis.
CO 2	Develop skills in sequence retrieval with BLAST, sequence alignment using ClustalW, and phylogenetic analysis with Phylip, essential for understanding genetic relationships.
CO 3	Learn gene prediction techniques using Genscan and Glimmer, protein structure prediction using tools like Psi-Pred and SwissModel, understanding gene function and structure.
CO 4	Apply statistical methods such as the Chi Square test and Student's T test for qualitative and quantitative data analysis, respectively, enhancing the interpretation of biological data.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	1	1	1	1	2	3	3	3
CO 2	3	3	3	1	1	3	3	3
CO 3	3	3	3	1	1	2	3	3
CO 4	3	1	1	1	1	3	3	3
Average CO	3	2	2	1	1	3	3	3

Practicals:

1. Introduction to Perl programming and use of BioPerl.
2. Introduction to Bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB.
3. Sequence retrieval using BLAST and Sequence analysis using clustalW & phylip.
4. Use of Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool.
5. Protein structure prediction: primary structure analysis, secondary structure prediction using psi-pred, homology modeling using Swissmodel. Molecular visualization using jmol, Protein structure model evaluation (PROCHECK). Preparation of competent cells for transformation.
6. Prediction of different features of a functional gene.
7. Chi square test for qualitative data analysis.
8. Application of Statistical design of experiments: Multivariate approach
9. Biological data analysis using Student's T test

Suggested Books:

1. Fundamentals of Biostatistics., B. Rosner.
2. An Introduction to Biostatistics., N. Gurumani.
3. Bioinformatics: Principles and Applications. Oxford University Press., Ghosh and Bibekanand.
4. Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell., Pevsner J.
5. Bioinformatics Algorithms Phillip Compeau and Pavel Pevzner.

MC 13: Agricultural Microbiology
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 42**

Course Outcomes:

CO 1	Describe the role of microorganisms in soil fertility, plant health, and agricultural productivity, and apply this understanding to optimize soil management practices for sustainable crop production.
CO 2	Identify and differentiate between beneficial and harmful microorganisms in agricultural systems, and devise strategies for the biological control of plant pathogens and pests to minimize crop losses and enhance yield.
CO 3	Apply fundamental microbiological techniques for the isolation, enumeration, and characterization of microorganisms relevant to agriculture, and interpret laboratory results
CO 4	Evaluate the impact of microbial biotechnology on agricultural practices, including biofertilizers, biopesticides, and bioremediation techniques, and assess their potential for enhancing agricultural sustainability and environmental stewardship.
CO 5	Critically analyze current research literature and emerging trends in agricultural microbiology, and synthesize this knowledge to propose innovative solutions for addressing challenges such as climate change, soil degradation, and food security in agricultural systems.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	2	3	2	3	2	-	3	3
CO 2	2	3	3	3	-	-	-	3
CO 3	3	-	3	3	3	-	3	3
CO 4	2	3	3	3	-	-	2	3
CO 5	3	2	3	3	-	-	3	3
Average CO	2	3	2	3	1	-	2	3

Teaching Topics:

Unit 1: Soil microbial ecology and microbial interactions: [10L]

Soil biota, types of organisms in different soils; Soil microbial biomass; Factors influencing the soil microflora. Different Agriculturally important beneficial microorganisms – free living, symbiotic (rhizobial, mycorrhizal, actinorhizal), associative and endophytic nitrogen fixers including cyanobacteria. Different interfaces of interactions - Plant-microbe, microbe-microbe, soil-microbe, soil-plant-microbe interactions leading to symbiotic, associative, endophytic and pathogenic interactions, unculturable soil biota. Plant growth promoting rhizobacteria (PGPR). Mechanism of plant growth promotion by PGPR.

Unit 2: Biological nitrogen fixation: [6L]

Biochemistry of N2fixation, *nif* operon, mechanism of nitrogen fixation. Symbiotic nitrogen fixation: Rhizobium-Legume association, Actinorhizal associations, contribution of symbiotic nitrogen fixation. Denitrification. Phosphate solubilization and mobilization. Mycorrhizae- Ecto and endomycorrhizae, VAM and their importance in agriculture.

Unit 3: Microbial Colonization of plant surfaces: **[6L]**
The rhizosphere and colonization, plant root exudates and their characteristics, Nutrients and plant community productivity, Influence of plant rhizosphere effect, Phyllosphere associated microflora and their role, Phytoalexin-Properties and induction.

Unit 4: Plant Diseases: **[10L]**
Development of disease in plant population. Factors in the development of plant disease epidemics. Diseases caused by Phanerogamic parasites and their management. Diseases due to unfavourable soil environment, drought and flooding stress etc. Nutritional deficiencies. Fungal Diseases of Crop Plants with special reference to etiology, disease cycle, perpetuation, epidemiology and management. Postharvest diseases in transit and storage; aflatoxins and other mycotoxins and their integrated management. Bacterial and Viral Diseases of Crop Plant Mode of transmission and pathogen vector relationships. Epidemiology and management.

Unit 5: Introduction to biofertilizers and Organic manures: **[6L]**
Definition, types of biofertilizers; Characteristic features of the following biofertilizer organisms: Azospirillium, Azotobacter, Bacillus, Pseudomonas, Rhizobium, Frankia, Anabaena and Nostoc. Mechanisms of action of different bio-inoculants for plant growth. Significance of biofertilizers. Mass scale production and quality control of bio-inoculants. Biofertilizer inoculation and microbial communities in the soil. Preparation, properties, and use in crop production, nutrient-enriched compost, green manure; Composting, vermicomposting

Unit 6: Biocontrol: **[4L]**
Concept, types, mode of action, uses and practical constraints & applications of biocontrol agents. Biocontrol agent for sustainable agriculture. Different types of biocontrol agents. Biopesticides and bioherbicides, Biopesticides- classification, advantages. Major biopesticides based on bacteria, viruses & fungi (Bacillus thuringiensis (Bt) toxin, Boverin, DeVine, Collego).

Component: Practical

Course Outcomes:

CO 1	Apply aseptic techniques and safety protocols to handle microorganisms safely in the laboratory, minimizing contamination risks and ensuring the integrity of experimental results.
CO 2	Isolate, cultivate, and characterize agriculturally relevant microorganisms from soil, plant tissues, water, and other environmental samples using classical and molecular microbiological methods.
CO 3	Evaluate the efficacy of microbial inoculants, biofertilizers, and biopesticides through in vitro and in vivo experiments, assessing their impact on plant growth promotion, disease suppression, and nutrient cycling in agricultural systems.
CO 4	Analyze soil microbiota composition and diversity using molecular techniques such as polymerase chain reaction (PCR), DNA sequencing, and bioinformatics analysis, and correlate microbial community structure with soil properties and agricultural management practices.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	3	3	1	3	3
CO 2	3	2	3	3	3	1	3	3
CO 3	3	3	3	3	3	1	3	3
CO 4	1	1	1	3	3	1	3	3
Average CO	3	2	3	3	3	1	3	3

Practicals:

1. Enumeration of soil microbial population of Bacteria and Fungi.
2. Isolation and characterization of nitrogen-fixing bacteria.
3. Isolation and characterization of Phosphorus solubilization bacteria.
4. Sampling and enumeration techniques for phyllosphere.
5. Sampling and enumeration techniques for rhizosphere.
6. Assessment of symbiotic and synergistic interactions amongst microbes.
7. EPS production by phyllosphere/rhizosphere bacteria.

Suggested Books:

1. Agricultural Microbiology: N. S Subbarao
2. Introduction to plant biotechnology., H. S Chawla
3. Plant Tissue Culture: Theory and Practice., Bhojwani and Razdan

MC – 14: Industrial and Food Microbiology
Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 42**

Course Outcomes:

CO 1	To understand the basics of fermentation and industrial processes used in the industry including but not limited to Fast Moving Consumable Goods (FMCG), pharmaceutical and food related products.
CO 2	Introduction of applications of bioreactors for the production of antibiotics and Active Pharmaceutical Ingredients (API).
CO 3	Bioreactor design, types and components will be introduced in this course.
CO 4	Students will learn to apply the concepts of Microbiology in nutritional evaluation and processing of consumer grade food products

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	2	1	2	3	3	3	3
CO 2	3	2	1	3	3	3	3	3
CO 3	3	2	1	3	3	3	3	3
CO 4	3	2	1	3	3	3	3	3
Average CO	3	2	1	3	3	3	3	3

Teaching Topics:

Module 1:

Unit 1: Isolation of industrially important microbial strains and fermentation media: [4 L] Sources of industrially important microbes and methods for their isolation, preservation and maintenance of industrial strains, strain improvement, Crude and synthetic media; molasses, cornsteep liquor, sulphite waste liquor, whey, yeast extract and protein hydrolysates.

Unit 2: Fermentation processes: [4 L]
Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (eg. baker's yeast) and continuous fermentations Components of a typical bio-reactor, Types of bioreactors-Laboratory, pilot- scale and production fermenters, constantly stirred tank and air-lift fermenters, Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration.

Unit 3: Down-stream processing: [2 L]
Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying.

Unit 4: Production of industrial products: [4 L]
Citric acid, ethanol, penicillin, glutamic acid, Vitamin B12, Vinegar, Enzymes (amylase, protease, lipase), wine.

Unit 5: Enzyme immobilization: [4 L]
Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes.

Module 2:

Unit 1: Microbial spoilage of various foods: [4 L]
Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned Foods.

Unit 2: Principles and methods of food preservation: [8 L]
Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins.

Unit 3: Fermented foods: [8 L]
Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce and tampeh, Probiotics: Health benefits, types of

microorganisms used, probiotic foods available in market.

Unit 4: Design of Bioreactor: **[4 L]**

Component: Practical

Course Outcome:

CO 1	Concepts of sterilization will be revisited as a mandate for promoting Good Lab Practice.
CO 2	Application of statistical significance for data interpretation and processing will be practised.
CO 3	Design and utilisation of batch-type bioreactors for the production of food products will be applied.
CO 4	Culture conditioning, collection of biological samples, biofilm characterization and inspection of contamination will be performed.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	3	3	2	3	3
CO 2	3	3	3	3	3	2	3	3
CO 3	3	2	3	-	2	1	3	3
CO 4	3	2	3	-	2	1	3	3
Average CO	3	3	3	2	3	2	3	3

Practicals:

1. MBRT of milk samples and their standard plate count.
2. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
3. Immobilization of whole cell and enzymes for industrial fermentation processes.
4. Isolation of spoilage microorganisms from spoiled vegetables/fruits/ bread /Yogurt/Dahi
5. Microbial fermentations for the production and estimation (qualitative and quantitative) of:
(a) Enzymes: Amylase and Protease (b) Amino acid: Glutamic acid (c) Organic acid: Citric acid
(d) Alcohol: Ethanol

Suggested Books:

1. Microbiology, M Pelczar
2. Prescott's Microbiology: J.M Willey
3. Industrial Microbiology., L.E.J.R. Casida
4. Prescott and Dunn's Industrial Microbiology., G Reed

INT 1: Internship
Credit: 3 (0L-0T-6P)
Component: Internship

Course Outcomes:

CO 1	Develop proficiency in various laboratory techniques and procedures relevant to bioscience, including molecular biology, microbiology, biochemistry, and cell culture.
CO 2	Gain the ability to collect, analyze, and interpret experimental data using statistical and computational tools, enhancing critical thinking and problem-solving skills.
CO 3	Improve written and oral communication skills through the preparation of scientific reports, presentations, and posters, facilitating effective dissemination of research findings.
CO 4	Understand the ethical considerations involved in bioscience research and demonstrate professionalism in laboratory conduct, adhering to safety protocols and ethical standards.
CO 5	Develop collaborative skills by working effectively within a team environment, fostering communication, cooperation, and mutual respect among colleagues.
CO 6	Gain insights into career pathways within the bioscience field, including academia, industry, and healthcare, and develop a professional network through interactions with mentors and peers.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	2	1	3	1	3	3	3	3
CO 2	2	1	3	1	3	3	3	3
CO 3	2	1	3	1	3	3	3	3
CO 4	3	1	3	1	3	3	3	3
CO 5	2	1	3	1	3	3	2	2
CO 6	3	1	3	1	3	3	3	3
Average CO	2	1	3	1	3	3	3	3

Guideline for Internship:

Every student has to perform an internship under the guidance of any one faculty from the department and has to submit a report on the internship. The evaluation will be done on the basis of the report, presentation of the report and performance during the internship.

Semester VII
MC 15: Data Science and Structural Biology Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 42**

Course Outcomes:

CO 1	Gain skills in preprocessing biological data, Python programming, and data visualization using techniques like histograms and scatter plots, alongside interactive visualization tools like Plotly and Bokeh.
CO 2	Understand supervised and unsupervised learning algorithms such as K-means clustering, PCA, linear and logistic regression, decision trees, random forest analysis, SVM, and neural networks, including cross-validation techniques.
CO 3	Acquire knowledge of protein and nucleic acid structure, membrane proteins, and techniques like X-ray crystallography, NMR, TEM, SEM, and Cryo-EM for biomolecular structure analysis.
CO 4	Develop proficiency in utilizing databases like PDB, NDB, UniProt, and visualization software like PyMOL and VMD for sequence-structure analysis, homology modeling, and protein-ligand interactions prediction.
CO 5	Understand the fundamentals of molecular dynamics simulations and their applications in studying dynamic behaviors of biomolecular systems at the atomic level.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	2	3	3	3	2	3	3
CO 2	3	2	3	3	3	2	3	3
CO 3	3	1	3	3	3	2	3	3
CO 4	3	1	2	3	3	2	3	3
CO 5	3	1	3	3	3	2	3	3
Average CO	3	1	3	3	3	2	3	3

Teaching Topics:

Unit 1: Overview of Data Science: [10L]
Sources of biological data: databases, experiments, sequencing, Data preprocessing techniques: cleaning, transformation, normalization, Introduction to Python Programming, Data visualization techniques: histograms, box plots, and scatter plots, Interactive visualization tools and libraries: Plotly, Bokeh

Unit 2: Overview of machine learning: [10L]

Supervised vs. unsupervised learning, Unsupervised Learning Algorithms: K-means clustering, Principal Component Analysis (PCA) for dimensionality reduction, Supervised Learning Algorithms: Linear and logistic regression, Decision trees, Random forest analysis, Support Vector Machines (SVM), Cross-validation techniques: k-fold cross-validation, Introduction to neural networks for data analysis.

Unit 3: Historical perspective and significance of structural biology: [12L]
Overview of protein and nucleic acid structure, Structure and function of membrane proteins, Lipid bilayers and their role in membrane protein structure, Techniques for studying biomolecular structures (X-ray crystallography, NMR), Principles of transmission electron microscopy (TEM) and

scanning electron microscopy (SEM), Cryo-EM and single-particle reconstruction.

Unit 4: Biological Databases: **[10L]**

Introduction to protein and nucleic acid structure databases (PDB, NDB, UniProt), Introduction to molecular visualization software (e.g., PyMOL, VMD), Sequence-structure relationships, Homology modeling and comparative protein structure prediction, Protein-Protein and Protein-ligand interactions prediction, Basics of molecular dynamics simulations.

Component: Practical

Course Outcomes:

CO 1	Gain skills in collecting and preprocessing biological data using Python, along with applying classification, regression, and clustering algorithms for analysis.
CO 2	Learn to create informative visualizations using Matplotlib, Seaborn, and Plotly, and interpret these visualizations to communicate results derived from biological data analysis.
CO 3	Acquire hands-on experience with VMD, PyMol, and protein structure prediction software for analyzing protein structures and performing protein-ligand docking.
CO 4	Develop proficiency in setting up and running molecular dynamics simulations using GROMACS, along with analyzing simulation trajectories to understand biomolecular system dynamics.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	3	3	3	-	3	2	3	-
CO 2	3	3	3	-	3	2	3	-
CO 3	3	2	3	-	2	1	3	-
CO 4	3	2	3	-	2	1	3	-
Average CO	3	3	3	-	3	2	3	-

Practicals:

1. Setup of programming environment (Python, Jupyter Notebook), Collecting biological data from different sources (e.g., databases, APIs), Cleaning and preprocessing biological data using Python libraries (Pandas, NumPy), Applying classification, regression, and clustering algorithms to biological datasets using scikit-learn and scipy, Creating informative visualizations using Matplotlib, Seaborn, and Plotly, Interpretation of visualizations and communication of results

2. Hands on experience on VMD and PyMol, Protein sequence analysis and prediction of secondary structure using protein structure prediction software (e.g., SWISS-MODEL, MODELLER), Performing protein-ligand docking using docking software (e.g., AutoDock Vina), Analysis of docking results and identification of potential drug candidates, Setting up and running molecular dynamics simulations using GROMACS, Analysis simulation trajectories and interpretation of results.

Suggested Books:

1. David Webster: Protein Structure Prediction: Methods and Protocols.
2. Yasha Hasija and Rajkumar Chakraborty: Hands on Data Science for Biologists Using Python.
3. Giovanni Cerulli: Fundamentals of Supervised Machine Learning: With Applications in Python, R, and S tata.

MC 16: Medical Microbiology and Cancer Biology Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 42**

Course Outcomes:

CO 1	Apply the concept about resident and transient microbial flora of human body and their pathogenecity for diagnosis and immunological analysis with respect of various infections
CO 2	Understand and explain the stages of different infections diseases, susceptibility of microorganisms to antimicrobial drugs
CO 3	Describe various hospital borne, air borne and water-borne diseases caused by bacteria. Virus, fungi, protozoa, its symptoms, transmission and control
CO 4	Understand antibacterial therapy and prophylaxis
CO 5	Understand the nature of cancer and the (molecular) processes underlying cancer formation and progression and explain the role of gene mutations play in the development of cancer
CO 6	Gain knowledge about the principles underlying anti-cancer therapies and the technologies used in cancer research and diagnosis

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8
CO 1	1	-	-	-	1	1	3	3
CO 2	1	-	-	-	1	1	3	3
CO 3	1	-	-	-	1	1	3	3
CO 4	1	-	-	-	1	1	3	3
CO 5	1	-	-	-	1	1	3	3
CO 6	1	-	-	-	1	1	3	3
Average CO	1	-	-	-	1	1	3	3

Teaching Topics:

Unit 1: History of medical microbiology: **[2L]**
Contribution of Antony von Leeuwenhoek, Luis Pasteur, Robert Koch, John Tyndal, Difference between Tyndallization and Pasteurization, Germ theory of disease, Kochs postulate, Discovery of Viruses, Principles of Modern Virology

Unit 2: **Normal microflora of the human body and host pathogen interaction: [8 L]**
Normal microflora of the human body: types of normal flora, factors determining the nature of the normal flora, factors that influence normal flora, normal flora at different sites: skin, nose, respiratory tract, mouth, gastrointestinal tract, urogenital tract, Importance of normal microflora - beneficial and harmful effect, probiotics, prebiotics and synbiotics, Host pathogen interactions. Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections. Transmission of infection, Pathophysiologic effects of LPS, Virus transmission.

Unit 3: Bacterial diseases: [8 L]
List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control Respiratory Diseases: *Streptococcus pyogenes*, *Haemophilus influenzae*, *Mycobacterium tuberculosis*. Gastrointestinal Diseases: *Escherichia coli*, *Salmonella typhi, Vibrio cholerae*, *Helicobacter pylori* Others: *Staphylococcus aureus, Clostridium tetani, Corynebacterium diphtheria*, *Corynebacterium botulinum*, Neisserial disease, Streptococcal disease.

Unit 4: Viral diseases: [6 L]
List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control: Polio, Herpes, Hepatitis, Rabies, Dengue, AIDS, Influenza.

Unit 5: Protozoan and fungal diseases: [4 L]
List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control, Malaria, **Leishmaniasis,** Tinea pedis (Athlete's foot), Histoplasmosis, Candidiasis

Unit 6: Epidemiology [3 L]
Epidemiological terminology, Measuring frequency, morbidity rate, mortality rate, Surveillance, Types of epidemics, evolution of pathogenic organisms, antigenic shift and drift.

Unit 7: Antimicrobial agents: General characteristics and mode of action. [5 L]
Antibacterial agents: Modes of action with examples: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin Antiviral agents: Mechanism of action of Amantadine, Acyclovir, Antibiotic resistance

Unit 8: Cancer Biology [6 L]
Introduction, cancer terminology, classification of cancer, origin of cancer, Properties of Cancer cells: Altered Control of Growth, Altered Sugar Metabolism, abnormal survival ability. Tumor microenvironment, steps of metastasis, cancer critical genes and tumor suppressor genes, , identification of cancer critical genes, Malignant Transformation of Cells, stages of colon cancer, Cancer immunotherapy

Component: Practical

Course Outcomes:

CO 1	Perform isolation of different bacteria from human samples and their cultural, morphological and biochemical characterization.
CO 2	Learn use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS etc.
CO 3	Perform antibacterial sensitivity and determine minimal inhibitory concentration (MIC) of an antibiotic.
CO 4	Isolate and identify antibiotics producing bacteria.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO 1	-	-	3	3	3	2	3	3
CO 2	-	-	3	3	3	2	3	3
CO 3	-	-	3	3	3	2	3	3
CO 4	-	-	3	3	3	2	3	3
Average CO	-	-	3	3	3	2	3	3

Practicals:

1. Identify bacteria (any three of *E. coli, Salmonella, Pseudomonas, Staphylococcus, Bacillus*) using laboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests
2. Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS
3. Study of bacterial flora of skin by swab method
4. Perform antibacterial sensitivity by Kirby-Bauer method
5. Determination of minimal inhibitory concentration (MIC) of an antibiotic.
6. Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis), dermatomycoses (ring worms)
7. Study of various stages of malarial parasite in RBCs using permanent mounts.
8. Antibiotic Assay - Antimicrobial Sensitivity Test (Disc Diffusion Method)
9. Isolation of antibiotics producing bacteria.

Suggested Books:

1. Pelczar MJ, Chan ECS and Krieg NR. Microbiology. McGraw Hill Book Company.
2. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. General Microbiology. McMillan
3. Willey JM, Sherwood LM, and Woolverton CJ. Prescott's Microbiology. McGraw Hill Higher Education.
4. Kayser FH, Bienz KA, Eckert J, Zinkemagel Medical Microbiology. Thieme.
5. Ryan KJ, C George Ray. Sherri's Medical Microbiology, McGraw Hill Book Company

MC 17: Environmental Microbiology and Ecology Credit: 5 (3L-0T-2P)

Course Component: Theory **Lecture Hour: 42**

Course Outcomes:

CO 1	Introduce students to the field of environmental microbiology that include microbes in natural environment such as soil, water and air
CO 2	Understand the significance of bioremediation and biodegradation and control of environmental pollution.
CO 3	Gain knowledge on various biogeochemical cycles, molecular and biochemical basis of biological nitrogen fixation.
CO 4	Gain knowledge on microbial interaction that includes microbe-microbe; plant-microbe and animal-microbe interaction.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8
CO 1	3	3	2	1	1	1	3	3
CO 2	3	3	2	1	1	1	3	3
CO 3	3	3	3	1	1	1	3	3
CO 4	3	3	2	1	1	1	3	3
Average CO	3	3	2	1	1	1	3	3

Teaching Topics:

Unit 1: Microbial Environments **[8L]**

Soil as a Microbial Environment: Biotic Stresses and Abiotic Stresses, Distribution of Microorganisms in Soil, Microorganisms in Subsurface Environments: Microorganisms in Shallow Subsurface Environments, Microorganisms in Deep Subsurface Environments

Aeromicrobiology: Important Airborne Pathogens, Important Airborne Toxins, Aerosols, Nature of Bioaerosols, Extramural Aeromicrobiology: Agriculture, Waste Disposal, Microbial Persistence in the Air: Relative Humidity: Temperature, Radiation, Oxygen, OAFs, and Ions

Aquatic Environments: Microbial Habitats in the Aquatic Environment, Planktonic Environment, Benthic Habitat, Microbial Mats, Biofilms

Extreme Environments: Low Temperature Environments, High Temperature Environments, Environments Based on Chemoautotrophy, Acidic Environments, Acid Mine Drainage

Unit 2:Microbial Interactions with Environment and Nutrient Cycling **[4L]**

Biogeochemical Cycling: Biogeochemical Cycles, Gaia Hypothesis; Carbon Cycle, Carbonate equilibrium, Carbon Reservoirs, Carbon Fixation and Energy Flow, Carbon Respiration; Biofertilizers and biopesticides.

Unit 3: Bioremediation of pollutants and Wastewater treatment **[5L]**

Environmental Law; Biodegradability: Genetic Potential, Toxicity, Bioavailability; Environmental

Factors Affecting Biodegradation; The essential, toxic and non-toxic metals in the environment; Microbial Metal Transformations: Oxidation–Reduction, Methylation; Mechanisms of Microbial Metal Resistance; Physicochemical Methods of Metal Remediation.
The Nature of Wastewater (Sewage); Properties of Sewage (BOD/COD); Oxidation Ponds; Sludge Processing; Water Treatment Processes; Organic Carbon and Microbial Growth in Distribution Systems.

Unit 4: Microorganisms as environmental indicators **[3L]**
The Concept of Indicator Organisms; Standards and Criteria for Indicators; Potential Indicator Organisms, Microbial Source Tracking

Unit 5: Introduction to ecology **[2L]**
Levels of biological organization, history of ecology, definition of ecology: species interactions, distribution and abundance

Unit 6: Population ecology **[6L]**
Types of population, unique and group attributes of population: demographic factors, life tables, fecundity tables, survivorship curves, dispersal and dispersion. Geometric, exponential and logistic growth, equation and patterns, population regulation - density-dependent and independent factors
/ life history strategies (r and K selection), types of interspecific interactions: Gauss's principle, Lotka-Volterra equation for competition.

Unit 7: Community ecology and ecosystem ecology **[9L]**
(a) Community: Concept, definition and characteristics – biodiversity and ecological succession
(b) Biodiversity: Types of biodiversity, utilization of biodiversity, measures of biodiversity: species richness, relative abundance, vertical stratification, zonation, ecotone and edge effect.
(c) Succession: Models and mechanisms.
(d) Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
(e) Energy flow in ecosystems, nutrient cycling, trophic levels and food webs.

Unit 8: Applied Ecology **[5L]**
(a) Climate change, biodiversity extinction and conservation strategies.
(b) Management strategies for tiger conservation, Wildlife Protection Act (1972)

Component: Project

Course Outcomes:

CO 1	Gain deeper understanding of ecology and environmental microbiology through practical experiences.
CO 2	Apply theoretical knowledge to real-world ecological and environmental scenarios.
CO 3	Develop observation, analysis, and appreciation for biodiversity and conservation.
CO 4	Foster interdisciplinary learning by integrating concepts from various fields.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8
CO 1	3	3	3	2	3	1	3	3
CO 2	3	3	2	2	2	1	3	3
CO 3	3	3	2	2	2	1	3	3
CO 4	3	3	2	1	1	1	3	3
Average CO	3	3	2	2	2	1	3	3

Guideline for the Project:

The student has to participate in any educational tour emphasizing on the ecology and evolution. She/ He has to submit a report on the project to the department as prescribed by the department.

Suggested Books:

1. Manual of Environmental Microbiology (ASM Books Book 33) 4th Edition, Cindy H. Nakatsu, Robert V. Miller, Suresh D. Pillai
2. Environmental Microbiology 3rd Edition, Ian L. Pepper, Charles P. Gerba , Terry J. Gentry
3. Wastewater Engineering- Treatment, disposal and Reuse. Metcalf and Eddy, Inc,.Tata McGraw Hill, New Delhi
4. Comprehensive Biotechnology. Vol. 4, M. Moo-young (Ed-in-chief), Pergamon Press, Oxford
5. Krebs, Charles J - Ecology_the experimental analysis of distribution and abundance-Pearson (2014)
6. Michael Begon, Robert W. Howarth, Colin R. Townsend. 2014. Essentials of Ecology-Wiley.
7. Ellison, Aaron M._Gotelli, Nicholas J - A primer of ecological statistics-Sinauer Associates, Inc., Publishers (2018)
8. Green, N. P. O., Soper, R., Stout, G. W., Taylor, D. J. (1997). Biological Science 1 and 2. United Kingdom: Cambridge University Press.

MC 18: Genomics, Proteomics and Metabolomics Credit: 2 (2L-0T-0P)

Course Component: Theory **Lecture Hour: 28**

Course Outcomes:

CO 1	Gain insight into the structure and organization of prokaryotic and eukaryotic genomes, including genes, repetitive DNA elements, and organelle genomes.
CO 2	Explore the evolutionary history of genomes, including gene duplication events, the role of non-coding DNA, and insights from model organisms and the Human Genome Project.
CO 3	Develop skills in protein separation, identification, and structural determination using advanced techniques like mass spectrometry, X-ray diffraction, and protein interaction mapping.
CO 4	Acquire knowledge of metabolome analysis methods, metabolic regulation, and engineering approaches for manipulating metabolic pathways to create new products.
CO 5	Learn to integrate data from genomics, proteomics, and metabolomics to understand biological systems comprehensively and explore interdisciplinary research opportunities.

CO 6	Application of Bioinformatics Tools: Apply bioinformatics tools and techniques for genome assembly, annotation, and analysis, enhancing research capabilities in genomics and related fields.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8
CO 1	3	2	1	2	1	1	3	3
CO 2	3	2	1	2	1	1	3	3
CO 3	3	2	1	2	1	1	3	3
CO 4	3	2	1	2	1	1	3	3
CO 5	3	2	1	2	1	1	3	3
CO 6	3	2	1	2	1	1	3	3
Average CO	3	2	1	2	1	1	3	3

Teaching Topics:

Unit 1: Introduction to Genomics [8L]

Genetic Features of Eukaryotic Nuclear Genomes, Genetic Features of Prokaryotic Genomes; Structure of prokaryotic and eukaryotic genes; genomic organization in prokaryotes (nucleoid, DNA supercoiling, topoisomerases), Structure of eukaryotic genes (description and experimental proofs), multigene family. Genome organization (ARS, centromere, telomere, chromatin structure), various forms of repetitive DNA (satellite, LINEs and SINEs), pseudogenes. Eukaryotic Organelle Genomes-The origins of organelle genomes, Physical features of organelle genomes, The genetic content of organelle genomes. DNA fingerprinting, RFLP, RAPD.

Unit 2: Genome Evolution [6L]

Genomes: the first ten billion years- the origins of genomes, Acquisition of new genes- by duplication events, from other species, Non-coding DNA and genome evolution: Transposable elements and genome evolution, The Human Genome Project, Genome assembly, genome annotation, Model organisms and its genome characteristics.

Unit 3: Introduction to Proteomics [8L]

Proteome, Separation of proteins by Two-dimensional electrophoresis; Mass spectrometry (ESI and MALDI); Amino acid sequencing of protein by Edman method (Traditional approach); Identification of proteins by tandem mass spectrometry; Shotgun proteomics; Peptide fingerprinting/mapping; Determination of 3D structure of protein by X-ray diffraction and NMR spectroscopy. Isotope-coded affinity tag (ICAT) method for quantitative proteome analysis; Protein-protein interaction using two-hybrid system, complementation, tandem affinity purification (TAP) tag method; Protein- protein interaction mapping; Protein microarrays

Unit 4: Introduction to metabolomics [6L]

Metabolome, Methods/ approaches employed to study metabolism; Methods for measurement of metabolites (targeted and untargeted). Metabolic regulation and control Homeostasis and metabolic control, metabolic flux, metabolic control Analysis, Metabolic engineering – Transfer of gene/s, partial pathways, and entire biosynthetic pathways for creating new products. Metabolic engineering for altering / redirecting metabolite flow. Limitations in Metabolic Engineering.

Suggested Books:

1. Andrezej K Konopka and James C. Crabbe, Compact Hand Book - Computational Biology, Marcel Dekker, USA, 2004.
2. Pennington & Dunn - Proteomics from Protein Sequence to Function, 1 st edition, Academic Press, San Diego, 1996.
1. Bioinformatics for omics data: methods and protocols (2011), Mayer, B., New York: Humana Press. ISBN 978-1617790270
2. Omics: Applications in Biomedical, Agricultural, and Environmental Sciences (2013), Barh D., Zambare V., Azevedo V. CRC Press. Taylor and Francis Group. ISBN 9781138074750
3. Applications of Advances Omics Technologies: from Genes to Metabolites (2014), Wilson and Wilsons. Elsevier. ISBN: 9780444626509
5. Principles of Proteomics (2013), Twyman, R., Garland Science, ISBN: 978- 0815344728

MC 19: Molecular Nanomachines Credit: 2 (2L-0T-0P)

Course Component: Theory **Lecture Hour: 28**

Course Outcomes:

CO 1	Learn about the structure and function of key molecular assemblies in cells, including cytoskeleton filaments, nucleic acids motor proteins, and membrane-associated rotary motor proteins.
CO 2	Gain insights into the roles of motor proteins like myosin, dyneins, kinesins, and others in genetic information maintenance, protein synthesis, and cellular motility.
CO 3	Explore the design and applications of artificial molecular assemblies, such as DNA-based molecular machines, for various biological and synthetic purposes.
CO 4	Understand how mimicry with non-biological components can create directional motion, sliding motion, and other motions, with implications for both natural and synthetic systems.
CO 5	Integrate knowledge of biological and synthetic approaches, fostering innovative thinking for potential applications across different fields.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8
CO 1	1	2	2	-	1	1	3	3
CO 2	1	2	2	-	1	1	3	3
CO 3	1	2	2	-	1	1	3	3
CO 4	1	2	2	-	1	1	3	3
CO 5	1	2	2	-	1	1	3	3
Average CO	1	2	2	-	1	1	3	3

Teaching Topics:

Module 1: Biological molecular assemblies **[14 L]**

Unit 1: Cytoskeleton filaments motor proteins:
Structure, dynamics and mechanism of energy transduction of
a) Myosin (ATP driven asymmetric directional movement along actin filaments)
b) Dyneins and kinesins Myosin (ATP driven asymmetric directional movement along microtubules)

Unit 2: Nucleic acids motor proteins:
Motor proteins for maintenance and processing of genetic information and protein synthesis (polymerases, topoisomerases, gyrases, helicases, ribosome) that function by associating with DNA and RNA molecules.

Unit 3: Membrane associated rotary motor proteins:
Structure and chemico-mechanical properties of
a) Bacterial flagella (essential for bacterial cell motility and chemotaxis)
b) Mitochondrial F_0F_1-ATP synthase (synthesize ATP molecules in mitochondria).

Module 2: Artificial molecular assemblies and potential applications **[14 L]**

Unit 1: Molecular machines with DNA:
DNA Tweezers, DNA based synthetic molecular walkers, motors, DNA rotor, biological applications of DNA nanomaterials.

Unit 2: Molecular mimicry with nonbiological components:
Generation of directional rotary motion (ATP synthase and flagellar mimic), directed sliding motion (myosin and kinesin mimic), multiple interlocked motion, coherent and tandem directed motion.

Semester VIII
MC 20: Microbial Quality Control in Industries
Credit: 4 (4L-0T-2P)

Course Component: Theory **Lecture Hour: 56**

Course Outcomes:

CO 1	Understand the basic concepts of Biosafety, GMP, Aseptic Operation and containment.
CO 2	Apply the principles of quality assurance and quality control to food and beverage industries.
CO 3	Analyse the quality control principles and guidelines in pharmaceutical industry for production and handling of products.
CO 4	Document, assess and evaluate the QC/QA norms for various industries.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8
CO 1	3	2	1	2	2	2	3	3
CO 2	3	2	1	2	2	2	3	3
CO 3	3	2	1	2	2	2	3	3
CO 4	3	2	1	2	2	2	3	3
Average CO	3	2	1	2	2	2	3	3

Teaching Topics:

Unit 1: Introduction to QC and QA **[14L]**

Introduction, quality control (QC) versus quality assurance (QA), Aseptic Operation and Containment. Biosafety in Industrial Biotechnology. Health hazards in biotechnology, Freeze-drying of biohazardous products, Industrial Safety and Hazard Management in Bio-Technology & related industry - live viruses, bacteria. Quality assurance and Quality control in industry – basic principles involved. Good Manufacturing Practices (GMP) and Hazard Analysis Critical Control Points (HACCP) in foods, cosmetics and pharmaceuticals.

Unit 2: QC and QA in food and beverage industry **[14L]**

Microbiological criteria of food products, beverages and water. Microbial quality assurance, monitoring of factory hygiene and sanitation, microbiological quality of ingredients, processing and finished products with regard to specified standards. Quality assurance and validation principles and their applications in industries related to food and beverage. FDA rationale, Good Practices and documentation requirements.

Unit 3: QC and QA in pharmaceutical products **[14L]**

International Biological standards, safety testing of pharmaceuticals, Quality control of antibiotics. Sterile Pharmaceutical Products: GMP aspects related to sterile products- General guidelines, personnel, building and premises, equipment, sanitation, processing, sterilization, Quality control and validation, Documentation. Introduction to Laboratory Safety, Good laboratory practices (GLP), regulatory agencies, handling & storage of chemicals, reagents, microbial specimens and its preservation.

Unit 4: Documentation, assessment and evaluation of QC/QA **[14L]**

Document preparation for QC/QA norms of different sectors. Quality control in Microbiology. Laboratory, assessment of aseptic condition, evaluation of possible channels of contamination, QC /QA norms for handling pathological samples.

Suggested Books

1. Prescott and Dunn's Industrial Microbiology, G. Reed.
2. Food Microbiology, W M Foster
3. Fermentation and Biochemical engineering., KM Ricahrd and SR Durbia

MC-21: Emerging Techniques and Trends in Microbiology
Credit: 2 (2L-0T-0P)

Course Component: Theory **Lecture Hour: 28**

Course Outcomes:

CO 1	Gain broad knowledge encompassing several new technologies that current experimental researchers are employing to probe complex system biology questions in life-sciences.
CO 2	Understand and appreciate better the basics of the new principles of current-day research tool-kit.
CO 3	Learn history, theoretical basis of latest technologies in area of biotechnology.
CO 4	Learn about various applications of these technologies.
CO 5	Get an opportunity to learn at least one application in depth through an assignment and/or seminar

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8
CO 1	3	2	3	2	2	2	3	3
CO 2	3	2	3	2	2	2	3	3
CO 3	3	2	3	2	2	2	3	3
CO 4	3	2	3	2	2	2	3	3
CO 5	3	2	3	2	2	2	3	3
Average CO	3	2	3	2	2	2	3	3

Teaching Topics:

Unit 1: Advanced Microscopy **[6L]**

Confocal microscope: scanning optical microscope, confocal principle, resolution and point spread function, light source: gas lasers & solid-state, primary beamsplitter; beam scanning, pinhole and signal channel configurations, detectors; contrast, spatial sampling: temporal sampling: signal-to noise ratio, multichannel images. Nonlinear microscopy: multiphoton microscopy; principles of two-photon fluorescence, advantages of two-photon excitation, deconvolving confocal images; image processing, three-dimensional reconstruction; advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence

Unit 2: Mass spectroscopy **[4L]**

Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.

Unit 3: Systems biology **[3L]**

High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modelling and designing testable predictions.

Unit 4: CRISPR-CAS **[4 L]**
History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for in vivo genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.

Unit 6: Nanobodies **[4L]**
Introduction to nanobodies, combining nanobody with phage-display method for development of antibody against native proteins, nanobody as a tool for protein structure-function studies, use of nanobodies for molecular imaging, catabolic antibodies using nanobodies.

Unit 7: Enzyme technology **[4L]**
Enzyme Biosensors and their Biomedical Applications. Biosensors for Environmental Monitoring. Hybrid enzymes - RNAzymes and ABzymes.

Unit 8: Tumor immunology **[5L]**
Immune surveillance; Tumor microenvironment, innate and adaptive immune response to cancer cells, tumor escape, suppression of T cell responses by T reg cells, Apoptosis of CD8+ effector T cells; Biomarkers in cancer; Approaches to cancer immunotherapy, cancer vaccines.

Suggested Books:

1. Campbell, I. D. Biophysical Techniques. Oxford: Oxford University Press.
2. Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. Methods in Molecular Biophysics: Structure, Dynamics, Function. Cambridge: Cambridge University Press.
3. Phillips, R., Kondev, J., & Theriot, J. Physical Biology of the Cell. New York: Garland Science.
4. Nelson, P. C., Radosavljević, M., & Bromberg, S. Biological Physics: Energy, Information, Life. W.H. Freeman.

MC-22: Microbiology Epilogue Credit: 2 (2L-0T-0P)

Course Component: Theory **Lecture Hour: 30**

Course Outcomes:

CO 1	Revision of biomolecules, cellular components, microbial diversity, and the central dogma of molecular biology, forming the core of biotechnological principles.
CO 2	Run through the disease and immunity, enabling the prevention, diagnosis, and treatment of diseases using biotechnological approaches.
CO 3	Explore the diversity of microorganisms and their application in agriculture, medicine and industry.
CO 4	Integrate biophysical techniques, computational analysis, and ethical considerations into biotechnological research, fostering innovation and problem-solving abilities.
CO 5	Understand ethical considerations and regulatory standards in microbiology, ensuring responsible and compliant professional practice.
CO 6	Cultivate critical thinking skills and promote innovation in biotechnological research, empowering students to address global challenges through microbiology.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8
CO 1	3	1	3	2	2	2	1	3
CO 2	3	1	3	2	2	2	1	3
CO 3	3	1	3	2	2	2	1	3
CO 4	3	1	3	2	2	2	1	3
CO 5	3	1	3	2	2	2	1	3
CO 6	3	1	3	2	2	2	1	3
Average CO	3	1	3	2	2	2	1	3

Teaching Topics:

Unit 1: [4L]
Biomolecules and their metabolism

Unit 2: [2L]
Cellular components and their activities

Unit 3: [2L]

Diversity of Microorganisms [4L]
Unit 4:
Molecular information flow through central dogma.

Unit 5: [2L]
Disease and Immunity

Unit 6: [2L]
Genes and their manipulations

Unit 7: [4L]
Biophysical techniques

Unit 8: [4L]
Computational and statistical approach to Microbiology

Unit 9: [4L]
Environment, Ecology and evolution

Unit 10: [2L]
Applied Microbiology – Industry, Medicine and Agriculture.

The mode of assessment will be on the basis of grand viva.

NM 6: Evolutionary Biology Credit: 2 (2L-0T-0P)

Course Component: Theory — Lecture Hour: 28

Course Outcomes:

CO 1	The knowledge about the theoretical framework of evolutionary biology, especially elementary concepts of natural selection, Mendelian genetics and population genetics.
CO 2	In-depth understanding about the two major evolutionary outcomes i.e., adaptation and speciation.
CO 3	The students will also learn about animal behaviour and its role in adaptation and speciation.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8
CO 1	3	1	3	2	2	2	1	3
CO 2	3	1	3	2	2	2	1	3
CO 3	3	1	3	2	2	2	1	3
Average CO	3	1	3	2	2	2	1	3

Teaching Topics:

Unit 1: History of evolutionary ideas [5L]

Theory of evolution: Lamarckism, Darwinism. Contributions of Mendel's experiments, genes as the units of heredity and sources of variations, Neo-Darwinian synthesis.

Unit 2: Evidence of evolution [3L]

Fossil records: process of fossilisation, types of fossils. Adaptive radiations, distribution of species, comparative studies, artificial selection. Domains of evolutionary biology: patterns and processes.

Unit 3: Adaptation [8L]

Concept of populations and calculation of allele frequencies in a population: Hardy-Weinberg law and equilibrium. Evolutionary forces disrupting Hardy-Weinberg equilibrium. Natural selection: definition, concept of fitness, selection coefficient, types of natural selection with examples - disrupting, stabilizing, directional. Genetic drift, basic concepts of founder's effect, bottleneck phenomenon. Sexual selection, sexual conflict and coevolution.

Unit 4: Speciation and Extinction [6L]

Species concepts and modes of speciation, isolating mechanisms and hybridisation. inter- population variations: clines, races. Concepts of neutral evolution, molecular divergence and molecular clocks. Major mass extinctions in the history of life and their impacts on biodiversity on earth.

Unit 5: Behavioural Ecology **[6L]**

Innate and learned behaviour. Social behaviour - communication, dominance, territoriality, mating systems, parental investment, biological rhythm. Methods of studying behaviour: ad libitum observations, focal animal sampling, scan animal sampling, etc.

Suggested Books

Text Books:

1. Green, N. P. O., Soper, R., Stout, G. W., Taylor, D. J. (1997). Biological Science 1 and 2. United Kingdom: Cambridge University Press.
2. Ridley, M. (2004). Evolution. Oxford: Wiley.
3. Davies, N. B., Krebs, J. R., West, S. A. (2012). An Introduction to Behavioural Ecology. United Kingdom: Wiley.

Reference Books:

1. Douglas J. Futuyma and Mark Kirkpatrick - Evolution-Sinauer Associates, INC (2017)
2. Alcock, J. (1989). Animal Behavior: An Evolutionary Approach. United States: Sinauer Associates.

ME -Project / Courses

At the final 8th semester, students may choose either a project or courses floated by the department in that semester.