Sister Nivedita University

Undergraduate course structure for Biotechnology

As per NEP 2020 regulation and according to UGC-CBCS

Course structure for

B.Sc. in Biotechnology

And

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

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

Sister Nivedita University

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Course structure for

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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			6							23
VIII		8/20	12/0								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	Basics of Microbiology	3	3	0	0
	Basics of Microbiology lab	2	0	0	4
NM 1	Introductory Virology and Biotechnology	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	Mammalian and Plant physiology	3	3	0	0
	Mammalian and Plant physiology 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	Inheritance Biology	3	3	0	0
	Inheritance Biology 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	Animal and Plant Biotechnology	3	3	0	0
	Animal and Plant Biotechnology 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	Disease and Disorders	3	3	0	0
	Disease and Disorders Lab	2	0	0	4
MC 14	Bioprocess Technology and Applications	3	3	0	0
	Bioprocess Technology and Applications 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	Ecology and Evolution	3	3	0	0
	Ecology and Evolution Project	2	0	0	4
MC 17	Pharmaceutical Science and Drug Delivery	3	3	0	0
	Pharmaceutical Science and Drug Delivery Lab	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	Developmental Biology	4	4	0	0
MC 21	Emerging Techniques and Trends in Biotechnology	2	2	0	0
MC 22	Biotechnology Epilogue	2	2	0	0
NM6	Microbial diversity and Metabolism	2	2	0	0
ME -Project / Courses	Project/ Research Design and Communication (Mandatory), [Pharmacovigilance, Bioentrepreneurship, 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 biotechnology.

Program Outcomes:

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

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

PO3: Identify and analyse problems in the area of biotechnology 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 biotechnology 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 biotechnological 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 biotechnology.

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 transdisciplinary 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.

Program Specific Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8
PSO 1	3	2	3	2	2	2	3	3
PSO 2	3	2	3	3	2	2	3	3
PSO 3	2	2	2	3	3	3	3	3
Average PSO	3	2	3	3	2	2	3	3

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, I2 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. Nelson, D.L., & Cox, M.M. (2017). Lehninger Principles of Biochemistry (7th ed.). W.H. Freeman and Company.
2. Rafi, M.D. (2019). Textbook of Biochemistry. University Press.
3. Stryer, L., Berg, J.M., & Tymoczko, J.L. (2019). Biochemistry (9th ed.). W.H. Freeman and Company.
4. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W., & Weil, P.A. (2018). Harper's Illustrated Biochemistry (31st ed.). McGraw-Hill Education.
5. Voet, D., & Voet, J.G. (2011). Biochemistry (4th ed.). Wiley.

MC 2: Basics of Microbiology
Credit: 5 (3L-0T-2P)
Course Component: Theory Lecture Hour: 36

Course Outcomes:

CO 1	Develop a better understanding about the structure of the prokaryotic cell
CO 2	Gain an overall idea about microbial growth and nutrition.
CO 3	Get an overview of the various microscopic and staining techniques.
CO 4	Understand the basic methods used for the physical and chemical control of microbes.
CO 5	Gain an insight into the structure and classification of viruses.

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: **Introduction to Microbiology** **[4L]**

History of Microbiology, The Conflict over Spontaneous Generation, Koch's Postulates.

Unit 2: Microbial Cell structure and organization **[8L]**

Bacteria: Classification, Types, Morphology (Size, Shape and Arrangement) Cell ultra-structure: Peptidoglycan structure and synthesis. Cytoplasmic matrix and components: Inclusion bodies. Reproduction and Growth (Binary Fission, Conjugation and Endospore formation) Eukaryotic microorganisms: Basic structure and function of algae, fungi and protozoa. Disease caused by them

Unit 3: Microscopy and Staining **[8L]**

Microscope-Principles, types and applications.. , Stains and Staining Solutions, Definition of Dye and Chromogen. Structure of Dye and Chromophore. Functions of Mordant and Fixative. Natural and Synthetic Dyes. Simple Staining, Differential Staining and Acid Fast Staining with specific examples

Unit 4: Microbial Cultivation and Enumeration **[10L]**

Cultivation of Microorganisms: Nutritional Requirements and Growth Factors. Classification of Organisms Based on Nutritional Types, Design and Types of Culture Media: Simple, Differential, Selective and Enriched. Concept of Isolation and Methods of Isolation. Pure Culture Techniques. Growth and Enumeration Growth Phases, Growth Curve. Arithmatic Growth and Growth Yield. Measurement of Growth. Chemostat and Turbidostat Enumeration of Microorganisms-Direct and Indirect Methods. Preservation of Cultures-Principle and Methods.

Unit 5: Sterilization Techniques [6L]

Definition: Sterilization and Disinfection. Types and Applications Dry Heat, Steam under pressure, Gases, Radiation and Filtration Chemical Agents and their Mode of Action-Aldehydes, Halogens, Quaternary Ammonium Compounds, Phenol and Phenolic Compounds, Heavy Metals, Alcohol, Dyes, and Detergents Ideal Disinfectant. Examples of Disinfectants and Evaluation of Disinfectant.

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 and fungi.
CO 5	Find how bacteria and fungi 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	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

Practicals:

1. Basic sterilization techniques
2. Pure culture techniques; Types of culture method Streak plate, Pour plate, Stab & Slant preparation
3. Isolation of bacteria
4. Gram’s staining, endospore, simple, negative.
5. Biochemical characterization of microbes

Suggested Books:

1. Willey, J.M., Sherwood, L.M., & Woolverton, C.J. (2020). Prescott's Microbiology (11th ed.). McGraw-Hill Education.
2. Pelczar, M.J., Chan, E.C.S., & Krieg, N.R. (1993). Microbiology (5th ed.). McGraw-Hill Education.
3. Tortora, G.J., Funke, B.R., & Case, C.L. (2018). Microbiology: An Introduction (12th ed.). Pearson.
4. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M., & Stahl, D.A. (2018). Brock Biology of Microorganisms (15th ed.). Pearson.

NM 1: Introductory Virology and Biotechnology
Credit: 2 (2L-0T-0P)
Course Component: Theory Lecture Hour: 24

Course Outcomes:

CO1	Describe the nature, structure, classification, and replication strategies of viruses, including bacteriophages, viroids, and prions.
CO2	Explain the applications of biotechnology in healthcare and agriculture.
CO3	Demonstrate an understanding of the tools and techniques used in genetic engineering and their applications in transgenic organisms.
CO4	Evaluate ethical, legal, and societal issues in biotechnology, including biosafety, bioethics, and intellectual property rights.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
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: Nature and Properties of Viruses [6L]

Introduction to viruses: discovery, nature, and types (viroids, prions, satellite viruses); viral origin theories. Basic structure and symmetry; enveloped vs non-enveloped forms. Methods of virus isolation, purification, and cultivation. Fundamentals of viral taxonomy. Bacteriophages: types, life cycles (lytic and lysogenic), lambda phage, gene regulation, and protein expression.

Unit 2: Virological transmission and techniques [6L]

Overview of viral transmission modes: persistent, non-persistent, vertical, and horizontal. Virus cultivation using embryonated eggs, lab animals, and cell cultures (primary, diploid, continuous). Techniques for virus detection, diagnosis, and quantification.

Unit 3: Fundamentals of Biotechnology [4L]

Concept of Biotechnology, Introduction to Vaccine, development of transgenic plants and animals, disease-resistant plants, Chimeric antibodies, Production of therapeutic proteins.

Unit 4: Tools in Biotechnology [4L]

Concept of Genetic Engineering: Definition, Tools used in recombinant DNA Technology, cloning vectors and host systems. Transgenesis: Production and significance of transgenic plants and animals. Introduction to bioinformatic tools-Basic concepts and examples.

Unit 5: Biotechnology in social welfare [4L]

Bioethics principles and frameworks, intellectual property rights in biotechnology, biosafety and risk assessment, public perception and communication of biotechnology with case studies of controversial biotechnological application.

Suggested Books:

1. Brown, T.A. (2021). Gene Cloning and DNA Analysis: An Introduction (8th ed.). Wiley-Blackwell.
2. Primack, R.B. (2020). Essentials of Conservation Biology (7th ed.). Sinauer Associates.
3. Snustad, D.P., & Simmons, M.J. (2015). Principles of Genetics (7th ed.). Wiley.
4. Dubey, R.C. (2020). A Textbook of Biotechnology. S. Chand & Company Ltd.
5. Knipe, D.M., & Howley, P.M. (Eds.). (2020). Fields Virology (7th ed.). Lippincott Williams & Wilkins.
6. Flint, S.J., Racaniello, V.R., Rall, G.F., & Skalka, A.M. (2020). Principles of Virology (5th ed.). ASM Press.
7. Dimmock, N.J., Easton, A.J., & Leppard, K.N. (2020). Introduction to Modern Virology (8th ed.). Wiley-Blackwell.

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

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, Noncompetitive - 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

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, virusinduced 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 Gprotein coupled receptors, signal transduction pathways (IP3-DAG pathway, mTOR pathway, JAKSTAT 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

Practicals:

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
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 [2L]

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) [6L]

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) [6L]

Translational machinery, charging of tRNA, aminoacyl-tRNA synthetases. Mechanisms of initiation, elongation, and termination of translation process in both prokaryotes and eukaryotes. 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: Mammalian and Plant Physiology
Credit: 5 (3L-0T-2P)
Course Component: Theory Lecture Hour: 36

Course Outcomes:

CO1	To understand the anatomical structures and physiological functions of different physiological systems.
CO2	To critically analyze and evaluate the mechanisms underlying the normal functioning of each system, as well as the pathophysiology of associated disorders, utilizing appropriate terminology and concepts.
CO3	To integrate knowledge across multiple systems to comprehend the interconnections and dependencies among different physiological processes within the human body.
CO4	Students will develop effective communication skills to convey complex physiological concepts and findings to diverse audiences, including peers, instructors, and healthcare professionals, using both written and oral formats.
CO5	To understand photosynthesis mechanisms, including light absorption, carbon fixation, and nitrogen metabolism, for applications in plant research and biotechnology.
CO6	To learn the roles and mechanisms of plant growth regulators and photoreceptors for applications in crop development and agriculture.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
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	3	3	3	3
CO 6	3	2	2	3	3	3	3	3
Average CO	3	2	1	3	3	3	3	3

Teaching Topics

Unit 1: Transport and Support Framework [8L]

Cardio-vascular System

Heart - Structure and functions, cardiac cycle, conduction system of the heart, ECG and its significance.

Circulatory system

Blood – composition and functions, blood groups. Blood Pressure – Factors affecting blood pressure, hypertension, Pulse. Overview of lymphatic system.

Musculoskeletal system

Skeletal system – Structure and functions of bones and joints. Muscular system – Skeletal, cardiac and smooth muscle structure and function.

Unit 2: Hormones and urino-genital systems [8L]

Excretory system

Structure and functions of kidney with nephron, ureter, urinary bladder, urethra. Mechanism of urine formation and its regulation, Micturition. Role of kidney in maintaining water, electrolyte and pH of blood. Acid-base balance.

Endocrine system

Hormones – Classification. Endocrine glands and their functions. Regulation of hormone secretion. Disorders of over and under secretion of hormones.

Reproductive system

Male reproductive system – Structure and functions. Spermatogenesis. Female reproductive system – Structure and functions. Oogenesis. Menstrual cycle, Puberty, Menopause. Placenta and its functions, Parturition. Physiology of lactation – Hormonal control in lactation.

Unit 3: Life-Sustaining Exchanges and Sensory Control [6L]

Respiratory system

Upper and lower respiratory organs. Mechanics of breathing. Lung volumes and capacities, gaseous exchange. Oxygen dissociation curve.

Nervous system

Central nervous system - Brain and spinal cord – structure and function, Peripheral nervous system, Autonomic nervous system – parasympathetic and sympathetic system. Special senses – vision, audition, olfaction, taste and touch.

Digestive system

Structure and functions of digestive system, movements of the digestive system. Associated organs of digestion– Liver, Gall bladder, Pancreas.

Unit 4: Transport and metabolism in plants [6L]

Water and solute transport. Photosynthesis: absorption of light, transfer of light energy, electron transport, photophosphorylation, C3, C4 and CAM pathways of carbon fixation, photorespiration. Nitrogen metabolism: Assimilatory reduction of nitrate.

Unit 5: Regulation of growth and development in plants [8L]

Plant growth regulators: Discovery, chemical nature and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid. Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins.

Component: Practical

Course Outcomes:

CO1	Histological Proficiency: Mastering microscopic examination and identification of tissues and organs.
CO2	Laboratory Skills Development: Gaining practical proficiency in histological techniques and physiological measurements.
CO3	Theory-Practice Integration: Fostering understanding of anatomical-physiological relationships through lab experiences.
CO4	Critical Analysis: Developing analytical skills to interpret experimental data and histological findings.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
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. Microscopic study of tissues and major organs of respiratory, excretory, glandular, reproductive, and digestive systems.
2. Microscopic examination of prepared slides - Fresh mount of blood and stained blood smear and identification of WBCs.
3. Blood count - red blood corpuscles count, white blood corpuscles count
4. Determination of coagulation time.
5. Recording blood pressure using sphygmomanometer, effect of exercise on pulse rate, and blood pressure.
6. Assessment of stress by determination of chlorophyll (total Chl. and Chl. a/Chl. b) and carotenoids present in leaves of the control and stressed plants.
7. To study the phenomenon of seedling growth (effect of light).
8. Separation of photosynthetic pigments by chemical methods.
9. To study the induction of hormonal activity (amylase activity) in germinating barley grains.

Suggested Books:

1. Chatterjee, C.C. (2005). Human Physiology (Vol. I & II). Medical Allied Agency, Calcutta.
2. Guyton, A.C., & Hall, J.E. (2016). Textbook of Medical Physiology (13th ed.). Elsevier.
3. Jain, A.K. (2018). Textbook of Physiology (Vol. I & II). Avichal Publishing Company, New Delhi.
4. Sembulingam, K., & Sembulingam, P. (2019). Essentials of Medical Physiology (6th ed.). Jaypee Brothers Medical Publishers.
5. Meyer, B.J., Meij, H.S., & Meyer, A.C. (2002). Human Physiology. AITBS Publishers and Distributors.

6. Taiz, L., & Zeiger, E. (2010). Plant Physiology (5th ed.). Sinauer Associates.

7. Hopkins, W.G., & Hüner, N.P.A. (2008). Introduction to Plant Physiology (4th ed.). Wiley International Edition.

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 Boos:

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: Inheritance Biology
Credit: 5 (3L-0T-2P)
Course Component: Theory Lecture Hour: 42

Course Outcomes:

CO 1	To Grasp Mendelian and non-Mendelian inheritance principles comprehensively.
CO 2	To Showcase understanding of genetic material behavior during cell division.
CO 3	Chromosome Comprehension: Demonstrate understanding of chromosome structures, banding patterns, and aberrations.
CO 4	Population Genetics Awareness: Exhibit knowledge of population genetics principles and analysis techniques.
CO 5	Microbial Genetics Proficiency: Display proficiency in genetic transfer methods and operon concepts in microbes.
CO 6	To apply knowledge effectively to analyze inheritance patterns and microbial genetics.

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: Concept of inheritance: [10L]
Mendelian inheritance: Gene, Allele, Allomorphs, Locus, Mendel's experiments and Laws: Genetic problems related to independent assortment. **Non mendelian inheritance**: Multiple Alleles, Codominance, Incomplete Dominance, Gene interaction, Pleiotropy, Penetrance and Expressivity, Epistasis. **Maternal inheritance:** Cytoplasmic and Uniparental inheritance, Inheritance of mitochondrial and chloroplast genes. **Sex linked inheritance:** X and Y linked inheritance, Sex determination.

Unit 2: Cellular pathway of inheritance: [10L]
Cellular pathway: behavior of genetic material during division. Recombination: Homologous and non-homologous recombination, Linkage, Crossing over, Gene mapping.

Unit 3: Chromosomal basis of inheritance and Community inheritance: [10L] Concept of euchromatin and heterochromatin, chromosome banding pattern, karyotype, giant chromosomes. **Chromosomal aberrations:** Structural aberration, Deletion, Duplication, inversition, transcolation (reciprocal and Robertsonian), Numerical Aberration, Anuploidy, Euploidy, Monosomy, Trisomy, Autopolyploidy, Genetic Effect and Cytology of different types of chromosomal aberration. **Population genetics**: Polygenic inheritance, Pedigree analysis, Karyotypes, In breeding and out breeding, Hardy Weinberg law (prediction, derivation).

Unit 4: Microbial genetics: **[12L]**

Methods of genetic transfers: transformation, conjugation, transduction and sex-duction, Interrupted mating. Operon: concept of operon, Lac operon: structure and regulation, Trp operon, Ara operon.

Component: Practical

Course Outcomes:

CO 1	Genetic Analysis Proficiency: Demonstrate competence in karyotyping and pedigree chart construction, understanding genetic inheritance patterns.
CO 2	Statistical Analysis Application: Apply probability and Chi-square analysis to interpret genetic data accurately, assessing significance effectively.
CO 3	Model Organism Understanding: Understand the significance of model organisms like Arabidopsis thaliana and Caenorhabditis elegans in genetic research, analyzing their genetic characteristics and implications succinctly.

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. Karyotyping with the help of photographs
2. Pedigree charts of some common characters like blood group, colour blindness and PTC tasting
3. Probability and Chi-square analysis 4. Problems with Hardy –Weinberg Laws.
5. Observation of Genetic model organisms (*Arabidopsis thaliana* and *Coenorrabditis elegans*)

Suggested Books

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2006). Principles of Genetics. VIII Edition John Wiley & Sons.
2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
4. Russell, P. J. (2009). Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis, W. H. Freeman & Co.

Semester V
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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
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. Willard, H.H., Merritt, L.L., Dean, J.A., & Settle, F.A. (1986). Instrumental Methods of Analysis (7th ed.). CBS Publishers and Distributors.
2. Freifelder, D. (1982). Physical Biochemistry: Applications to Biochemistry and Molecular Biology (2nd ed.). W.H. Freeman and Company.
3. Volkenshtein, M.V. (1977). General Biophysics (Vol. I & II). Academic Press.
4. Pullman, B., & Voinov, M. (1981). Molecular Biophysics. Springer.
5. Upadhyay, A., Upadhyay, K., & Nath, N. (2005). Biophysical Chemistry (3rd ed.). Himalaya Publishing House.
6. Mahes, S. (2003). Biophysics. New Age International (P) Ltd.

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

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

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
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	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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
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: Animal and Plant Biotechnology
Credit: 5 (3L-0T-2P)
Course Component: Theory Lecture Hour: 36

Course Outcomes:

CO 1	Identify the important milestones in the plant tissue culture and learn the concepts and principles of plant tissue culture, including techniques of sterilization and media preparation.
CO 2	Understand and describe the different pathways of plant regeneration, including, micropropagation, culturing of virus-free plants, methods to conserve germplasm and application of the plant genetic engineering in agriculture.
CO 3	Understand the concept and principles of animal cell culture, including, basic techniques of mammalian cell cultures and maintenance of cell culture.
CO 4	Identify and acquire skills on methods for embryo technology and animal breeding and learn applications and importance of animal biotechnology in human welfare.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
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: Introduction to Plant Biotechnology [2L]

History of PTC, Concept of Cellular Totipotency. Laboratory Organization, Sterilization Techniques, Media Preparation. Types of media – MS, Nitsh, Gamborgs. Plant growth regulators

Unit 2: Plant tissue culture [8L]

Plant Gene Expression Cassettes – Selectable Marker, Reporter Genes, Promoters in Plant Vectors. Transposons in plants, Crop improvement through genetic engineering: Insect Resistance, Virus Resistance, Herbicide Resistance, Bacterial Resistance, Stress (Biotic & Abiotic) Resistance. Cytoplasmic Male Sterility, Generation of Marker free Plant. GMO and ehthical issue.

Unit 3-Plant genetic engineering [8L]

Plant Gene Expression Cassettes – Selectable Marker, Reporter Genes, Promoters in Plant Vectors. Transposons in plants,.

Genetic engineering of plants – Insect Resistance, Virus Resistance, Herbicide Resistance, Bacterial Resistance, Stress (Biotic & Abiotic) Resistance.

Unit 4: Introduction to animal biotechnology [3L]

History and Scope of Animal tissue culture. Design & layout of ATC laboratory. Requirements for Animal cell culture. Types of media, ingredients of media. Foetal Bovine Serum.

Unit 5: Animal Cell Culture [8L]

Basic Techniques of mammalian cell culture, Disaggregation of animal tissue. Primary culture & secondary culture. Evolution of cell line and continuous cell line, Characterization of cell lines. Monolayer, suspension culture. Organ culture, Embryo culture. Maintenance of cell culture. Common cell culture contaminants

Unit 6: Animal breeding and application of animal biotechnology [7L]

Embryo Technology and Animal Breeding: Invitro fertilization, Embryo transfer, ICSI, Embryo splitting, Fertility control and regulation, test tube babies. Cell cloning methods. Applications of animal tissue culture for invitro testing of drugs. Production of transgenic animals & molecular pharming, animal cloning techniques. Cell culture based vaccines. Ethical values in animal biotechnology.

Component: Practical

Course Outcomes:

CO 1	Master the preparation of MS media and establishment of shoot tip cultures, essential for plant tissue culture techniques.
CO 2	Demonstrate expertise in isolating protoplasts enzymatically and separating chlorophyll A and B using column chromatography.
CO 3	Exhibit competence in preparing animal cell culture media, culturing chick embryo fibroblasts, and managing adherent and suspension cell cultures effectively.
CO 4	Show proficiency in transfection techniques for animal and plant cells and conduct viability tests and accurate cell counting, crucial for genetic manipulation and cell health assessment

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
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
CO 4	3	3	2	3	2	3	3	3
Average CO	3	3	2	3	2	3	3	3

Practicals:

1. Design and layout of plant and animal cell culture lab
2. MS media preparation and establishment of shoot tip culture using MS medium
3. Agrobacterium culture and its co cultivation with plant cell
4. Shoot tip culture and Callus culture
5. Preparation and sterilization of complete animal cell culture media
6. Culture of chick embryo fibroblast (monolayer)
7. Culture and subculture of adherent cell and suspension cell

Suggested Books:

1. Chawla, 2003. Introduction to Plant Biotechnology (2ndedn) Oxford and IBH Publishers
2. R.C. Dubey, A Text Book of Biotechnology. S. Chand & Co Ltd, New Delhi.
3. Chrispeel M.J, Sadava D.E.1994. 2nd Revised edition, Plants, Genes and Agriculture, Jones and Barlett Publication, Boston.
4. Satyanarayana. U,2008, Biotechnology, Books and Allied (p) Ltd 5. Ramawath,2003. Plant biotechnology, S. Chand and Co, edition 2.
5. M. Ranga,2006. Animal Biotechnology, Studam publishers.
6. R. Sasidhara 2006.Animal Biotechnology, MJP Publishers

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

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

Course Outcome:

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, Fstatistics, 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: Disease and Disorders
Credit: 5 (3L-0T-2P)

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

Course Outcomes:

CO 1	Understand the historical contributions and modern principles of medical microbiology, including key figures, germ theory, and viral discovery.
CO 2	Explore the human microbiome, its significance, and interactions with pathogens. Comprehend infection dynamics, transmission routes, and the impact of probiotics on human health.
CO 3	Identify major bacterial, viral, protozoan, and fungal diseases, and their characteristics. Learn about disease symptoms, transmission modes, and preventive measures.
CO 4	Gain insight into epidemiological concepts and surveillance methods, including frequency measurement, epidemic types, and pathogen evolution.
CO 5	Understand the mechanisms of action of antimicrobial agents and the development of resistance. Explore strategies for combating antibiotic resistance and managing infectious diseases effectively.
CO 6	Gain knowledge of cancer biology, including tumor development, metastasis, and critical genes. Understand the principles and applications of cancer immunotherapy for personalized treatment approaches.
CO 7	Develop skills in sample collection, transportation, and laboratory diagnosis of infectious diseases. Learn to recognize diagnostic characteristics crucial for accurate disease identification and management.

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
CO 6	2	3	2	3	-	-	2	3
CO 7	2	3	2	3	-	-	3	3
Average CO	2	3	2	3	1	-	2	3

Teaching Topics:

Unit 1: History of medical microbiology: **[3L]**
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:** **[6 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: [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 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. [5L]

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 [5L]

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

Unit 9: Sample collection, transport and diagnosis [4L]

Collection, transport and culturing of clinical samples and their identification characteristics

Component: Practical

Course Outcomes:

CO 1	Master the identification of common bacteria using cultural, morphological, and biochemical tests.
CO 2	Understand the composition and utility of key differential media for bacterial identification.
CO 3	Develop practical skills in microbial sampling, particularly in studying skin bacterial flora.
CO 4	Learn techniques for antibiotic sensitivity testing, enabling evaluation of bacterial susceptibility and resistance.

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. 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 14: Bioprocess Technology and Applications
Credit: 5 (3L-0T-2P)

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

Course Outcomes:

CO 1	Understand the basics of industrial processes, product classes, and the role of microorganisms.
CO 2	Learn about microbial utilization in various industrial processes, enhancing knowledge of fermentation and product synthesis.
CO 3	Develop proficiency in designing media and sterilization techniques crucial for industrial fermentation.
CO 4	Understand the kinetics of microbial growth and product formation, essential for process optimization.
CO 5	Gain insights into fermenter design, mass transfer principles, and fermentation types used in biotechnology.
CO 6	Acquire knowledge of purification techniques such as centrifugation and chromatography for product isolation and quality assurance.

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	3	3	3	3
CO 6	3	2	2	3	3	3	3	3
CO 7	3	2	2	3	3	3	3	3
Average CO	3	2	1	3	3	3	3	3

Teaching Topics:

Unit 1: **[6 L]**

Introduction: Prerequisites of practical industrial processes, Major classes of products and processes, Microorganisms used in industrial processes.

Unit 2: **[8 L]**

Industrial application of microbes: Industrial use of bacteria (Lactic acid production, acetic acid production, amino acid production, Insulin production), Industrial use of yeast (Alcohol fermentation Baker's yeast, Food yeast), Industrial use of molds (Penicillin production, citric acid production, enzyme production), microbes in petroleum industry and mining industry.

Unit 3: **[8L]**

Media design and sterilization: Designing of media for fermentation process, Types of media, design and usage of various commercial media for industrial fermentation, Sterilization of media, thermal death time, decimal reduction time, design of sterilization equipment.

Unit 4: **[8L]**

Kinetics of microbial growth: Phases of cell growth in batch culture, simple unstructured kinetic models of microbial growth, Monod model, Growth associated and non-growth associated product formation kinetics, Leudking-Piret model.

Unit 5: **[8L]**

Fermentation process: Different types of fermentations, Mass transfer, Basic design and construction of fermenter and ancillaries, An overview of aerobic and anaerobic fermenters and their application in biotechnology industry, solid-substrate fermentation and its applications.

Unit 6: **[4 L]**

Downstream processing: Introduction to different types of downstream processing, Principles of centrifugation, filtration, chromatography (Partition chromatography, size exclusion chromatography, HPLC, GC)

Component: Practical

Course Outcomes:

CO 1	Understand the production of cellulose, protease, gelatinase, and catalase by microorganisms for industrial applications.
CO 2	Explore the effects of dye and pH on bacterial growth, vital for optimizing production processes.
CO 3	Develop proficiency in operating bioreactors and fermenters, essential for scaling up microbial production.
CO 4	Gain insight into specific microbial products like penicillin and alcohol, enhancing understanding of their production processes and industrial use.

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. Cellulose, Protease and Gelatinase production by microorganisms
2. Catalase production by microorganisms 3. Effect of dye on bacterial growth-crystal violet
4. Effect of pH on bacterial growth.

5. Bioreactor / laboratory Fermenter demonstration.
6. Penicillin production
7. Alcohol Fermentation

Suggested Books:

1. 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: Ecology and Evolution Credit: 5 (3L-0T-2P)

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

Course Outcomes

CO 1	Grasp the historical evolution of ideas from Lamarckism to Neo-Darwinian synthesis, and comprehend the evidence supporting evolution.
CO 2	Understand the mechanisms of adaptation through natural selection, genetic drift, and sexual selection, along with the concepts of speciation and extinction.
CO 3	Explore population ecology, community structure, and interactions, including behavioral ecology aspects and ecosystem dynamics.
CO 4	Apply ecological knowledge to address real-world challenges like climate change, biodiversity loss, and wildlife conservation through management strategies and legislation.

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: 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 [6L]

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 [4L]

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: Introduction to ecology [2L]

Levels of biological organization, history of ecology, definition of ecology: species interactions, distribution and abundance

Unit 6: Population ecology [8L]

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, LotkaVolterra equation for competition.

Unit 7: Behavioural Ecology [4L]

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.

Unit 8: Community ecology and ecosystem ecology [6L]

Community: Concept, definition and characteristics – biodiversity and ecological succession Biodiversity: Types of biodiversity, utilization of biodiversity, measures of biodiversity: species richness, relative abundance, vertical stratification, zonation, ecotone and edge effect. Succession: Models and mechanisms. Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. Energy flow in ecosystems, nutrient cycling, trophic levels and food webs.

Unit 9: Applied Ecology [4L]

Climate change, biodiversity extinction and conservation strategies. Management strategies for tiger conservation, Wildlife Protection Act (1972)

Component: Project

Course Outcomes:

CO 1	Gain deeper understanding of ecology and evolution through practical experiences.
CO 2	Apply theoretical knowledge to real-world ecological and evolutionary 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. Green, N. P. O., Soper, R., Stout, G. W., Taylor, D. J. (1997). Biological Science 1 and 2.
2. Krebs, Charles J – Ecology: the experimental analysis of distribution and abundance-Pearson
3. Ridley, M. (2004). Evolution. Oxford: Wiley.
4. Davies, N. B., Krebs, J. R., West, S. A. (2012). An Introduction to Behavioural Ecology. United Kingdom: Wiley.
5. Michael Begon, Robert W. Howarth, Colin R. Townsend. 2014. Essentials of Ecology-Wiley.
6. Ellison, Aaron M., Gotelli, Nicholas J - A primer of ecological statistics-Sinauer Associates, Inc., Publishers (2018).
7. Primack, R. B., Sher, A. (2016). An Introduction to Conservation Biology. United States: Sinauer.
8. Kamaljit S. Bawa, Meera Anna Oommen, and Richard B. Primack. 2011. Conservation Biology: A Primer for South Asia.
9. Douglas J. Futuyma and Mark Kirkpatrick - Evolution-Sinauer Associates, INC (2017).
10. Alcock, J. (1989). Animal Behavior: An Evolutionary Approach. United States: Sinauer Associates.

MC 17: Pharmaceutical Science and Drug delivery
Credit: 5 (3L-0T-2P)

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

Course Outcomes:

CO 1	The basic principles of pharmacology including different types of drugs formulations and their respective advantages and disadvantages, various routes of drug administration and their respective advantages and disadvantages for specific therapeutic indications, various factors that affect drug absorption, drug distribution and drug excretion.
CO 2	The basics of pharmacokinetics including acronym ADME (Absorption, Distribution, Metabolism and Elimination), the chemical characteristics of drugs (e.g. solubility, pKa) and other factors (e.g. regional differences in blood flow, transporters, non-specific binding) that influence drug absorption.
CO 3	The basics of pharmacodynamics including the relationship between drug dose (or concentration), receptor occupation and biological response, drug selectivity, potency, efficacy, full and partial agonism and neutral and negative antagonism.
CO 4	Understanding on the various stages of drug discovery, lead seeking method and lead optimization.
CO 5	The various approaches for development of novel drug delivery systems.
CO 6	The formulation and evaluation of Novel drug delivery systems.

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: Introduction to drug discovery **[2L]**
Drug Discovery, Drug Development, Source of Drugs, Structural effects on drug action.

Unit 2: Approaches to New Drug Discovery **[4L]**
Drugs Derived from Natural Products, Existing Drugs as a Source for New Drug Discovery, Screening for New Drug Leads, Modern "Rational Approach" to Drug Design, Approaches to Lead Optimization:

Unit 3: Enzymes as Targets of Drug Design **[2L]**
Enzyme kinetics, Enzyme inhibition and activation, Approaches to the Rational Design of Enzyme Inhibitors

Unit 4: Receptors as Targets of Drug Design [6L]

Receptor Theory, Receptor Complexes and Allosteric Modulators, Second and Third Messenger Systems, Molecular Biology of Receptors, Receptor Models and Nomenclature, Receptor Binding Assays, Lead Compound Discovery of Receptor agonists and antagonists

Unit 6: Pharmacokinetic characterization of drugs [10L]

Pharmacokinetics of drugs following one/ two compartment open models with first order elimination kinetics as applied to rapid intravenous injection, Intravenous transfusion and oral administration. Determination of absorption rate constant using Wagner-Nelson, Loo Riegelman methods. Flip-flop models, method of residual. Urinary excretion data and its application in pharmacokinetic characterization of drugs. Pharmacokinetics of multiple dosing. Physiologic pharmacokinetics models: Mean Residence Time; Statistical Moment Theory; Application and limitations of physiologic pharmacokinetic models.

Unit 7: Pharmacodynamics [8L]

Principles of drug action, Mechanism of drug action, Receptors - Agonist, partial agonist, inverse agonist, antagonist, Receptors - Transducer mechanism. Dose-response relationship, Drug efficacy & potency, Therapeutic index, LD 50 & ED 50, Synergism and Drug antagonism. Factors modifying drug action.

Unit 8: Controlled drug delivery systems [10L]

Introduction, terminology/definitions and rationale, advantages, disadvantages, selection of drug candidates. Approaches to design controlled release formulations based on diffusion, dissolution and ion exchange principles. Physicochemical and biological properties of drugs relevant to controlled release formulations.

Polymers: Introduction, classification, properties, advantages and application of polymers in formulation of controlled release drug delivery systems. Targeted drug Delivery: Concepts and approaches advantages and disadvantages, introduction to liposomes, niosomes, nanoparticles, monoclonal antibodies and their applications.

Component: Practical

Course Outcomes:

CO 1	Gain hands-on experience in preparing diverse pharmaceutical formulations, from simple syrups to nanoparticle formulations.
CO 2	Develop skills in analyzing pharmaceutical products, including estimating active ingredient content and measuring entrapment efficacy.
CO 3	Learn and apply GLP principles to ensure accuracy and safety in formulation preparation and analysis.
CO 4	Improve research abilities through experiment conduction, data analysis, and interpretation, contributing to pharmaceutical science advancements.

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. Preparation of 30 ml of Simple Syrup IP.
2. Preparation of Elixir
3. Preparation of aqueous iodine solution. 4. Preparation of 30ml of Calamine lotion.
5. Preparation of 30gm of Dusting powder.
6. Preparation of Tetracycline Capsule IP
7. Estimation of paracetamol content in different Brands of Paracetamol capsules available in market.
8. Preparation of Chitosal Nanoparticle formulation and measurement of Entrapment efficacy.
9. Preparation of Silver Nanoparticle formulations with different reducing agents and measurement of Entrapment efficacy.
10. Preparation of Liposomal Formulation of any standard bioflavonoid and measurement of Entrapment efficacy.

Suggested Books:

1. Essentials of Medical Pharmacology – K.D Tripathi
2. A test book of Pharmaceutical Analysis – Kenneth A conners
3. Drug Design – B. Razdan
4. Drug carriers for vascular drug delivery. Koren E, Torchilin VP. IUBMB Life. 2011 Aug;63(8):

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 GenomesThe origins of organelle genomes, Physical features of organelle genomes, The genetic content of organelle genomes

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 twohybrid 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: Developmental Biology
Credit: 4 (4L-0T-0P)

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

Course Outcomes:

CO 1	Explore the fundamentals of development and evolution, including sexual and asexual reproduction, life cycles, and homology.
CO 2	Understand potency, induction, competence, and differentiation, along with morphogenetic gradients and stem cell biology.
CO 3	Study gametogenesis, fertilization, and early embryonic development, including germ layer formation and organogenesis.
CO 4	Examine pattern formation, organ development, and neuronal differentiation in animals.
CO 5	Learn about ovule development, pollination, fertilization, and seed/fruit development in plants.
CO 6	Explore programmed cell death, aging, and senescence in organisms.

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
CO 5	3	2	1	2	2	2	3	3
CO 6	3	2	1	2	2	2	3	3
Average CO	3	2	1	2	2	2	3	3

Teaching Topics:

Module I

Unit 1: **[8L]**

Development and evolution: Sexual reproduction and asexual reproduction, life cycle, homology, recapitulation theory.

Unit 2: **[8L]**

Basic concepts of development: Potency, induction, competence, differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells.

Unit 3: **[10L]**

Gametogenesis, fertilization, placenta formation and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development; zygote formation, cleavage, blastulation, gastrulation and formation of germ layers in animals.

Module II

Unit 1: **[10L]**

Morphogenesis and organogenesis in animals: Axes and pattern formation in Drosophila, amphibian and chick; organogenesis-vulva formation in Caenorhabditis elegans, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons.

Unit 2: **[10L]**

Plant developmental biology: Development of ovule, pollination, fertilisation, development of seeds and fruits.

Unit 3: **[10L]**

End of development and aging: Programmed cell death, aging and senescence.

Suggested Books:

1. Gilbert, S. F. (2014). Developmental biology (10th ed.). Sinauer Associates.
2. Wolpert, L., Tickle, C., & Martinez Arias, A. (2015). Principles of development (5th ed.).
3. Slack, J. M. W. (2013). Essential developmental biology (3rd ed.). Wiley-Blackwell.
4. Scott F. Gilbert, Michael J. F. Barresi, & Brigitte Boisselier (2016). Developmental Biology. Sinauer Associates.
5. Hardin, J., Bertoni, G., & Kleinsmith, L. J. (2015). Becker's world of the cell (9th ed.). Pearson.

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

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

Course outcomes:

CO 1	Learn confocal microscopy principles, advanced fluorescence techniques, and image processing.
CO 2	Gain expertise in ionization methods, mass analyzers, and proteomics applications.
CO 3	Explore high throughput screening, bioinformatics, and mathematical modeling for testable predictions.
CO 4	Understand CRISPR-CAS mechanisms and applications in genome engineering and therapeutics.
CO 5	Discover nanobodies' role in antibody development, molecular imaging, and protein studies.
CO 6	Explore enzyme biosensors, hybrid enzymes, and tumor immunology for cancer therapy.

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
CO 6	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 twophoton 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 [3L]

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,

MC-22: Biotechnology 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 biotechnological applications in pharmaceutics and agriculture, contributing to advancements in healthcare and food production.
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 biotechnology, 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 biotechnology.

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

Unit 4: **[4L]**
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 Biotechnology

Unit 9: **[4L]**
Development of animal and plant system

Unit 10: **[2L]**
Applied Biotechnology – Pharmaceutics and Agriculture.

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

NM 6: Microbial Diversity and Metabolism
Credit: 2 (2L-0T-0P)

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

Course Outcomes:

CO 1	Understand diverse microbial groups like Archaebacteria, extremophiles and photosynthetic eubacteria.
CO 2	Learn unique adaptations and metabolic pathways of microorganisms to extreme environments.
CO 3	Explore taxonomic classification and metabolic features of various microbial groups.
CO 4	Endospore Formation and Gliding Mechanisms: Study endospore formation, gliding mechanisms, and characteristics of mollicutes.
CO 5	Actinomycetes and Eukaryotic Microbiology: Gain insights into Actinomycetes, protozoa, algae, and fungi morphology and cellular activities.

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
Average CO	3	1	3	2	2	2	1	3

Teaching Topics:

Unit 1: Archaebacteria and Extremophilic bacteria: [4 L]

Characteristics of Archaebacteria, different classes of Archaebacteria, Methanogens: cell structure and energy metabolism, Halophiles: cell structure and metabolism, Thermoacidophiles: Sulfolobus, Thermoplasma and Thermoproteus group. Bacteria of extreme environments, Thermophilic, Psycrophilic, Acidophilic, Alkaliphilic, Halophilic, Osmophilic, Barophilic, Xerophilic, Radiorasistant and Hypolith.

Unit 2: Photosynthetic eubacteria: [4L]

Cyanobacteria: Nitrogen fixation, anoxygenic photosynthesis, pigment synthesis, different groups of Cyanobacteria, Purple bacteria: purple sulfur bacteria and purple non-sulfur bacteria, Green bacteria: green sulfur bacteria and green non-sulfur bacteria.

Unit 3: Chemoautotrophic and Methophilic bacteria: [4 L]

Nitrifying bacteria, Sulfur oxidizers, Iron bacteria, Hydrogen bacteria, Carboxydobacteria, Chemolithotrophic bacteria, Methophilic bacteria: metabolism and carbon assimilation, methanotrophs and methylotrophs.

Unit 4: Gram negative aerobic and anaerobic bacteria: [4 L]
Aerobic Pseudomonads, *Rhizobium* group, Prosthecate bacteria, *Azotobacter* group, Acetic acid bacteria, Sheathed bacteria, Spirillum group. Gram negative fermentative bacteria: Fumarate respiration, Nitrate respiration, different groups of Gram negative anaerobic bacteria.The Spirochetes, The Rikettsias, The Chlamydias.

Unit 5: Gliding eubacteria, Endospores forming bacteria and The Mollicutes: [4 L] Myxobateria, Cytophaga group, Filamentous gliding chemoheterotrophs. The aerobic spore forming bacteria and the anaerobic spore forming bacteria. Cellular structure, reproduction, metabolism, *Mycoplasma, Acholeplasma, Spiroplasma, Anaeroplasma, Ureaplasma.*

Unit 8: The Actinomycetes: [4 L]
Characteristics of Actinomycetes: Motility, cell wall structure, mycelia actinomycetes, major groups of actinomycetes.

Unit 7: Eukaryotic Microbiology [4L]
Morphology and cellular activity of Protozoa, Algae and Fungi.

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.

ME -Project / Courses

At the final 8th semester, students may choose either a project or courses floated by the department in that semester. Project/ Research Design and Communication (Mandatory), [Pharmacovigilance, Bio-entrepreneurship, Molecular Diagnostics, Biosafety and Public health (Any 2)]

ME Project
Credit: 12 (0L-0T-24P)

Course Component: Practical **Lecture Hour: 48**

ME Courses (Mandatory)
Research Design And Communication
Credit: 4 (4L-0T-0P)

Course Component: Theory **Lecture Hour: 48**

CO 1	Understand and comprehend the basics in research methodology and applying them in research/ project work.
CO 2	Select an appropriate research design.
CO 3	Able to take up and implement a research project/ study.
CO 4	Collect the data, edit it properly and analyse it accordingly. Thus, it will facilitate students' prosperity in higher education.
CO 5	Develop skills in qualitative and quantitative data analysis and presentation.
CO 6	Demonstrate the ability to choose methods appropriate to research objectives.

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	3	3	3	3	3	3	3
Average CO	3	2	3	3	3	3	2	3

Unit 1: Foundations of Research: **[6L]**

This section covers the meaning, objectives, motivation, and utility of research. It explores the concept of theory, the role of empiricism, and differentiates between deductive and inductive approaches to theory. Additionally, it discusses the characteristics of the scientific method, emphasizing the language of research with key terms such as concept, construct, definition, and variable. It also explains the overall research process.

Unit 2: Problem Identification and Formulation: **[6L]**

This focuses on identifying and formulating research problems, including the development of research questions and investigative questions. It also addresses measurement issues, the formation of hypotheses, the qualities of a good hypothesis, and the distinctions between null and alternative hypotheses. The logic and importance of hypothesis testing are also discussed.

Unit 3: Research Design: **[10L]**

This section emphasizes the concept and importance of research design, along with the features that define a good design. It explores exploratory research designs, including their concepts, types, and uses, as well as descriptive research designs with a focus on their concepts, types, and uses. The experimental design process, particularly the roles of independent and dependent variables, is also covered.

Unit 4: Qualitative and Quantitative Research: **[6L]**
This discusses the concepts of qualitative and quantitative research, including measurement, causality, generalization, and replication. It also covers the merging of these two research approaches.

Unit 5: Measurement: **[4L]**
This explores the concept of measurement, identifying what is measured in research, and the common problems encountered, such as validity and reliability. It introduces the levels of measurement: nominal, ordinal, interval, and ratio.

Unit 6: Sampling: **[2L]**
This section explains the concepts related to sampling, including statistical population, sample, sampling frame, sampling error, sample size, and non-response. It outlines the characteristics of a good sample and discusses probability sampling techniques like simple random sampling, systematic sampling, stratified random sampling, and multi-stage sampling. Additionally, it covers considerations for determining sample size.

Unit 7: Data Analysis: **[4L]**
This part covers data preparation and different analysis methods. It includes univariate analysis techniques like frequency tables, bar charts, pie charts, and percentages. Bivariate analysis is discussed through cross-tabulations and the Chi-square test, including hypothesis testing for associations.

Unit 8: Paper Writing: **[6L]**
This explains how to interpret data and write research papers. It covers the layout of a research paper, journals in specific disciplines such as Computer Science, and how to assess journal impact factors. It also discusses when and where to publish, along with ethical issues related to publishing, including plagiarism and self-plagiarism.

Unit 9: Using Research Resources: **[2L]**
This section highlights the use of encyclopedias, research guides, handbooks, and academic databases in disciplines like Computer Science.

Unit 10: Research Tools and Techniques: **[2L]**
This final section discusses methods for searching required information effectively, using reference management software such as Zotero or Mendeley, formatting software like LaTeX or MS Office, and plagiarism detection tools.

ME Courses (Optional)
Bioentrepreneurship
Credit: 4 (4L-0T-0P)

Course Component: Theory Lecture Hour: 48

Course Outcomes:

CO1	Write, and critically review a business plan
CO2	To acquaint the students about the role of entrepreneurship in the growth and economic development of the nation
CO3	Know the importance of bioethics, biosafety and IPR

Unit: 1 Basics of Bioentrepreneurship [13L]

Introduction to bioentrepreneurship – Biotechnology in a global scale, Scope in Bioentrepreneurship, Importance of entrepreneurship. Meaning of entrepreneur, function of an entrepreneur, types of entrepreneur, and advantages of being entrepreneur. Innovation – types, out of box thinking, opportunities for Bioentrepreneurship. Entreprenuership development programs of public and private agencies (MSME, DBT, BIRAC, Startup and Make in India). Patent landscape, IP protection and commercialization strategies. Global bio business and industry future trends.

Unit: 2 Knowledge Centre and R&D [13L]

Knowledge centers Universities, innovation centre, research institutions and business incubators. R&D - technology development and upgradation, assessment of technology development, managing technology transfer, industry visits to successful bio-enterprises, regulations for transfer of foreign technologies, quality control, technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GLP, GCP & GMP)

Unit 3: Entrepreneurship Opportunity In Industrial Biotechnology [12L]

Business opportunity, Essential requirement, marketing, strategies, schemes, challenges and scope-with case study on Plant cell and tissue culture technique, polyhouse culture. Herbal bulk drug production, Nutraceuticals, value added herbal products. Bioethanol production using Agri waste, Algal source. Integration of system biology for agricultural applications. Biosensor development in Agri management. Pesticides, Herbicides etc. Integrated compost production- microbe enriched compost. Bio pesticide/insecticide production. Fermented products-probiotic and prebiotics. contract research

Unit 3: Entrepreneurship Journey [10L]

Success story and failure story of different entrepreneur around the globe.

ME Courses (Optional)
Pharmacovigilance
Credit: 4 (4L-0T-0P)

Course Component: Theory **Lecture Hour: 48**

Course Outcomes:

CO1	Understand the foundational concepts of pharmacovigilance, including the history and importance of drug safety monitoring, global and national pharmacovigilance programs, the identification and management of adverse drug reactions (ADRs), and the key terminologies used in the field
CO2	Understand drug and disease classification systems, standardization practices, and the role of drug dictionaries and coding in pharmacovigilance, along with the ability to establish and manage pharmacovigilance programs in various settings.
CO3	Analyze vaccine safety through various surveillance methods and effectively communicate safety findings and crisis management to stakeholders.
CO 4	Understand and apply safety data generation processes and ICH guidelines for pharmacovigilance across different phases of drug development and post-approval monitoring.
CO 5	Analyze the impact of genetics on adverse drug reactions, evaluate drug safety in special populations, and understand regulatory frameworks and differences in pharmacovigilance practices in India and globally.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	3	3	3	3	2
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	3
CO4	3	2	3	3	2	3	3	3
CO5	3	3	3	3	2	2	3	3
Ave CO	3	3	3	3	3	3	3	3

Unit 1: Introduction to Pharmacovigilance

Overview of Pharmacovigilance: Exploration of the history and evolution of pharmacovigilance, highlighting the critical role of medicine safety monitoring. Global and National Pharmacovigilance Initiatives: Detailed examination of the WHO International Drug Monitoring Programme and the Pharmacovigilance Program of India (PvPI). Understanding Adverse Drug Reactions (ADRs): Definitions and classifications of ADRs, with a focus on the processes of detection and reporting. Causality Assessment in ADRs: Introduction to various methods used in causality assessment, including severity, seriousness, predictability, and preventability evaluations. Management of Adverse Drug Reactions: Strategies and approaches for managing ADRs effectively. Fundamental Terminologies in Pharmacovigilance: A study of key terminologies related to adverse medication events and regulatory language used in pharmacovigilance.

Unit 2: Drug and Disease Classification

Classification Systems for Drugs: Examination of the anatomical, therapeutic, and chemical classifications of drugs, including the international classification of diseases. Standardization in Pharmacology: Overview

of daily defined doses and the use of international non-proprietary names (INNs) for drugs. Drug Dictionaries and Coding in Pharmacovigilance: Introduction to the WHO adverse reaction terminologies, MedDRA (Medical Dictionary for Regulatory Activities), standardized MedDRA queries, WHO drug dictionary, and the EudraVigilance medicinal product dictionary. Information Resources in Pharmacovigilance: Exploration of essential drug information resources and specialized databases for adverse drug reactions (ADRs). Establishing Pharmacovigilance Programs: Guidelines for setting up a pharmacovigilance program within a hospital, the establishment and operation of a drug safety department in the pharmaceutical industry, the role of Contract Research Organizations (CROs), and the creation of a national pharmacovigilance program.

Unit 3: Vaccine Safety Surveillance

Vaccine Safety Monitoring: Analyzing vaccine safety through pharmacovigilance, focusing on identifying vaccine failures and monitoring adverse events that occur post-immunization. Pharmacovigilance Approaches: Passive Surveillance: Collecting data through spontaneous reporting and compiling case series. Stimulated Reporting: Methods to actively encourage the reporting of vaccine-related adverse events. Active Surveillance: Systematic data collection through sentinel sites, drug event monitoring programs, and registries. Observational Studies in Pharmacovigilance: Utilizing cross-sectional studies, case-control studies, and cohort studies to assess and compare vaccine safety. Focused Clinical Investigations: Conducting targeted studies to explore specific safety concerns related to vaccines. Communication in Pharmacovigilance: Effective Communication Strategies: Ensuring clear and accurate communication in all pharmacovigilance activities. Crisis Management Communication: Handling communication effectively during drug safety crises. Stakeholder Communication: Engaging with regulatory agencies, business partners, healthcare providers, and the media to ensure transparency and trust.

Unit 4: Safety Data Generation and Guidelines

Safety Data Collection: Preclinical Phase: Safety assessments conducted before clinical trials. Clinical Phase: Safety monitoring during clinical trials. Post-Approval Phase: Ongoing safety surveillance after drug approval (Pharmacovigilance Studies). ICH Guidelines for Pharmacovigilance: Overview of ICH: Structure and goals of the International Council for Harmonisation (ICH) regarding pharmacovigilance. Expedited Reporting: Procedures for rapid reporting of serious adverse events. Individual Case Safety Reports: Guidelines for documenting and reporting individual adverse drug reactions. Periodic Safety Update Planning: Strategies for regular safety updates throughout the drug lifecycle. Good Clinical Practice (GCP): Standards for conducting pharmacovigilance studies to ensure reliability and safety.

Unit 5: Advanced Topics in Pharmacovigilance

Pharmacogenomics of Adverse Drug Reactions: Exploring how genetic factors influence adverse drug reactions (ADRs), with a focus on pharmacokinetic (PK) parameters and related examples. Drug Safety in Special Populations: Pediatrics: Safety considerations for drug use in children. Pregnancy and Lactation: Evaluating drug safety during pregnancy and breastfeeding. Geriatrics: Assessing drug safety in elderly populations. CIOMS Guidelines: CIOMS Working Groups: Overview of the Council for International Organizations of Medical Sciences (CIOMS) working groups and their contributions. CIOMS Form: Understanding the CIOMS reporting form for adverse drug reactions. Pharmacovigilance in India: D&C Act and Schedule Y: Regulatory framework under the Drugs and Cosmetics Act and Schedule Y related to pharmacovigilance in India. Comparing Indian and Global Standards: Identifying differences between Indian and international pharmacovigilance requirements.

ME Courses (Optional)
Molecular Diagnostics
Credit: 4 (4L-0T-0P)

Course Component: Theory **Lecture Hour: 48**

Course Outcome

CO1	Develop a foundational understanding of the principles and importance of molecular diagnostics, including the role of DNA, RNA, and proteins in diagnostic processes.
CO2	Gain hands-on experience and theoretical knowledge of key molecular biology techniques, including PCR, DNA/RNA sequencing, and protein analysis methods, for diagnostic purposes.
CO3	Learn to apply molecular diagnostic techniques in clinical settings for diagnosing infectious diseases, genetic disorders, and cancer, with insights into personalized medicine and emerging technologies.
CO 4	Acquire skills in laboratory practices, including safe sample handling, quality assurance, and troubleshooting, ensuring accurate and reliable diagnostic outcomes.
CO 5	Analyze case studies and tackle real-world challenges in molecular diagnostics, developing critical thinking and problem-solving abilities related to the use of these techniques in healthcare.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	1	1	3	3	2
CO2	3	3	3	1	1	3	3	2
CO3	3	3	3	1	1	3	3	3
CO4	3	2	3	1	1	3	3	3
CO5	3	3	3	3	1	2	3	3
Ave CO	3	3	3	2	1	3	3	3

Unit 1: Introduction to Molecular Diagnostics **[6 L]**

Overview and Importance of Molecular Diagnostics, Basics of Molecular Biology (DNA, RNA, Proteins), Techniques in Molecular Diagnostics, Applications and Clinical Relevance

Unit 2: DNA and RNA Techniques **[12 L]**

Polymerase Chain Reaction (PCR), Quantitative PCR (qPCR), DNA Sequencing Technologies, RNA Sequencing and Analysis, Genotyping and Mutation Analysis, Microarray Technology

Unit 3: Protein-Based Techniques **[8 L]**

Western Blotting and Immunoassays, ELISA and Luminex Technologies, Mass Spectrometry for Proteomics, Protein Structure and Function Analysis

Unit 4: Diagnostic Applications **[10 L]**

Infectious Disease Diagnostics, Genetic Disorders and Screening, Cancer Diagnostics and

Personalized Medicine; Prenatal and Newborn Screening; Emerging Technologies and Future Trends

Unit 5: Laboratory Practices and Quality Control [6 L]

Laboratory Setup and Safety, Sample Collection and Handling, Quality Assurance and Control, Troubleshooting and Error Analysis,

Unit 6: Review and Practical Insights [6 L]

Review of Techniques and Applications, Case Studies in Molecular Diagnostics, Practical Challenges and Solutions, Final Q&A and Wrap-Up

ME Courses (Optional)
Biosafety and Public Health
Credit: 4 (4L-0T-0P)

Course Component: Theory — Lecture Hour: 48

Course Outcome

CO1	Understand and apply the principles of biosafety, including risk assessment, management, and containment strategies, to prevent hazards in various settings.
CO2	Gain insights into public health fundamentals, including epidemiology, disease surveillance, and health promotion, with a focus on global health challenges and policies.
CO3	Develop expertise in managing infectious diseases through knowledge of pathogens, transmission, vaccination strategies, and antimicrobial resistance, with practical understanding through case studies.
CO 4	Understand the risks and regulatory frameworks associated with environmental and occupational health, particularly in managing chemical and biological hazards.
CO 5	Acquire practical skills in implementing laboratory safety protocols, including the use of PPE, waste disposal, and incident management, ensuring compliance with biosafety regulations and effective response to accidents.

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	2	3	1	3	3	2
CO2	3	3	3	3	1	3	3	2
CO3	3	3	3	3	1	3	3	3
CO4	3	2	3	3	1	3	3	3
CO5	3	3	3	3	1	2	3	3
Ave CO	3	3	3	3	1	3	3	3

Unit 1: Introduction to Biosafety **[8L]**

Principles of Biosafety, Biosafety Levels and Containment Facilities, Risk Assessment and Management, Safety Procedures and Protocols

Unit 2: Public Health Fundamentals **[8L]**

Introduction to Public Health, Epidemiology and Disease Surveillance, Health Promotion and Disease Prevention, Global Health Issues and Policies

Unit 3: Infectious Disease Management **[12L]**

Pathogens and Transmission, Disease Outbreaks and Epidemics, Vaccination and Immunization Strategies, Antimicrobial Resistance, Public Health Response to Emerging Infectious Diseases, Case Studies in Disease Management (2 hours)

Unit 4: Environmental and Occupational Health [8L]

Environmental Health Risks; Occupational Health and Safety; Managing Chemical and Biological Hazards; Public Health Policies and Regulations

5. Biosafety in Laboratory Settings [8L]

Laboratory Safety Protocols, Personal Protective Equipment (PPE) and Waste Disposal, Biosafety Training and Certification, Incident Management and Reporting (2 hours)

6. Review and Integration [8L]

Review of Key Concepts and Practices, Integrated Case Studies, Discussion on Recent Trends and Challenges, Student Presentations and Final Q&A