Central University of Punjab

M.Sc. Microbiology

Session- 2021-2023

Department of Microbiology
School of Basic Sciences

Graduate Attributes

The graduates will have the knowledge of microbial, molecular and cellular processes and their applications which can be utilized in multidisciplinary or multi-professional contexts for conducting research in microbiology for the betterment of society and careers in the industry, agriculture, and applied research where the biological system is increasingly employed.

The Graduates will be effective problem solvers, be able to apply critical, creative and evidence based thinking to conceive innovative responses to the future challenges. They will have a capacity to accept and give constructive feedback, act with integrity and accept responsibility for their actions.

Course Structure

Semester – I

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Credits
MIC.506	Biochemistry	Core	3	0	0	3
MIC.507	Microbiology	Core	3	0	0	3
MIC.508	Cell Biology	Core	3	0	0	3
MIC.509	Molecular Genetics	Core	3	0	0	3
MIC.510	Microbiology Practical-I	Skill Based	0	0	8	4
Discipline Elective (opt any one)						
MIC.511	Techniques in Microbiology	Discipline elective	3	0	0	3
MIC.512	Introduction to Cell and Tissue Culture	Discipline elective	3	0	0	3
ZOL.525	Nanobiology	Discipline elective	2	1	0	3
CHM.575	Natural Product Chemistry	Discipline elective	3	0	0	3
FST.573	Technology of Spices, Sugar and Chocolate	Discipline elective	3	0	3	3
Interdisciplinary Course (IDC)						
XXX	Choose from Interdisciplinary Course offered by other departments	Interdisciplinary Course (IDC)	2	0	0	2
MIC.529	Basics of Microbiology	Interdisciplinary Course (IDC) for other department students	2	0	0	2
MIC.539	Introduction to Immune System	Interdisciplinary Course (IDC) for other department students	2	0	0	2
					Total Credits	**21**

Semester – II

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Credits
MIC.521	Immunology	Core	3	0	0	3
MIC.522	Molecular Biology	Core	3	0	0	3
MIC.523	Microbial Physiology and Metabolism	Core	3	0	0	3
MIC.526	Research Methodology and Bioinformatics	Compulsory Foundation	3	0	0	3
MIC.527	Biostatistics	Compulsory Foundation	3	0	0	3
MIC.528	Microbiology Practical- II	Skill Based	0	0	6	3
Discipline Elective (opt any one)						
MIC.524	Environmental Microbiology	Discipline Elective	3	0	0	3
MIC.525	Microbial Pathogenicity	Discipline Elective	3	0	0	3
ZOL.552	Cancer Biology	Discipline Elective	2	1	0	3
LHG.528	Population Genetics and Genetic Epidemiology	Discipline Elective	3	0	0	3
BCH.518	Secondary Metabolites and Xenobiotic Metabolism	Discipline Elective	3	0	0	3
Value Added Course (VAC)						
MIC.504	Ethics for Science	VAC	2	0	0	2
XXX	Choose from Interdisciplinary Course offered by other departments	VAC	2	0	0	2
					Total Credits	**23**

Semester – III

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Credits
MIC.551	Industrial Microbiology	Core	3	0	0	3
MIC.552	Food and Dairy Microbiology	Core	3	0	0	3
MIC.553	Bacteriology & Virology	Core	3	0	0	3
MIC.554	Microbiology Practical –III	Skill Based	0	0	6	3
MIC.555	Ecology, Evolution & Developmental Biology	DEC	0	2	0	2
MIC.558	Entrepreneurship in Microbiology	Compulsory Foundation	1	0	0	1
Discipline Elective(opt any one) /MOOC						
MIC.556	Genetic Engineering and Recombinant DNA Technology	Discipline Elective	3	0	0	3
MIC.557	Pharmaceutical Microbiology	Discipline Elective	3	0	0	3
ZOL.554	Neurobiology and Degeneration	Discipline Elective	3	0	0	3
BCH.526	Clinical Diagnostics	Discipline Elective	3	0	0	3
BOT.555	Molecular Stress Physiology	Discipline Elective	3	0	0	3
MIC.600	Research Proposal	Skill Based	0	0	8	4
					Total Credits	**22**

Semester – IV

Course Code	Course Title	Course Type	Credit Hours			
MIC.600	Dissertation	Skill Based	0	0	40	20
					Total Credits	**20**

L: Lectures; T: Tutorial; P: Practical; Cr: Credits, DE: Discipline Elective, VAC: Value Added Course

Evaluation Criteria for Theory Courses

Core, Discipline Elective, Compulsory Foundation, Value Added and Interdisciplinary Courses		
	Marks	Evaluation
Internal Continuous Assessment (course wise)	25	Various methods *
Mid-semester test (MST)	25	Subjective
End-semester test (EST)	50	Subjective (70%) Objective (30%)

***** The internal assessment for different courses can be based on Surprise Tests, in-depth interview, unstructured interview, Students Teams, case based evaluation, video based evaluation, student generated questions, case analysis, simulated problem solving, media assisted evaluation, Application cards, Minute paper, open book techniques, classroom assignments, homework assignments, term paper.

	Discipline Enrichment Course		**Entrepreneurship Course**	
Examination Type	Marks	Evaluation	Marks	Evaluation
Mid-semester test (MST)	50	Objective	25	Objective
End-semester test (EST)	50	Objective	25	Subjective

The objective type examination includes one word answers, fill-in the blank, sentence completion, true/false, MCQs', matching, analogies, rating and checklists.
The subjective type examination includes very short answers (1-2 lines), short answers (one paragraph), essay type with restricted response, and essay type with extended response.

Details of syllabus

Semester – I

L	T	P	Credits
3	0	0	3

Course Code: MIC.506
Course Title: Biochemistry

Total Hours: 45

Learning Outcomes:

Students will be able to:

- Appraise the fundamental knowledge about various biomolecules such as proteins, carbohydrates, nucleic acids and lipids.
- Apply the biochemical fundamentals and basic concepts of enzymes with the microbial metabolism and biological systems.

Course Contents

Unit I **12 Hours**

Chemistry of Life & Bioenergetics: Ionic bonding, Ion-dipole. Covalent, H-bonds, Van der Waals interaction, Hydrophobic and hydrophilic interactions Water as a biological solvent and its role in biological processes, pH, Henderson-Hasselbalch equation, concept of buffer, strength and range of buffer, important biological buffers. Thermodynamics, entropy, enthalpy, Gibbs free energy equation and feasibility of reaction, free energy and equilibrium constant, determination of free energy of biological oxidation reduction reactions under standard and non-standard conditions, coupled reactions. ATP and other different groups of high energy compounds.

Exercise: Numerical exercises for understanding the concept of pKa and buffer range, calculations for free energy and equilibrium constants, students applying and explaining thermodynamic principle in metabolism.

Unit III **12 Hours**

Macromolecules I- Proteins and Nucleic Acids: Proteins: Structural features of amino acids, classification of amino acids, peptide linkage: partial double bond nature, determination of primary structure of polypeptide (N-terminal, C-terminal determination, method of sequencing of peptides), structural classification of proteins, primary, secondary, tertiary, quaternary structures of proteins. Ramchandran plot. Nature of Nucleic Acids.

Structure of purines, pyrimidines, nucleosides and nucleotides. Physicochemical properties of nucleic acids - Denaturation of nucleic acids.

Hyperchromic effect and Tm. Chargaff's rule, Secondary structure of DNA - Watson and Crick model. Secondary structure of tRNA - clover leaf model.

Exercise: Problem based learning for Determination of primary structure of proteins, N-terminal and C-terminal determination, Interpretation of Tm curve by students in the class.

Unit III **11 Hours**

Macromolecules II- Carbohydrates, Lipids: Carbohydrates: Monosaccharides, disaccharides, oligosaccharides and polysaccharides, concepts of epimer, isomer, starch, glycogen, chitin, cellulose. Lipids: Saturated and unsaturated fatty acids, triacylglycerols, phospholipids, sphingolipids, sterols, Biological membranes.

Exercise: Practicing nomenclature of lipid molecules according to convention, arranging them according to melting points, Recognising aldoses, ketosis and epimers.

Unit IV **11 Hours**

Metabolism: Fatty acid oxidation. Biosynthesis of fatty acids, triacylglycerols and phospholipids. Catabolism of Glycogen. Amino acid catabolism- Urea Cycle Deamination and transamination reactions. *De novo* biosynthesis of purines and pyrimidines, Ribonucleotide reductase and its role in nucleic acid metabolism.

Exercise: Numerical approaches in calculating ATP generation from the oxidation of odd and even chain fatty acids, Problem based learning approach for understanding metabolic pathways.

Suggested Reading:

1. Berg, J.M., Tymoczko, J.L., Gatto, Jr., G.J., and Stryer, L. (2015). *Biochemistry,* 8th Edition.
2. Geoffrey L. Zubay (2017). *Principles of Biochemistry by* Brown Co, USA.
3. Moat A.G., Foster J. W Spector M. P. (2002) *Microbial Physiology* John Wiley & Sons.
4. Nelson D. L. and Cox M. M. (2017) Lehninger *Principles of Biochemistry* by W. H. Freeman.
5. White, D, Drummond J. Fuqua C (2011) *The Physiology and Biochemistry of Prokaryotes* Oxford University Press.
6. Cohen G. N. (2014) *Microbial Biochemistry* Springer.
7. Ferrier D. R. (2013) *Lippincott's Illustrated Reviews: Biochemistry* Lippincott Williams & Wilkins.
8. Irwin H. Segel (2004) *Biochemical Calculations* Wiley.
9. Palmer, T. Horwood E (1991) *Understanding Enzymes* Wiley.
10. Nelson D.L, Cox M.M (2017) *Lehninger principles of biochemistry Freeman & company*

Weblinks:
- https://epgp.inflibnet.ac.in/
- https://swayam.gov.in/
-https://lms.cup.edu.in/course/index.php?categoryid=65

Modes of transaction
-Lecture
-Problem solving
-Panel discussion
-Tutorial

L	T	P	Credits
3	0	0	3

Course Code: MIC.507
Course Title: Microbiology

Total Hours: 45

Learning Outcomes:

Students will be able to:
- Describe the microbial systematics and their significance.
- Recall the basics of microbial growth and their application in day to day life.
- Classify the beneficial versus harmful microorganisms.
- Comprehend the microbiological principles that can optimize, enhance or inhibit the microbial growth in different settings viz industrial microbiology, medical microbiology.

Course Contents

Unit I **12 Hours**

Microbial Taxonomy: Major characteristics used in taxonomy – morphological, physiological and metabolic, genetic and molecular taxonomy. Classification of bacteria and Archaea according to the Bergey's Manual of Systematic Bacteriology and their economic significance. **Scope and history of Microbiology**: Cell structure, different components, function and their significance in microbes. Detailed account of biogenesis and function of microbial cell structure appendages: flagella- structure, assembly and mechanism of movement; pili and fimbriae- types, structure and their role. External cell surface structures: capsule, glycocalyx, slime layer and S-layer. Overview of gram negative and gram positive bacterial cell wall, outer

membrane lipopolysaccharide (LPS). Cell wall synthesis and its inhibitors including different antibiotics.
Exercise: Preconception/Misconception Check, One Sentence Summary, Imagine, Group discussion about emerging pathogens (SARS-CoV-2, Ebola, Marburg etc)

Unit II **11 Hours**

Growth and cell division: Measurement of growth, growth physiology, cell division, growth yields, growth kinetics, steady state growth and continuous growth. Microbial stress response to different environmental conditions. **Archaeal diversity, cell structure and model organisms:** Phylogenetic diversity and key features of different phyla. General characteristics of archaeal cell structure and comparison with eubacteria. Detailed account of model archaeal organisms: *Methanococcus, Halobacterium, Pyrococcus* and *Sulfolobus.*
Exercise: Pyramiding / Snowball Groups, Memory Matrix, Student poll, Class quiz, self-directed learning.

Unit III **12 Hours**

Mechanism of Antibiotic and Resistance: Mode of action of antibiotics and chemotherapeutic drugs: inhibitors of cell wall synthesis, Protein Synthesis, Nucleic Acid Synthesis and Metabolism, Antibiotic sensitivity assays, Antibiograms. Antibiotic resistance in bacteria-various molecular factors that contribute to the development of resistance, Monoclonal antibodies as therapeutic agents to resistance bacteria.

General features and classification of fungi, life cycle patterns, Endophytic fungi and its importance, Economic importance of fungi and yeast. **Pathogenic Fungi:** Morphological characteristics, pathogenesis and laboratory diagnosis of following pathogenic fungi: *Microsporum; Trichophyton; Histoplasma capsulatum; Blastomyces dermatitidis; Candida albicans; Cryptococcus neoformans; Pneumocystis carinii, Aspergillus spp.*

Exercise: Asking questions, Quizzes, Presentation, unstructured interview, Students Teams.

Unit IV **10 Hours**

Algae: Classification; reproduction and life cycles; algal toxins, algal bloom, algae as a source of antibiotics. **Protozoal Pathogens:** General description, life cycle, pathogenesis, diagnosis and treatment of and diseases caused by Protozoa- *Plasmodium spp, Giardia intestinalis, Trypanosoma spp, Leishmania spp, Entamoeba histolytica.*

Exercise: Case studies, Debate, Asking questions, Objective structured practical examinations (OSPE)

Suggested Reading:

1. Pelczar, M. J., Chan, E.C.S. and Krieg, N.R. (2020). *Microbiology: Concepts and Applications*. McGraw-Hill Inc. USA.
2. Joanne Willey, Kathleen Sandman and Dorothy Wood (2019) *Prescott's Microbiology*. 11th Edition, McGraw-Hill Science, USA.
3. Tortora, G.J., Funke, B.R. and Case, C.L. (2016). *Microbiology: An Introduction*. Benjamin Cummings, USA.
4. Bauman, R.W. (2011). *Microbiology with Diseases by Body System*. Benjamin Cummings, USA.
5. Capuccino, J.G. and Sherman, N. (2004). *Microbiology-A Laboratory Manual*. Benjamin Cummings, USA.
6. Pommerville, J.C. (2010). *Alcamo's Fundamentals of Microbiology*. Jones & Bartlett Publishers, USA.
7. *Experiments In Microbiology, Plant Pathology and Biotechnology*. 4th Edition (2010). New Age Intl. Publishers Ltd. - New Delhi.
8. Strelkauskas, A., Strelkauskas, J. and Moszyk-Strelkauskas, D. (2009). *Microbiology: A Clinical Approach.* Garland Science, New York, USA.

Web Sources:

https://lms.cup.edu.in/course/index.php?categoryid=65
-https://epgp.inflibnet.ac.in/
-https://www.biointeractive.org/classroom-resources/citric-acid-cycle

Modes of transaction

-Lecture
- Problem solving
-Panel discussion
- Group discussion

L	T	P	Credits
3	0	0	3

Course Code: MIC. 508
Course Title: Cell Biology

Total Hours: 45

Learning Outcomes:

Students will be able to:

- Demonstrate the structure and basic components of prokaryotic and eukaryotic cells.
- Describe the cell organelles and their related functions.
- Apply the basic core of scientific and quantitative knowledge to enhance understanding of cell structure and function at the molecular level.

Course Contents

Unit I **10 Hours**

Introduction to the Cell: Evolution of the cell. Prokaryotes and eukaryotes, Prokaryotic and eukaryotic genomes and single cell to multicellular organisms. **Membrane Structure and Function:** Models of membrane structure, Membrane proteins, Membrane carbohydrates, Membrane transport of small molecules, Membrane transport of macromolecules and particles.

Exercise: Group test reading, Debate, Brainstorming, Quiz based assessment, group discussion.

Unit II **11 Hours**

Structural Organization and Function of Intracellular Organelles: Structure and function of nucleus, Chromosome Structure, Chromatin and its regulation, nucleosome and its assembly, Ribosomes, lysosomes, peroxisomes, Golgi apparatus, endoplasmic reticulum, mitochondria and chloroplast. Oxidation of glucose and fatty acids, Electron transport oxidative phosphorylation, and photosynthesis. **Protein Secretion and Sorting:** Organelle biogenesis and protein secretion, synthesis and targeting. Intracellular traffic, vesicular traffic in the secretory pathway, protein sorting in the Golgi bodies, traffic in the endocytic pathway, exocytosis.

Exercise: Problem solving, Debate, Memory Matrix, Practicals based learning and assessment, open book tests.

Unit III **12 Hours**

The Cytoskeleton: The nature of cytoskeleton, Intermediate filaments, Microtubules, Actin filaments, Cilia and centrioles, Organization of the cytoskeleton. **Cell communication and cell signaling:** Cell adhesions, Cell junctions and the extracellular matrix, Cell-cell adhesion and communication, Cell matrix adhesion, Collagen the fibrous protein of the matrix, Non-collagen component of the extracellular matrix.

Exercise: Problem based learning, Muddiest Point, Crossword Puzzle, Students teaching, paper presentation on ECM and its components.

Unit IV **12 Hours**

Cell Growth and Division: Overview of the cell cycle and its control, the molecular mechanisms for regulating mitotic and meiotic events, Amitosis, Cell cycle control, Checkpoints in cell cycle regulation and dysregulation. Cell to cell signaling, Overview of the extracellular signaling, Identification of cell surface receptors, G-protein coupled receptors and their effectors, Second messengers, Enzyme-linked cell surface receptors, Interaction and regulation of signaling pathways.

Exercise: Practicals, team teaching, Quiz, Brainstorming, Presentations.

Suggested Reading:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell*. Garland publishers, Oxford.
2. Alberts B, Hopkin K, Johnson AD *et al.* (2019) *Essential Cell Biology*, 5th Ed., W W Norton & Company.
3. George Plopper; David Sharp; Eric Sikorski (2014) Lewin's Cell Third edition Jones and Bartlett learning
4. Gupta, P.K. (2008). *Cytology, Genetics and Evolution*. Rastogi publications, Meerut, India.
5. Gerald Karp, Janet Iwasa , Wallace Marshall (2015). *Karp's Cell and Molecular Biology: Concepts and Experiments*. 8th edition John Wiley &Sons. Inc. New Delhi, India.
6. De Robertis, E.D.P. and De Robertis, E.M.F. (2017). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
7. Lodish, H, Birk, A, et al. (2016) *Molecular Cell Biology*. 8th ed. WH Freeman.
8. Cooper Geoffrey (2018) The Cell: A Molecular Approach Eighth Edition Sinauer Associates

Web Sources:

https://lms.cup.edu.in/course/index.php?categoryid=65

https://epgp.inflibnet.ac.in/

Modes of transaction

-Lecture
- Problem solving
- Group discussion
- Self-directed learning

L	T	P	Credits
3	0	0	3

Course Code: MIC.509
Course Title: Molecular Genetics

Total Hours: 45

Learning Outcomes:

Students will be able to:

- Illustrate the basic principles of inheritance at the molecular, cellular and organism levels.
- Elaborate the concepts of hereditary information and how they work in living organisms and to apply them to real life situations.

Course Contents

Unit I **10 Hours**

Mendelian Principles: Dominance, segregation, independent assortment, Allele, multiple alleles, pseudoallele, complementation tests **Extensions of Mendelian Principles:** Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters. **Extra- Chromosomal Inheritance:** Chloroplast and Mitochondrial inheritance; Cytoplasmic inheritance.

Exercise: Making self-pedigree tree and family history, numericals based on Mendelian laws.

Unit II **11 Hours**

Gene Mapping Methods: Molecular markers: RAPD, RFLP, SSR, SNP, ISSR, and SCAR; Linkage maps, tetrad analysis in *Neurospora*, mapping with molecular markers, development of mapping population in plants. **Human Genetics:** Pedigree analysis, LOD score for linkage testing, karyotypes, genetic disorders. **Quantitative Genetics:** Polygenic inheritance, heritability and its measurements, QTL mapping.

Exercise: Experiments, Panel discussion on inherited diseases.

Unit III **12 Hours**

Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal vs somatic mutants, insertional mutagenesis, applications in reverse and forward Genetics; Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications; Hardy Weinberg equilibrium. Molecular basis of spontaneous and induced mutations. **Recombination:** Site-specific, homologous, DNA transposition, retrotransposition and non-homologous end joining (NHEJ).

Exercise: Problem based learning, numericals for Hardy Weinberg equilibrium.

Unit IV **12 Hours**

Microbial Genetics: Microbes as tools for genetic studies. Organization of genetic material in bacteria; and viruses, Gene transfer mechanisms, F plasmid; Lambda phage: structure, genetic makeup and life cycle (lytic and

lysogeny); Natural transformation and competence; Molecular basis of natural transformation – DNA uptake competence systems in gram positive and gram negative bacteria. Bacterial Conjugation- Properties of the F plasmid, F+ x F - mating, F' x F- conjugation. Transduction- Generalized and specialized transduction, virus life cycle and replication.
Exercise: Research paper presentation, Problem based learning sessions, Class quiz.

Suggested Reading:

1. Snusted, D.P., Simmons, M. J. (2015). *Principles of Genetics*. 7th Edition, John Wiley & Sons, New York.
2. Raven P, Johnson GB, Mason KA, Losos JB, Singer SS (2014). *Biology*, 10th Edition, McGraw-Hill, USA.
3. Griffiths AJF, Wessler SR, Carroll SB, Doebley J (2015). *An Introduction to Genetic Analysis*. 11th Edition W.H. Freeman publication, USA.
4. Larry Snyder, Larry Snyder, Joseph E. Peters, Tina M. Henkin, Wendy Champness (2013) *Molecular Genetics of Bacteria*, 4th edition; ASM Press.
5. Watson, J.D., Baker,T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2014). *Molecular Biology of the Gene*. 7th Edition, Benjamin Cummings, USA.

Web Sources:

https://lms.cup.edu.in/course/index.php?categoryid=65

https://epgp.inflibnet.ac.in/

https://www.biointeractive.org/classroom-resources/inheritance-and-mutations-singlegene-disorder

https://www.biointeractive.org/classroom-resources/analyzing-pedigrees

Modes of transaction

-Lecture
-Problem Solving
-Self-Learning
-Inquiry training
-Co-operative learning

Tools used

Videos, Google Drive

L	T	P	Credits
3	0	0	3

Course Code: MIC.511

Course Title: Techniques in Microbiology

Total Hours: 45

Learning outcomes

- Develop practical skills in dealing with techniques and methodology applied in the study of microbiology
- Demonstrate the competence to plan, organise, perform and interpret scientific experiments.

Unit I **11 Hours**

Spectroscopy: Basic concepts, principles and biological applications of spectroscopy: absorption spectroscopy, fluorescence spectroscopy, phosphorescence, Infrared and Raman spectroscopy, Optical Rotatory Dispersion (ORD), Circular Dichroism (CD) and Nuclear Magnetic Resonance (NMR) & Electron Spin Resonance (ESR).X-Ray Diffraction. **Chromatographic techniques:** Basics of Chromatography, Paper, Thin layer and Column chromatography; Protein purification; Liquid chromatography; Gas chromatography, Affinity Chromatography, Gel Filtration, Ion Exchange Chromatography. HPLC.

Exercise: Visit and demonstration of NMR, GC-MS and HPLC. Classroom Opinion Polls

Unit II **11 Hours**

Immunological Techniques

Methods for immunoglobulin determination-quantitative and qualitative antigen and antibody reactions, agglutination-precipitation, immunocytochemistry, radioimmunoassay (RIA), Enzyme Linked Immunosorbent Assay (ELISA), immunofluorescence, immunoblotting and Flow cytometry.

Exercise: Learning by doing, small group based exercises.

Unit III **11 Hours**

Techniques in Cell Biology: Types of Microscopy (phase contrast, fluorescent, electron microscopy (SEM/TEM), Scanning-probe, Atomic force and Confocal microscopy. Centrifugation: Principle and applications and types (Differential,

Density Gradient, Iso-density centrifugation). Electrophoretic techniques: Principle of Electrophoresis, Agarose Gel Electrophoresis, Polyacrylamide gel electrophoresis, Counter current Electrophoresis, Immuno-Electrophoresis, Support media; Colony counter, Isoelectric focussing, colorimetry, Turbidimetry.

Exercise: Visit and demonstration of SEM, Confocal, practicals for electrophoresis and centrifugation, Paper discussion.

Unit IV. **12 Hours**

Techniques in Molecular Biology: Polymerase chain reaction (PCR): Principle, types and applications, PCR based markers: RAPDs, SSRs, SNPs, ISSRs, and SCARs etc. Blotting techniques: Southern, Northern, Western, Dot blotting and hybridization, DNA fingerprinting. Mutation Analyses Techniques: Restriction mapping, SSCP DNA sequencing technology. Gene expression analysis.

Exercise: Practicals and Student-generated test questions, Problem solving.

Suggested Reading:

1. Nelson D. L. and Cox M. M. (2017) Lehninger *Principles of Biochemistry* by W. H. Freeman.
2. Cohen G. N. (2014) *Microbial Biochemistry* Springer.
3. Ferrier D. R. (2013) *Lippincott's Illustrated Reviews: Biochemistry* Lippincott Williams & Wilkins.
4. Celis, J.E. (2006). *Cell biology: A laboratory handbook*, Vol 1, 2, 3. Academic Press, UK.
5. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. John Wiley &Sons. Inc. New Delhi, India.
6. Watson, J.D., Baker,T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2014). *Molecular Biology of the Gene*. 7th Edition, Benjamin Cummings, USA.
7. Tizard (2008). *Immunology: An Introduction*. Cengage Learning, Thompson, USA.
8. Kindt, T. J., Osborne, B.A. and Goldsby, R.A. (2007). *Kuby Immunology* 7th Edition. W.H. Freeman, USA.
9. Abbas. (2008). *Cellular and Molecular immunology*. CBS Publishers & Distributors, India.
10. Stevens C.D., (2021) *Clinical immunology & serology: A laboratory perspective*. F.A. Davis company

Web Sources:

https://www.biointeractive.org/classroom-resources

https://www.vlab.co.in

Modes of transaction

-Lecture
-Problem solving
-Panel discussion
-Tutorials
-Google Classroom

L	T	P	Credits
3	0	0	3

Course Code: MIC.512
Course Title: Introduction to Cell and Tissue Culture

Total Hours: 45

Learning Outcomes:

The students will be able to:

- Outline the background of animal tissue culture.
- Execute this knowledge in other fields and planning projects in the fields of molecular biology and biotechnology.
- Design the cell culture based experiments in a research setting as well as industrial setting with a thorough clarity in the basic principles.

Course Contents

Unit I **11 Hours**

Introduction to Animal Cell culture: Basics terms and definitions, historical background, Importance of animal cell culture technology, laboratory facilities-design, equipments and safety parameters, waste disposal in a cell culture set-up. Aseptic techniques for animal cell cultivation.

Exercise: Lab tour for understanding lab setup, BSLs, aseptic methods, waste disposal.

Unit II **12 Hours**

Cell Culture Technology: Basic requirement for growing animal cells - Cell culture reagents, media preparation and their types. Maintenance of cell culture: Culturing, sub-culturing, passaging, cell metabolism during culture, Cell culture types: primary and continuous culture, *in vitro* transformation of animal cells, anchorage-dependence, monolayer and suspension culture, normal cells and transformed cells. Scaling up- techniques for cells in suspension and in monolayer. Cell line preservation and authentication. Contamination check and prevention: bacterial, yeast, fungal, mycoplasma, viral testing.

Exercise: Students Teams, hands-on training in tissue culture, Student-generated test questions.

Unit III **12 Hours**

Study of Biological system using Cell Culture Techniques: Functional assays based on cell culture: Cell morphology, Quantitation, Growth pattern, DNA content and cell cycle, Cytotoxicity assays, Study of Cell Death: senescence, apoptosis and necrosis, Cell proliferation, Cell viability measurements, Karyotype analysis, FISH. Immunolabeling of cells to study molecular expression pattern–Microscopy, Flow-cytometry, Cytospin, Immunohistochemistry, Transfection, Transient, stable cell line generation and Gene Silencing.

Exercise: Data interpretation and discussions from published papers on various techniques.

Unit IV **12 Hours**

Cell and Tissue culture- Trends and Breakthroughs: Hybridoma technology for monoclonal antibody production, production of genetically-engineered cells and their applications, use of cell cultures in the production of biologicals, Insect Cell Culture and its application., Types of stem cells, current stem cell therapies, stem cells in heart, brain and spinal cord regeneration and regenerative medicine Regenerative Medicine: Tissue engineering, Three-dimensional culture, multicellular tumour spheroids (MCTS)-mono and co-cultures, re-aggregate organ cultures, drug testing *in-vitro.* Nanotechnology.

Exercise: Presentations on recent trends/breakthroughs, Case study, Team teaching.

Suggested Reading:

1. Michael Butler (2005), *Animal Cell Culture and Technology.* BIOS Scientific Publishers
2. John R.W. Masters (2000), *Animal Cell Culture-A Practical Approach.* Oxford University Press
3. Freshney Ian (2017) *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications.* 7th Edition, Wiley-Blackwell.
4. Trent, R. J. (2012). *Molecular Medicine, Genomics to Personalized Healthcare.* Academic Press

Web Sources:

https://www.vlab.co.in

https://www.biointeractive.org/classroom-resources

Modes of transaction

-Lecture

-Self-directed Learning

-Group discussion

- Team teaching

- Experimentation

L	T	P	Credits
0	0	8	4

Course Code: MIC.510
Course Title: Microbiology Practical -I

Total Hours: 120

Learning Outcomes:
The students will be able to:

- Design the experiments pertaining to biochemistry, microbiology, cell biology & genetics.
- Demonstrate the concepts of enzyme activity, microbial identification, cell based experiments and genetic processes.

Course Contents

Part A. Biochemistry

1. Introduction to Good Laboratory Practices
2. Preparation of solutions, buffers, pH setting etc.
2. Quantitative estimation of proteins, sugars, total lipids and amino acids.
3. Isolation of protein from biological sample
4. Enzyme activity assays: invertase, amylase, alkaline phosphatase
5. Quantitative estimation of phenolic compounds.

Part B. Microbiology

1. Use of Microscope and working in a biosafety cabinet; Preparation of growth media: Liquid and Solid media
2. Microbiological techniques for isolation of pure cultures: Streak Plate, Spread Plate and Pour Plate techniques
3. Staining of bacterial cultures: Simple staining, Negative Staining, Gram Staining, Acid-Fast stain, fungal staining.
4. Glucose uptake by *E. coli / Saccharomyces cerevisiae* (Active and Passive diffusion)
5. Effect of UV, gamma radiations, pH, disinfectants, chemicals and heavy metal ions on micro-organisms.
6. Preparation of microbiological media. Autotrophic media, minimal media, basic media, enriched media, enrichment media, differential media. Microbial growth studies.

7. Isolation of bacteria and fungi from different sources (soil, air, water) and determination of CFU.
8. Testing of Antibiotic sensitivity/resistance
9. Use of selective and/or differential media for isolation and identification of specific bacterial cultures.
10. Biochemical tests to characterize bacterial cultures: Catalase test, Oxidase test, Methylene blue test

Part C. Cell Biology

1. Demonstration and using Microscope, pH meter, weighing balance and centrifuge.
2. Study of different types of prokaryotic and eukaryotic cells.
3. Using haemocytometer
4. Types of stains
5. Temporary staining for epithelial cells and blood cells.
6. Cell counting using various stains.
7. Preparations of temporary mount and study the different stages of Mitosis (Onion root tip).
8. Study of polyploidy in onion root tip by colchicine treatment.
9. Study of structure of cell organelles through electron micrographs
10. To demonstrate the presence of nucleus, mitochondria and other cell organelles using vital stains.
11. Depicting nature of cellular membranes: Osmosis, Hypertonicity, Hypotonicity, Isotonicity

Part D. Genetics

1. Learning the genetic basis of blood group typing.
2. Identification of inactivated X chromosome as Barr body and drumstick
3. To demonstrate and understand the principle of Hardy-Weinberg equilibrium. Calculation of genotypic and allelic frequencies for a specific trait in a random sample.
4. Techniques for screening and isolation of bacterial cultures with specific phenotypic/genotypic characteristics.
5. Differentiating genetic variants (species/strains) using RFLP.
6. Studying *Drosophila melanogaster* as a Model organism: Identification of normal and mutant flies (*Drosophila melanogaster*), Demonstration of *Drosophila* polytene chromosomes

- Practical may be modified depending on available faculties/facilities.

Modes of transaction

-Lecture cum demonstration
-Problem Solving
-Self-Learning
-Inquiry training
-Team teaching
- Experimentation

Evaluation Criteria for Practical Courses: Students are evaluated for a total of 100 marks with following distribution:

Continuous assessment- 50 Marks:

Maintaining the lab records/notebooks: 15 Marks

Surprise test/quiz/objective type test during the semester: 15 Marks

Good laboratory Practices, Designing and execution of experiments: 10 Marks

Attendance during day to day practical: 10 Marks

Final Practical Examination- 50 Marks:
Minor Experiment (10 Marks), Major Experiment (to be performed, 20 Marks) and viva-voce (20 Marks)

Suggested Reading:

1. Michael J. Leboffe (2011) *A Photographic Atlas for the Microbiology laboratory*.
2. Prakash S. Bisen (2014) *Laboratory Protocols in Applied Life Sciences*. Taylor & Francis Group, LLC
3. John Harley (2016) *Laboratory Exercises in Microbiology*, 10th Edition by John Harley
4. Benson's Microbiological *Applications Lab Manual*, 2016.
5. James G. Cappuccino & Natalie Sherman (2014) *Microbiology: A Laboratory Manual,* 10th Edition.
6. Aneja KR (2014) *Laboratory Manual of Microbiology and Biotechnology*.
7. Alberts, B. Bray, D. Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell.* Garland publishers, Oxford.
8. Celis, J.E. (2006). *Cell biology: A laboratory handbook,* Academic Press, UK.
9. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons. Inc., New Delhi, India.
10. Sawhney, S.K. and Randhir, S. (2005). *Introductory Practical Biochemistry*. Alpha Science International Ltd. New Delhi, India.

Web Sources:

- https://epgp.inflibnet.ac.in/
- https://www.vlab.co.in

- https://www.biointeractive.org/classroom-resources
- YouTube links

L	T	P	Credits
2	0	0	2

Course Code: MIC. 529
Course Title: Basics in Microbiology (IDC)

Total Hours: 30

Learning Outcomes:
The students from different streams with a very basic knowledge and understanding of microbes, pathogens and their control will able to:

- Impart a basic foundation of microbiology to the students from different backgrounds.
- Acquire a broad understanding of different group of microorganisms important in health, diseases and industry.

Course Contents

Unit I **7 Hours**

Introduction to Microbiology: Scope and history of Microbiology, Classification of Bacteria, Fungi, Protozoa, Algae, and viruses. **Basic principles and techniques used in bacterial classification.** Phylogenetic and numerical taxonomy. General characteristics, structure and classification of plant animal and bacterial viruses.
Exercise: Spontaneous quiz on identification of microorganism based on given characteristic

Unit II **8 Hours**

Microbial Growth, and Nutrition: Microbial growth. Bacterial generation time. Monoauxic, Diauxic and synchronized growth curves. Factors affecting microbial growth. Principles of microbial nutrition- Chemoautotrophs, chemo-heterotrophs, photoautotrophs and photo-heterotrophs. Types of growth media, pure culture methods. Culture maintenance and preservation
Exercise: Data Interpretation of different growth curve, classifying microorganism based on nutritional requirements

Unit III **8 Hours**

Pathogens: Medically important bacteria. Retroviruses, Viroids, Prions and emerging viruses such as HIV, Avian and swine flu viruses and SARS-CoV-2. Medically important fungi and protozoans. **Beneficial applications of microbes**: Human Microflora, Pre and Probiotics, Industrially important microbes.
Exercise: Groupwise discussion on therapeutic approaches against pathogenic microorganism

Unit IV **7 Hours**

Control of Microorganism: Control of Microorganism by physical and chemical agents. Narrow and broad spectrum antibiotics, Mode of action of Antimicrobial agents. Antibiotic resistance mechanisms.

Exercise: Case studies and hands-on experiments.

Suggested Reading:

1. Madigan,M.T.,Martinko, J.M., Bender, K., and Buckley, D. (2011) *Brock Biology of Microorganisms,* 13th Ed., Pearson Education, USA
2. Tauro, P., Kapoor,K.K. and Yadav, K.S. (1996). *Introduction to Microbiology*, New Age Pub., New Delhi
3. Pelczar, M.J. et al. (2020), *Microbiology- Concepts and Applications*, International Ed. McGraw Hill Publication, New York
4. Black, J.G. (2012), *Microbiology: Principles and Explorations*, 8 Sons, USA.
5. Willey, J.M., Sherwood, L., and Woolverton, C. (2013) *Prescott's Microbiology* 9th Revised Edition, McGraw Hill Higher Education, New York
6. Pommerville, J.C. (2009) *Alcamo's Fundamentals of Microbiology*, Jones and Bartlett Publishers.
7. Tortora, G.J., Funke, B.R., Case, C.L. (2016) *Microbiology -An Introduction*, Pearson education Pvt. Ltd. Singapore.
8. Talaro K.P, Chess B., (2018) *Foundations in Microbiology,* McGraw-Hill education

Web Sources:

https://www.biointeractive.org/
https://swayam.gov.in/
https://www.biointeractive.org/classroom-resources/bacterial-identification-virtual-lab

Modes of transaction

-Lecture
-Brain storming
-Problem solving

Tools used

YouTube, Video, Google, PPT

L	T	P	Credits
2	0	0	2

Course Code: MIC. 539

Course Title: Introduction to Immune system (IDC)

Total Hours: **30**

Learning Outcomes:

The students will be able to:

- Instill awareness on very basics of immune system
- Identify the components of the human immune response that work together to protect the host.

Unit I **7 Hours**

Elements of the Immune system: Cells, Organs, and microenvironments of the immune system. Innate and adaptive immunity, cellular and humoral immunity, inflammatory and regulatory networks and small biochemical mediators (cytokines).

Exercise: Students teaching on phylogenetic aspects of immune system

Unit II **8 Hours**

Function of immune system: Discriminate between self and non-self. A functional immune system confers a state of health through effective elimination of infectious agents (bacteria, viruses, fungi, and parasites) and through control of malignancies by protective immune surveillance.

Exercise: Panel discussion about evasion mechanism employed by pathogens

Unit III **7 Hours**

Immunodeficiency and dysfunction as the basis of disease: Immune Deficiency and Immune dysfunction. Allergies, Types of hypersensitivity reactions. Immunity to microbes (bacteria, fungi, virus and protozoans), tumors and AIDS.

Exercise: Case studies on immune disorders, Presentations

Unit IV **8 Hours**

Immunological Processes and Therapeutics: Hybridoma technology and vaccine, natural, synthetic and genetic, development of vaccine. Methods for immunoglobulin determination-quantitative and qualitative antigen and antibody reactions, agglutination-precipitation, immunofluorescence ELISA and Flowcytometry.

Exercise: Problems on data interpretation for ELISA, Flow Cytometry, antigen-antibody reactions

Suggested Reading:

1. Abbas. (2017). *Cellular and Molecular Immunology*. CBS Publishers & Distributors, India.
2. Charles, A. and Janeway, J. R. (2001). *Immunobiology: The Immune system in health and disease.* Blackwell Publishing, USA.
3. Delves, P. J., Roitt, I. M. and Seamus, J. M. (2017). *Roitt's essential immunology (Series– Essentials).*Blackwell Publishers, USA.
4. Elgert, K. D. (2009). *Immunology: Understanding the immune system*. Wiley-Blackwell, USA.
5. Kindt, T. J., Osborne, B. A. and Goldsby, R. A. (2013). *Kuby Immunology* 7th Edition. W. H. Freeman, USA.
6. Sawhney, S. K. and Randhir, S. (2005). *Introductory practical biochemistry*. Alpha Science International Ltd. New Delhi, India.
7. Tizard. (2009). *Immunology: An Introduction*. Cengage Learning, Thompson, USA

Web Sources:

https://swayam.gov.in/
https://www.biointeractive.org/

Modes of transaction

-Lecture
-Problem Solving
-Inquiry training
-Team teaching

L	T	P	Credits
3	0	0	3

Semester II

Course Code: MIC.521

Course Title: Immunology

Total Hours: 45

Learning Outcomes:

After the completion of the course students will be able to:

- Describe the fundamental concepts in immunology using correct scientific terminologies.
- Interpret the concept of specificity in immunology and discrimination of self from non-self in host
- Apply the knowledge in health and disease from an immunological perspective.

Course Contents

Unit I **11 Hours**

Immune System: Overview of immune system; origin of Immune cells, their types and organs of immune systems; innate adaptive immunity and their components, PAMPs and PRRs. Recognition of self and non-self. Nature of antigen. Components of acquired immunity. Humoral immunity and cell mediated immunity. Immunoglobulins, basic structure, classes and subclasses, structural and functional relationships. Molecular Mechanisms of Antibody Diversity and Cellular Immunity: Organization of genes coding for constant and variable regions of heavy chains and light chains, antibody diversity & class switching.

Complement System: Complement components, their structure and functions and mechanisms of complement activation by classical, alternative and lectin pathway.

Exercise: Concept mapping, spontaneous quizzes, role playing

Unit II **10 Hours**

Functions of Acquired Immunity: Cells of acquired immunity, Th1 and Th2 responses, cytokines, chemokines, interferons, interleukins, antigen recognition-membrane receptors for antigens. Structure and functions of Major Histocompatibility Complex (MHC) and Human Leukocyte Antigen (HLA) system, polymorphism, distribution variation and function. Association of MHC with disease and superantigen, recognition of antigens by T and B-cells, antigen processing, role of MHC molecules in antigen presentation and co-stimulatory signals.

Exercise: Problem based learning, quescussion

Unit III **12 Hours**

Immunity and Human Diseases: Types of hypersensitivity, features and mechanisms of immediate and delayed hypersensitivity reactions. Immunity to bacterial, fungal, viral and protozoan diseases, immunity to tumors, and allergies. Immunology of Autoimmunity, Congenital diseases and Immunodeficiencies. Recent advances for diseases like AIDS, hepatitis, cancer, SARS-CoV-2 and malaria. Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines.
Exercise: Case studies, research paper discussion, quizzes

Unit IV **12 Hours**

Monoclonal Antibodies and Diagnostic Immunology: Immunotoxins production, characterization and applications in diagnosis, therapy and basic research. Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies.
Exercise: Improved discussion, snowballing, Problem based learning

Suggested Reading:

1. Kindt, T. J., Osborne, B.A. and Goldsby, R.A. (2018). *Kuby Immunology* 8th Edition. W.H. Freeman, USA.
2. Abbas. (2017). *Cellular and Molecular immunology*. 9th Edition, CBS Publishers & Distributors, India.
3. Charles, A. and Janeway, J.R. (1994). *Immunobiology: The immune system in health and disease.* Blackwell Publishing, USA.
4. Delves, P.J., Roitt, I.M. and Seamus, J.M. (2006). *Roitt's Essential Immunology (Series–Essentials).* Blackwell Publishers, USA.
5. Elgert K.D. (2009). *Immunology: Understanding the immune system.*
6. Paul, W.E. (1993). *Fundamental Immunology.* Raven Press, SD, USA.
7. Sawhney, S.K. and Randhir, S. (2005). *Introductory practical biochemistry*. Alpha Science International Ltd. New Delhi, India.
8. Tizard (2008). *Immunology: An Introduction*. Cengage Learning, Thompson, USA.

Web Sources:

https://swayam.gov.in/
https://www.biointeractive.org/

Modes of transaction

-Lecture
-Inquiry training
-Panel discussion
-Problem solving
-Self-learning

L	T	P	Credits
3	0	0	3

Course Code: MIC.522
Course Title: Molecular Biology

Total Hours: 45

Learning Outcomes.
The students will be able to:

- Describe the molecular structure of DNA, RNA and their replication, damage and repair.
- Explain the basic and advanced concepts related to molecular processes in a cell and how they are related to biochemical processes in microbes and higher organisms.
- Propose the applications of molecular biology to societal needs with reference to medicine, industry and agriculture.

Course Contents

Unit I **12 Hours**

Structure and Conformation of Nucleic Acids: Structure of DNA, Denaturation and Renaturation, Conformation of nucleic acids (A, B, Z), Organelle DNA. **Genome organization:** Repetitive DNA, interrupted genes, gene shuffling. **DNA replication**: Arrangement of replicons in a genome, various modes of replication, continuous, discontinuous synthesis, various replication enzymes, replication fork and priming, leading and lagging strand, elongation, termination, specific features of replication in prokaryotes and eukaryotes, action of topoisomerases, telomere maintenance and chromatin assembly, single stranded DNA replication, relationship between DNA replication and cell cycle, and DNA copy number maintenance. Molecular biology techniques.
Exercise: Student-generated test questions, Experimental evidences

Unit II **12 Hours**

Recombination and Repair of DNA: DNA repair and recombination, DNA mismatch repair, Double Strand Break repair, recombination as a molecular biology tool, CRISPR-Cas systems for editing, regulating and targeting genomes.
Transcription and mRNA Processing: Types of RNA, Prokaryotic &, eukaryotic transcription, general and specific transcription factors, Regulatory elements and mechanisms of transcription regulation, Transcriptional and posttranscriptional gene silencing: Initiation, Elongation & Termination of transcription, Capping, Polyadenylation, Splicing, editing, mRNA stability, RNA interference and microarray analysis, RNA editing.
Exercise: Application Article, Problem based learning.

Unit III **10 Hours**

Translation: Genetic code, prokaryotic & eukaryotic translation, the translation machinery, mechanisms of chain initiation, elongation and

termination, regulation of translation, co-and post- translational modifications, mode of action of antibiotics.
Exercise: Asking Questions, Crossword Puzzle, Case Studies.

Unit IV **11 Hours**

Gene Regulation: Prokaryotic – lac, trp, gal and ara operons, lambda gene regulation during lysogeny and lytic cycle; Eukaryotic – yeast, higher eukaryotes, hormonal regulation of genes, epigenetic regulation; Gene network analysis, co-expression.
Exercise: Team teaching, Group Text Reading, Problem Solving.

Suggested Reading:

1. Watson, J.D., Baker,T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2014). *Molecular Biology of the Gene*. 7th Edition, Benjamin Cummings, USA
2. Green, M.R., Sambrook, J. (2012). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.
3. Lodish, H, Birk, A, et al. (2016) *Molecular Cell Biology*. 8th ed. WH Freeman.
4. Nancy Craig, Rachel Green, Carol Greider, Gisela Storz, and Cynthia Wolberger (2019) Molecular Biology. Principles of Genome Function. Third Edition. Oxford University Press
5. Michael M. Cox; Jennifer Doudna ;Michael O'Donnell (2015) Molecular Biology Principles and Practice Second Edition, WH Freeman and company
6. David P. Clark, Nanette J. Pazdernik and Michelle R. McGehee (2019) Molecular Biology: Principles and Practice Elsevier Inc. USA
7. Robert F. Weaver (2011)Molecular Biology McGraw-Hill Education; 5th edition

Web Sources:

-https://www.biointeractive.org/classroom-resources/bacterial-identification-virtual-lab
- https://www.youtube.com/watch?v=VgAuZ6dBOfs

Modes of transaction

-Lecture
-Problem Solving
-Self-Directed Learning
-Inquiry training
-Co-operative learning
-Team teaching

Tools used

Study Videos, Google Classroom/Drive

L	T	P	Credits
3	0	0	3

Course Code: MIC.523
Course Title: Microbial Physiology and Metabolism

Total Hours: 45

Learning Outcomes:
The students will be able to:

- Illustrate the metabolic diversity exhibited by microorganisms, their thermodynamics and regulatory networks that support their survival and growth.
- Grasp basic mechanisms of energy-yielding and consuming processes
- Compile the knowledge about microbial transport system, and mechanism of bacterial sporulation in a broad spectrum of micro-organism.

Course Contents

Unit I **10 Hours**

Bacterial Photosynthesis: Photosynthetic microorganisms, photosynthetic pigments, and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria**.** Carbon dioxide fixation pathways**.**
Exercise: Brainstorming, Discussions and Group Learning, Debates.

Unit II **11 Hours**

Bacterial Respiration: Bacterial aerobic respiration, components of electron transport chain, free energy changes and electron transport, oxidative phosphorylation and theories of ATP formation, inhibition of electron transport chain. Electron transport chain in heterotrophic and chemolithotrophic bacteria. **Bacterial Anaerobic Respiration:** Introduction. Nitrate, carbonate and sulfate as electron acceptors. Electron transport chains in some anaerobic bacteria. Catalase, superoxide dismutase, mechanism of oxygen toxicity.
Exercise: Presentations, Debates, Quiz, Critical Thinking

Unit III **12 Hours**

Bacterial Permeation: Structure and organization of membrane (Glyco-conjugants and proteins in membrane systems), fluid mosaic model of membrane. Methods to study diffusion of solutes in bacteria, passive diffusion, facilitated diffusion, different mechanisms of active diffusion. Proton Motive Force, PTS, role of permeases in transport, different permeases in *E. coli*. Transport of amino acids and inorganic ions in microorganisms and their mechanisms.
Exercise: Student-generated test questions, Classroom Opinion Polls.

Unit IV **12 Hours**

Bacterial Sporulation: Sporulating bacteria, molecular architecture of spores, induction and stages of sporulation, Influence of different factors on sporulation. Cytological and macromolecular changes during sporulation. Heat resistance and sporulation. **Bacterial Chemolithotrophy:** Physiological groups of chemolithotrophs, ammonia oxidation by members of Genus Nitroso group, nitrite oxidation by Nitro group of genera. Oxidation of molecular hydrogen by hydrogeno-monas species. Ferrous and sulfur/sulfide oxidation by *Thiobacillus* species.

Exercise: Concept Maps, Application Articles, Experimental evidence.

Suggested Reading:

1. Caldwell D.R. (1995) *Microbial Physiology and Metabolism*. Brown Publishers.
2. Moat A.G., Foster J.W. and Spector M.P. (2002). Microbial Physiology, 4th edition. John Wiley and sons inc., publication.
3. Brun. Y.V. and Shimkets L.J. (2000) *Prokaryotic Development*. ASM Press.
4. Kim B.H. and Gadd G.M. (2008). Bacterial physiology and metabolism. Cambridge University Press, Cambridge.
5. Cohen, Georges N.(2014) Microbial Biochemistry Third edition Springer Netherlands
6. White, D. (2011) *The Physiology and Biochemistry of Prokaryotes*, 4th Edition, Oxford University Press
7. Madigan, Bender, Buckley, Sattley & Stahl, (2019) Brock Biology of Microorganisms, 16th Edition Pearson education, USA

Modes of transaction

-Lecture
-Problem solving
-Panel discussion
-Tutorial

L	T	P	Credits
3	0	0	3

Course Code: MIC. 524
Course Title: Environmental Microbiology

Total Hours: 45

Learning Outcomes:

The students will be able to:

- Identify how microbes interact in the environment.

- Categorize the composition of industrial waste water and xenobiotics, and their treatment using microorganisms.
- Utilize this knowledge in small household set up or in large scale industrial remedial set ups.

Unit I **10 Hours**

Environment and Ecosystem: Biotic and abiotic environment. Environmental segments. Composition and structure of environment. Concept of biosphere, communities and ecosystems. Ecosystem characteristics, structure and function. Food chains, food webs and trophic structures. Ecological pyramids.
Exercise: Concept mapping, Class discussion, spontaneous quizzes

Unit II **12 Hours**

Microbiology of Waste-water: Concepts C-BOD, N-BOD and COD, Oxygen-sag curve. General characteristics of industrial waste-water coming from sugar industries, tanneries, paper-pulp and alcohol industries. Disinfection of drinking water with anti-microbial agents. Coliform test of potable water. Primary treatment of wastewater, treatment of industrial effluent by aerobic treatment methods; Trickling filters, and Oxidation ponds. Methods of anaerobic treatment of sludge. Bioaccumulation of heavy metal ions from industrial effluents. Removal of nitrogen and phosphorous and volatile organic matter from water. Water borne risk to human health.
Exercise: Numerical exercises for BOD, COD calculation, Interpretation for oxygen sag curve

Unit III **12 Hours**

Microbial Toxicology: General chemistry of pollutants.Particulate matter, poly-aromatic hydrocarbons, organosulfur, organophosphorous, organohalides, organonitrogen, organometallic compounds. Fog and smog, acid rain Dose-response relationship, Determination of LD50, Effect of heavy metals, pesticides on the microbial population in air, water and soil. Ames test to determine the genotoxicity of toxicants. Mode of action of carcinogens, Microbial tolerance and resistance against heavy metals, antibiotics and pesticides.
Exercise: Case studies, research paper discussion

Unit IV **11 Hours**

Degradation of Xenobiotics: Concepts of xenobiotics, bio-concentration and bio-magnification, Bio-transformation and biodegradation of xenobiotics like organophosphates and organohalides compounds, plastic, paints. Genetically Modified Organisms released and its environmental impact assessment and ethical issues.
Exercise: One minute concepts, improved discussion, Quizzes

Suggested Reading:

1. Baker, K.H. And Herson D.S. (1994). *Bioremediation*. MacGraw Hill Inc. N.Y.
2. E Eldowney, S. Hardman D.J. and Waite S. (1993). Pollution: Ecology and Biotreatment Longman Scientific Technical.
3. R. K. Trivedy (1998) *Advances in Waste Water Treatment Technologies*. Volumes II and I. Global Science Publication.
4. Lawrence, P., Wacekett, C. and Douglas Hershberger. (2000) *Biocatalysis and Biodegradation: Microbial transformation of organic compounds.* ASM Publications.
5. Christon J. Hurst (2001). *A Manual of Environmental Microbiology*. 2nd Edition. ASM Publications.
6. Ian Pepper, Charles Gerba, Terry Gentry (2014) *Environmental Microbiology* 3rd Edition; Academic Press.
7. N.S. Subba Rao. (2020). *Bio-fertilizers in Agriculture and Forestry*. CBS Publisher and Distributor.

Web Sources:

https://swayam.gov.in/

Modes of transaction:

-Lecture
-Demonstration
-Lecture cum demonstration
-Inquiry training
-Group discussion
-Field visits

L	T	P	Credits
3	0	0	3

Course Code: MIC.525
Course Title: Microbial Pathogenicity

Total Hours: 45

Learning Outcomes:

The students will be able to:

- Describe virulence determinants – colonization, toxins, enzymes and invasiveness with varied examples from different pathogens.

- Illustrate facultative or obligate intracellular and describe molecular Koch's postulates and multiplicity of virulence factors and coordinated regulation of virulence genes.
- Categorise 1-IV secretion systems, importance of biofilms and quorum sensing
- Propose the concepts of antimicrobial, multidrug efflux pumps, extended spectrum β-lactamases, X-MDR Mycobacterial tuberculosis, methicillin-resistant *S.aureus* (MRSA)

Unit I **11 Hours**

Introduction and Techniques to Study Bacterial Pathogenesis: Host defence mechanisms such as Phagocytosis, opsonization and complement, Non-specific, innate and adaptive host defence. Genetic and Bioinformatics approaches, Proteomic approaches, Systems biology based approaches to Host pathogen Interaction. Human Microbiome and their role in therapeutics.
Exercise: Student-generated test questions, Classroom Opinion Polls

Unit II **12 Hours**

Molecular Microbial Pathogenicity: Molecular Koch's postulates, multiplicity of virulence determinants, coordinated regulation of virulence genes, and environmental regulation of virulence determinants by two component signal transduction systems, antigenic variation; type three secretion system (TTSS, T3SS), Role of biofilms and quorum sensing in microbial pathogenecity. Environmental changes and infectious diseases: Global warming-led increase in vector-borne and water-borne infectious diseases; Impact of increasing urbanization, international travel and trade on infectious diseases.
Exercise: Quiz, Critical Thinking, Brainstorming

Unit III **10 Hours**

Emerging and Re-emerging Pathogens: Illustrate emerging and re-emerging pathogens using *V. cholerae* 0139, X-MDR M. tuberculosis, *Helicobacter pylori, Entero-haemorrhagic E. coli* (EHEC), EBOLA, Bird/swine flu, MERS-CoV, SARS-CoV-, AIDS, and opportunistic fungal pathogens. Mechanisms of emergence of new pathogens: horizontal gene transfer (HGT) and pathogenicity islands (PAI).
Exercise: Extempore of recent pathogenic events, Peer Review

Unit IV **12 Hours**

Molecular Microbial Epidemiology: Objectives of microbial epidemiology. Biochemical and Immunological tools - biotyping, serotyping, phage typing,; Molecular typing: RAPD, rep (REP, ERIC, BOX)-PCR, IS based typing, PFGE, AFLP, MLST, VNTR and whole genome sequence; **Rapid diagnostic principles:** Nucleic acid probes in diagnostic microbiology, nucleic acid

amplification methods, Real-time PCR, Lateral flow assays, diagnostic sequencing and mutation detection, automated instruments for detection / diagnosis of infectious agents.
Exercise: Discussions and Group Learning, Paper discussion, hands-on training

Suggested Reading:

1. Jawetz, Melnick, & Adelberg (2016) *Medical Microbiology* by Carroll KC, Hobdon JA, Miller S, Morse SA, Mietzner TA. Lange Publication.
2. Locht C and Simonet M, Caister (2012) *Bacterial Pathogenesis: Molecular and Cellular Mechanisms* by Academic Press.
3. Persing DH, Tenover FC, Hayden R, Leven M, Miller MB, Nolte FS, Tang YW, Belkum AAV. (2016) *Molecular Microbiology: Diagnostic Principles and Practice.* American Society for Microbiology Press.
4. Nelson KE and Williams CM (2019) *Infectious Disease Epidemiology: Theory and Practice.* Jones and Bartlett.
5. Mahon, Connie R. Lehman, Donald C. Manuselis, George (2007) *Textbook of Diagnostic Microbiology.* USA: Saunders.
6. World Organization for Animal Health: "*Manual of Diagnostic Tests and Vaccines for Terrestrial Animals"* Volumes I & II, 6th Edition, 2010.
7. Rao, Juluri R, Fleming, Colin C., Moore, John E., (2006) *Molecular Diagnostics: current technology and Applications.* Horizon Bioscience, U. K.

Web Sources

https://www.cdc.gov/
https://www.who./

Modes of transaction:

-Lecture
-Demonstration
-Lecture cum demonstration
-Inquiry training
-Group discussion

L	T	P	Credits
3	0	0	3

Course Code: MIC.526
Course Title: Research Methodology and Bioinformatics
Total Hours: 45

Learning Outcomes: Student will be able to:

- Illustrate various aspects of research methods, ethics, technical and scientific writings and literature search.
- Demonstrate various bioinformatics tools and techniques.

Course Contents

Unit I **10 Hours**

General Principles of Research: Meaning and importance of research, critical thinking, formulating hypothesis and development of research plan, review of literature, interpretation of results and discussion. Scientific writing: writing synopsis, research manuscript and dissertation. Literature search and survey, e-Library, web-based literature search engines.

Exercise: Research presentation and poster preparation. Plagiarism and open access publishing.

Unit II **11 Hours**

Bioethics and Biosafety: Good Laboratory Practices, Sterilization techniques, Cell and tissue culture techniques: Plants and animals. Biosafety for human health and environment. Biosafety issues for using cloned genes in medicine, agriculture, industry, and ecoprotection. Genetic pollution, Risk and safety assessment from genetically engineered organisms. CDC/DBT/ICMR guidelines for biosafety. Ethical theories, Ethical considerations during research, Ethical issues related to animal testing and human project. Intellectual property rights (IPRs), Patents copyrights.

Exercise: Paper discussion (research paper versus review article), case studies on patent filing.

Unit III **12 Hours**

Biological databases: Nucleotide Sequence Databases, GenBank, DDBJ, EMBL, Sequence Flatfile and submission process, Protein sequence databases, UniProt in detail, Mapping databases, Genomic databases, Data mining. **Sequence analysis:** Gene Prediction methods and programs, Markov and Hidden Markov models in gene prediction, Promoter analysis, RNA secondary structure thermodynamics, Dynamic programming and genetic algorithms for secondary structure prediction, refining multiple sequence alignment based on RNA secondary structure predictions, Vienna RNAfold, Evolution and origins of sequence polymorphisms, SNP discovery methods and databases, Genotyping, International haplotype map project, 1000 genomes project. **Analysis for protein sequences:** Predicting features of individual residues, Predicting function, Neural networks, Protein structure prediction, Protein structure databases.

Modelling and structure: From protein sequence to structure, theoretical and practical aspects of protein sequence alignments, secondary, tertiary structure prediction, comparative modeling, Docking, protein-protein and protein-ligand docking. Techniques for 3-D structure determination like X-ray, NMR, MS/MS analysis. Immunoinformatics approaches.
Exercise: Hands on training on bioinformatics tools, Peer Evaluation and Review, Training Games for Learners.

Unit IV **12 Hours**

Inferring relationships: Global Vs. local sequence alignments, Dotplots, Scoring matrices, Pairwise sequence alignment, BLAST, Position-Specific scoring and PSI-BLAST, MegaBLAST, BL2SEQ, BLAT, FASTA Vs BLAST, Protein multiple sequence alignments, Multiple structural alignments, Shotgun sequencing, Sequence assembly and finishing. **Phylogenetic analysis:** Basics of phylogenetics, Nucleotide substitution models and selection, Distance-matrix-based methods, Neighbor-Joining, Fitch-Margoliash, Outgroups, UPGMA, Minimum evolution, Maximum parsimony, Maximum likelihood, Bayesian inference, Searching for trees, Rooting trees, Bootstrapping, Likelihood ratio tests.
Exercise: Hands on training on bioinformatics tools, Quiz, Brainstorming.

Suggested Reading:

1. Gupta, S. (2005). *Research Methodology and Statistical Techniques.* Deep & Deep Publications (p) Ltd. New Delhi.

2. Kothari, C.R., Garg, G. (2019). *Research Methodology: Methods and Techniques.* 4th Edition, New Age International (p) Limited. New Delhi.

3. Fleming, D. O. and Hunt, D.L. (2006). *Biological Safety: Principles and Practices*. American Society for Microbiology, USA.
4. Rockman, H. B. (2004). *Intellectual Property Law for Engineers and Scientists*. Wiley-IEEE Press, USA.
5. Shannon, T. A. (2009). *An Introduction to Bioethics*. Paulist Press, USA.
6. 4. Kauda J. (2012). *Research Methodology: A Project Guide for University Students*. Samfunds literature Publications.
7. Vaughn, L. (2009). *Bioethics: Principles, Issues, and Cases.* Oxford University Press, UK.
8. WHO (2005). *Laboratory Biosafety Manual*. World Health Organization.
9. Lesk, A.M. (2019). Introduction to Bioinformatics. 5th Edition, Oxford University Press, UK.
10. Ramsden, J. (2021). Bioinformatics: An Introduction (Series: Computational Biology). 4th Edition, Springer International Publishing.
11. Baxevanis, A.D. and Ouellette, B.F.F. (2005). *Bioinformatics: A Practical guide to the Analysis of Genes and Proteins*. Wiley-Interscience, USA.
12. Hall, B.G. (2011). *Phylogenetic Trees Made Easy: A How-To Manual*. Sinauer Associates, Inc. USA.

13. Zvelebil, M. and Baum, J. (2007). *Understanding Bioinformatics*, Garland Science, New York, USA.
14. Ye, S.Q. (2008). *Bioinformatics: A Practical approach*. Chapman & Hall/CRC, UK.
15. Mount, D. (2012). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
16. Graur, D., Li, W. H. (2000). *Fundamentals of Molecular Evolution*. Sinauer Associates.
17. Tisdall, J. (2001). *Beginning Perl for Bioinformatics*. O'Really Publishers.
18. Orengo, C., Jones, D., Thornton, J. (2005). *Bioinformatics: Genes, Proteins and Computers* (Advanced Texts). Taylor and Francis Publishers.

Web-links

- https://www.cdc.gov/
- https://www.who./
- http://dbtindia.gov.in/regulations-guidelines/regulations/biosafety-programme
- https://pubmed.ncbi.nlm.nih.gov/
- -https://www.uniprot.org-https://pubmed.ncbi.nlm.nih.gov/
- https://blast.ncbi.nlm.nih.gov/Blast.cgi
- https://scholar.google.com

Modes of transaction

-Lecture
-Demonstration
-Lecture cum demonstration
-Inquiry training
-Panel discussion
-Problem solving
-Self-directed learning

L	T	P	Credits
3	0	0	3

Course Code: MIC.527
Course Name: Biostatistics

Total Hours: 45

Learning Outcomes: Student will be able to:

Demonstrate the outcome of results using biostatistical approaches in testing hypothesis, designing experiments, analyzing experimental data and interpreting the results.

Unit I **11 Hours**

Experimental design and analysis Sampling Design, Sampling Techniques, Sampling theory, Various steps in sampling, collection of data-types and methods. Probability and Non-Probability, Sample Size and its Determination, Qualities of a good Sample. Collection and Presentation of Data- Constructing an Instrument for Data Collection- Methods for Data Collection. Summarizing Data, Frequency Distribution Tables, Graphical Presentation, Frequency Distribution Graphs, Univariate Graphs. Validity and Reliability of Research Instruments- Ethical issues in Data Collection; Processing and Displaying Data.

Exercise: Case studies, Peer Evaluation and Review

Unit II **12 Hours**

Overview of Biostatistics: Differences between parametric and non-parametric statistics, Univariant and multivariant analysis. Frequency distribution. Mean, Median, Mode, Probability Distribution, Standard deviation, Variation, Standard error, significance testing and levels of significance, Hypothesis testing. Measures of central tendency and dispersal, Histograms, Probability distributions (Binomial, Poisson and Normal), Sampling distribution, Kurtosis and Skewness. **Exercise:** Problem solving, numerical, Training Games for Learners, Student-generated test questions.

Unit III **10 Hours**

Computer application of statistical software, Microsoft Excel as statistical tool, formatting of excel spreadsheet cells, formula based calculation in excel sheets. Use of statistical packages such as Graphpad prism, SPSS, Sigma plot analysis etc.

Exercise: Hands on training on excel, statistical tools, Using SPSS, Prism and Graphpad.

Unit IV **12 Hours**

Statistical Tools: Student's t-test, Paired t-test, Mann-Whitney U-test, Wilcoxon signed-rank, One-way and two-way analysis of variance (ANOVA), Critical difference (CD), Least Significant Difference (LSD), Kruskal–Wallis one-way ANOVA by ranks, Friedman two-way ANOVA by ranks, x^2 test. Standard errors of regression coefficients and types of correlation coefficient. **Regression and correlation**: Standard errors of regression coefficients, Comparing two regression lines, Pearson Product - Moment Correlation Coefficient, Spearman Rank correlation coefficient, Power and sampling size in correlation and regression.

Exercise: Case studies, Data analysis, practicing numerical for biostatistics.

Suggested Reading:

1. Norman, G. and Streiner, D. (2014). *Biostatistics: The Bare Essentials*, Decker Inc. USA, 4th edition.
2. Rao Nageswara G. (2018) Biostatistics & Research Methodology, 1st Ed. PharmaMed Press
3. Samuels, M.L., Witmer, J., Schaffner, A. (2016). *Statistics for the Life Sciences*. , 5th edition, Prentice Hall publishers.
4. Sokal, R.R. and Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research.* W.H. Freeman publishers. 3rd edition.
5. Emden, H.F. (2019). *Statistics for Terrified Biologists*. Blackwell Publishers.
6. Bernard Rosner (2015) Fundamentals of Biostatistics 8th Edition, Cengage Learning.

Weblinks:

-https://pubmed.ncbi.nlm.nih.gov/
- https://blast.ncbi.nlm.nih.gov/Blast.cgi
- https://scholar.google.com

Modes of transaction

-Lecture cum demonstration
-Inquiry training
-Problem solving
-Self-learning

L	T	P	Credits
0	0	6	3

Course Code: MIC.528
Course Title: Microbiology Practical-II

Total Hours: 90

Learning Outcomes:

The students will be able to:

- Plan experiments related to clinical microbiology and virology which will enhance their laboratory skills, and scientific knowledge.
- Distinguish between various types of microbial media, culturing methods,
- Inspect and isolate the microbes from the day to day sources.

- Outline the basic molecular biology, cell culture and immunological techniques and correlate them with their fundamental concepts in the subject
- Assess the use of molecular biology, cell culture and immunological techniques in health and diseases,
- Elaborate the molecular biology techniques and their application to study bacterial and mammalian cells, cellular DNA, RNA, proteins along with different aspects of immune processes.

Course Contents

Part A. Microbiology

1. Preparation of Media: Nutrient broth, Nutrient agar, plates, slants, soft agar; Pure culture technique: Streak plate, spread plate and pour plate methods.
2. Staining methods: Simple staining, Negative Staining, Gram Staining, Acid-Fast stain.
3. Culturing methods of microbes – slant and stab cultures, tube culture, flask cultures, shake flask cultures
4. Methods for studying microbial respiration
5. Preparation of different types of culture media/observation. Blood Agar, Chocolate Agar, Mannitol salt agar, Blair Parker medium, MacConkey agar, Lowensten-Jension medium, Wilson Blair Bismuth sulphite medium, Biochemical media.
6. Tests for disinfectants (Phenol coefficient/RWC)
7. Study of normal micro-biota of mouth; isolation, identification and preservation of microorganisms
8. Study of normal micro-biota of skin; isolation identification and preservation of microorganisms
9. Identification and Biochemical tests of respiratory tract bacterial pathogen using avirulent strain of MTCC Culture of *Streptococci/ Klebsiella pneumoniae*.
10. Identification and Biochemical tests of gastrointestinal bacterial infection using avirulent strain of MTCC Culture of *Salmonella / Shigella* spp.
11. Laboratory examination and identification and biochemical tests of pus specimens using avirulent strain of MTCC Culture for *Staphylococcus aureus*, *Streptococcus pyogenes* and *Pseudomonas aeruginosa*.
12. Laboratory examination of sputum: Collection of sputum. Microbiological examination of sputum for pus cells and predominant bacteria. Ziehl-Neelsen staining to detect the presence of Mycobacterium using avirulent strain of MTCC Culture.
13. Determination of MIC values for antimicrobial chemicals
14. Identification of pathogenic bacteria (any three of *E. coli*, *Salmonella*, *Pseudomonas*, *Staphylococcus*, *Bacillus*) based on cultural, morphological and biochemical characteristics.
15. Biochemical, enzymatic and serological tests (Coagulase, Catalase, WIDAL, VDRL tests).
16. PCR based diagnosis.
17. Estimation of infectivity titer of a virus sample using Plaque assay.

18. Production of a purified virus stock and its quantitation.

Part B. Immunology and Research Methodology

1.To perform Total Leukocyte Count/Differential Leukocyte count of the given blood sample.
2. Separation of serum from blood.
3. To isolate mononuclear cells from peripheral blood various lysis and separation methods.
4. To analyse cell viability by dye exclusion method.
5. Media preparation for animal cell culture.
6. Growth and maintenance of cell lines.
7. Recovery of cells from monolayer: Chemical and mechanical methods.
8. To analyse cytotoxicity of a treatment in a given cell line and calculating LD50 dose.
9. Lymphocyte proliferation assay.

10. Double immunodiffusion test using specific antibody and antigen.
11. To perform immunoelectrophoresis using specific antibody and antigen.
12. Dot Immuno blot assay (DIBA).
13. ELISA
14. Polyacrylamide gel electrophoresis and Western blotting.
15. Demonstration of Flow Cytometry.
16. Immunohistochemistry: H & E staining, Fluorescent staining, Fluorescent Microscopy, Confocal Microscopy

Part C. Molecular Biology

1. Isolation of genomic DNA
2. DNA amplification by Polymerase Chain Reaction (PCR).
3. Ligation and E.coli transformation using chemical transformation, plating, colony selection,
4. Isolation of plasmid DNA, restriction enzyme digestion and agarose gel electrophoresis.
5. Construction of restriction map by single and double digestion, Designing DNA probe,
Southern blot hybridization (demonstration only).
6. RNA isolation from biological samples.
7. cDNA synthesis and real time PCR (qPCR).
8. DNA sequencing (demonstration only).
9. NCBI BLAST search and Primer design.
10. Multiple Sequence Alignment and Phylogenetic analysis using MEGA
11. Determination of genes mapped within a specific chromosomal locus using GeneLoc integration resource and gene orthologue prediction using Ensembl.
12. Protein-protein interactions using STRING; Introduction to KEGG and Metacyc databases

Practical may be modified depending on available faculties/facilities.

Exercise

Objective structured practical examination
Oral presentation on current advancements in immunology
Group discussion
Self-directed learning

Modes of transaction

-Lecture cum demonstration
-Problem Solving
-Self-Learning
-Inquiry training
-Experimentation

Evaluation Criteria for Practical Courses: Students are evaluated for a total of 100 marks with following distribution:

Continuous assessment- 50 Marks:

Maintaining the lab records/notebooks: 15 Marks
Surprise test/quiz/objective type test during the semester: 15 Marks
Good laboratory Practices, Designing and execution of experiments: 10 Marks
Attendance during day to day practical: 10 Marks

Final Practical Examination- 50 Marks:
Minor Experiment (10 Marks), Major Experiment (to be performed, 20 Marks) and viva-voce (20 Marks)

Suggested Reading:

1. Michael J. Leboffe (2011) *A Photographic Atlas for the Microbiology laboratory*.
2. Prakash S. Bisen (2014) *Laboratory Protocols in Applied Life Sciences*. Taylor & Francis Group, LLC
3. John Harley (2016) *Laboratory Exercises in Microbiology*, 10th Edition by John Harley
4. Benson's Microbiological *Applications Lab Manual*, 2016.
5. James G. Cappuccino & Natalie Sherman (2014) *Microbiology: A Laboratory Manual,* 10th Edition 2014
6. Aneja KR (2014) *Laboratory Manual of Microbiology and Biotechnology*.
7. Alberts, B. Bray, D. Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell.* Garland publishers, Oxford.
8. Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.
9. Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology*. CRC Press, Taylor and Francis Group, UK.

10. Michael J. Leboffe (2011) *A Photographic Atlas for the Microbiology laboratory*.
11. *Laboratory protocols in Applied Life Sciences* (2014). Taylor & Francis Group, LLC
12. James G. Cappuccino &Natalie Sherman (2014) *Microbiology: A Laboratory Manual,* 10th Edition 2014
13. Aneja KR (2014) *Laboratory Manual of Microbiology and Biotechnology*.
14. Alberts, B. Bray, D. Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell.* Garland publishers, Oxford.
15. Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.
9. Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology*. CRC Press, Taylor and Francis Group, UK.

Software tools and Web Sources

BLAST, MEGA

- https://blast.ncbi.nlm.nih.gov/Blast.cgi
- https://www.vlab.co.in
- https://www.cdc.gov/
- https://www.who./

Semester – III

L	T	P	Credits
3	0	0	3

Course Code: **MIC.551**
Course Title: **Industrial Microbiology**

Total Hours: **45**

Learning Outcomes:
The students will be able to:

- Summarize the use of microorganisms for the value added products through fermentation and other large scale processes.
- Apply the upstream and downstream processes in the large scale production of several primary and secondary metabolites of microbial origin
- Apply the knowledge of basic industrial microbiology in actual research and industry.

Course Contents

Unit I **12 Hours**

Introduction: Scope and historical development; Sources of industrially important microbes, strain development, types of fermentation and fermenters, process optimization, and recent developments in fermentation technology. Types of fermentation systems; Bioreactor designs and operations. **Downstream processing of microbial products:** Filtration, centrifugation, cell disruption, liquid-liquid extraction, chromatography, membrane processes, drying (lyophilization and spray drying), and crystallization. Types of fermentation systems; Bioreactor designs and operations.
Exercise: Case studies, industry visits,

Unit II **12 Hours**

Microbes in Industry: Alcohol production- Preparation of medium, Fermentation process and recovery; Production of Malt beverages: Production of Beer- malting process, mashing process and finishing; other malt products. Production of Wine: Microbial process, wine from grapes, Fermentation and recovery, types of wine-white and red wine. Production of distilled beverages or liquors- rum, whiskey and brandy; Microbial production of organic acids-vinegar production (substrate, Microbial processing and product recovery); Citric Acid- fermentation, recovery and uses; Lactic acid-fermentation, medium and manufacturing process, recovery and uses. Production of vitamins: Vitamin B12 (Cyanocobalamine) production; Riboflavin (vitamin B2) production, Single cell protein, Mushroom production Biopolymers-xanthan gum and PHA's (Bioplastics), Bioethanol, Biobutanol, Biodiesel, Biohydrogen production by

using microorganisms. Biofertilizers and composting, Bacteriophages in control of bacteria. Microbial biosensors and its applications.

Exercise: Panel Discussion, Industry visits, hands-on experiments, Concept Mapping

Unit III **10 Hours**

Development and production of microbial products: Organic Metabolites- Ethanol, Acetone; Citric acid, Acetic acid, Lactic acid, Gluconic acid, Itaconic acid, Amino acids; Enzymes- Amylases, Glucose Isomerase, L Asparaginase, Proteases, Renin, Penicillin acylases, Lactases, Pectinases, Lipases; Vitamins- Vitamin B12, Riboflavin, B carotene; Antibiotics: beta-Lactam antibiotics; Amino acid and peptide antibiotics; Carbohydrate antibiotics; Tetracycline and anthracyclines; Nucleoside antibiotics; Aromatic antibiotics. Biotransformation of steroid and non-steroid compounds. Recombinant biomolecules and therapeutic proteins, vaccines production, DNA based vaccines, antibody production, therapeutic enzymes.

Exercise: Discussions and Group Learning, Concept Mapping.

Unit IV **11 Hours**

Metabolic Engineering and Microbial nanotechnology: Introduction to metabolic engineering**:** Concept and importance of metabolic engineering, basic enzyme kinetics, metabolite regulation of metabolic pathways, basic metabolic control analysis (MCA), metabolic fluxes and basic flux balance analysis (FBA), Applications of MCA and FBA for the improvement of microbial strains and plant cells fermentation processes. Microbial synthesis of Nanoparticles. Synthesis of nanodrugs – metal nanoparticles and drug delivery vehicles – Nanoshells – Tectodentrimers Nanoparticle drug systems – Diagnostic applications of nanotechnology. Regulatory Approvals and Clinical Trials: Good laboratory practice (GLP), Current Good Manufacturing Practice (CGMP), different phases of clinical trials, difference between biologics, biosimilar and biobetter, development of biosimilars and generic biomolecules, analysis of process economics.

Exercise: Training Games for Learners, Problem-solving Activities for Learners.

Suggested Reading:

1. Cruger W and Cruger A. (2004). *Biotechnology - A Textbook of Industrial Microbiology*. Panima.
2. Nduka Okafor, Benedict C. Okeke (2018),Modern Industrial Microbiology and Biotechnology Second edition CRC Press
3. Allan Whitaker, Peter F. Stanbury, and Stephen J. Hall (2016) *Principles of Fermentation Technology.Third Edition Butterworth-Heinemann*
4. Gary Higton, Michael J. Waites, Neil L. Morgan, John S. Rockey (2001) *Industrial Microbiology: An Introduction.*

5. Richard H. Baltz , Arnold L. Demain , Julian E. Davies (2010) Manual of Industrial Microbiology and Biotechnology Third edition American Society for Microbiology Press
6. L.E.J.R. Casida (2019) Industrial Microbiology Second Edition New Age International Private Limited
7. George Stephanopoulos, Aristos A. Aristidou , Jens Nielsen (1998)Metabolic Engineering: Principles and Methodologies Academic Press

Modes of transaction:

-Lecture

-Demonstration

-Lecture cum demonstration

-Inquiry training

-Group discussion

L	T	P	Credits
3	0	0	3

Course Code: MIC.552
Course Title: Food and Dairy Microbiology

Total Hours: 45

Learning Outcomes:
The students will be able to:

- Identify the microbiology of food and dairy products
- Explain the food spoilage and preservation methods.
- Propose the industrial aspect of dairy microbiology.
- Provide solution for pathogenic and spoilage microorganisms associated with different foods and their commercial importance.

Course Contents
Unit I **11 Hours**

Microbial Growth in Food: Intrinsic, extrinsic and implicit factors, Microbial interactions, Inorganic, organic and antibiotic additives. Physical and chemical factors influencing the destruction of microorganisms including thermal death time, Z, F and D values. Food Borne Diseases: Importance and significance of microorganisms in food. Food borne diseases- Bacterial food borne diseases- (Staphylococcal intoxication, Botulism, Salmonellosis, Shigellosis, EHEC E. coli infection, *Listeria monocytogenes* infection, *Clostridium perfringens* gastroenteritis, *Bacillus cereus* gastroenteritis; Food-borne fungi- Mycotoxins in foods and its implication on crops.
Exercise: Training Games for Learners, Problem-solving Activities for Learners

Unit II **13 Hours**

Microbiology of Food: Microbial habitat of specific food materials, adaptations and changes in microbiome of vegetables, fruits, milk, fermented and non-fermented milk products, fresh meats, poultry and non-dairy fermented foods. Microbial spoilage of foods: Types and causes of spoilage of cereals and cereals products, spoilage of vegetables and fruits, spoilage of meat and meat products, spoilage of fish and other sea foods, spoilage of eggs and other poultry products, spoilage of milk and milk products.

Exercise: Quiz, Critical Thinking, Brainstorming,

Unit III **11 Hours**

Fermented and Dairy Food Products: Microorganisms involved in food fermentations. Starter cultures for fermented dairy products (*Streptococcus thermophillus*, *Lactobacillus bulgaricus*). Fermented milk products- Acidophilus and Bulgarian milk, yoghurt, cheese, Kefir, Koumiss; Fermented grains and vegetable products - Sauerkraut, Soy sauce, Tempeh, Miso, and Kimchi; Single cell protein, Role of microorganisms in beverages – tea and coffee fermentations. Vinegar Fermentation. Prebiotic and Probiotics in foods and its benefits.

Exercise: Problem based learning, Quiz, Critical Thinking, Brainstorming

Unit IV **10 Hours**

Food Preservation and Safety: Use of High and low temperature, Control of water activity, Use of Radiations in preservation, Modified atmosphere packaging, High pressure processing, chemical preservatives and naturally occurring antimicrobials; Bacteriocins and their applications. Microbial testing of food, Microbiological quality standards of food and regulatory bodies: FDA (Food and Drug Administration), HACCP (Hazard Analysis and critical control points), FSSAI (Food Safety and Standards Authority of India). **Exercise:** Discussions and Group Learning, Concept Mapping

Suggested Reading:

1. Ray, B. and Bhunia, A. (2013). *Fundamental Food Microbiology*, 5th revised edition. CRC press Inc.
2. Frazier, W.C. and Westhoff, D.C. (2013). *Food Microbiology.* 5th Ed. Tata McGraw Hill.
3. Doyle, M.P. and Buchanan, R.L. (2012), *Food Microbiology*, ASM Press, Washington.
4. Jay, J.M., Loessner, M.J. and Golden, D.A. (2005) *Modern Food Microbiology*, 7th ed. Springer-Verlag New York
5. Richard K. Robinson, (2002). Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products, Wiley-Blackwell; 3rd Edition.
6. Doyle, M. P. and Beuchat, L. R., 2007, Food Microbiology-Fundamentals and Frontiers, ASM Press.

7. Elmer H. Marth, James Steele, (2001). Applied Dairy Microbiology, Second Edition, CRC Press.

Modes of transaction:

-Lecture
-Demonstration
-Lecture cum demonstration
-Inquiry training
-Group discussion
-Self-learning
- Field visits

L	T	P	Credits
3	0	0	3

Course Code: MIC.553
Course Title: Bacteriology and Virology

Total Hours: 45

Learning Outcomes:
The students will be able to:

- Outline the concept of various cellular processes during disease development.
- Classify the relevance of microbes and diseases caused by bacteria, and viruses.
- Comprehend the clinical diagnostics and treatment of the different diseases caused by these microbes.

Course Contents

Unit I **12 Hours**

History and Molecular Basis of Microbial Pathogenesis: Historical development in the field of medical microbiology, Establishment of pathogenic microorganisms: Entry, spread and tissue damage. Mechanism of bacterial adhesion, colonization and invasion of mucous membranes of respiratory, enteric and urogenital tracts. Biofilms and quorum sensing, Quorum quenching modulation of apoptotic processes. Bacterial secretion system and its importance: Secretion pathway, SecB secretion pathway, SRP pathway, Tat pathway. Protein secretion and types of secretory systems in Gram-negative and Gram-positive bacteria. Sortases and Injectosome.
Exercise: Quiz, Critical Thinking, Brainstorming

Unit II **11 Hours**

Introduction and Biology of Pathogenic Bacteria: Important developments in medical microbiology, Morphological characteristics, pathogenesis and laboratory diagnosis including rapid methods of following pathogenic bacteria; *Staphylococcus, Streptococcus, Enterococcus, Escherichia coli, Neisseria,*

Klebsiella, Salmonella, Shigella, Vibrio, Campylobacter, Pseudomonas, Acinetobacter, Yersinia, Treponema, Haemophilus, Bordetella, Bacillus, Clostridium, Corynebacterium, Mycobacterium, Actinomyces, Nocardia, Fusobacterium, Listeria, Rickettsiae, Chlamydiae, Spirochetes. Nosocomial Infections and their treatment.
Exercise: Case Studies, Paper discussion, application Articles.

Unit III **11 Hours**

General Virology and Pathogenesis: Brief outline on the history and discovery of viruses, nomenclature and classification of virus, morphology and ultrastructure; Viral genomic organization, structure and replication. Prion and viroids. Viral Pandemics. **Viral infections and Pathogenesis:** Determinants of tissue tropism, penetration and uncoating, biosynthesis of genetic material, maturation, release, and transmission of infection, host defense, innate immune response and adaptive immune response. Replicative strategies employed by DNA viruses, RNA viruses. Identification of virus prototypes associated with different virus replication schemes. **Emerging Viral Diseases**: Introduction, life cycle, pathogenesis, diagnosis and treatment of Herpesvirus, Influenza virus, Hepatitis Viruses, Coronaviruses, Retroviruses and Flaviviruses.

Exercise: Inquiry training, extempore of recent pathogenic events, Student-generated test questions

Unit IV **11 Hours**

Diagnostic and therapeutic Virology: Oncogenic viruses, oncogenic DNA and RNA viruses, viral transformation by activation of cellular signal transduction pathways, viral transformation via cell cycle control pathways. **Diagnostic Virology**: Visualization and enumeration of virus particles, Detection of viruses: physical, biological, immunological and molecular methods. Serological methods. **Viruses as therapeutic agents:** Viral Chemotherapy and Vaccine, Fusion or entry inhibitors, Nucleoside analogs, reverse transcriptase inhibitors, protease inhibitors: mechanism of action and drug resistance. Recent advances in development of antiviral vaccines.
Exercise: Case Studies, Discussions and Group Learning

Suggested Reading:

1. Atlas, R.M. (1994) Principles of Microbiology, McMillan, New York
2. Tortora, G.J., Funke, B.R. and Case, C.L. (2016). *Microbiology: An Introduction.* Benjamin Cummings, USA.
3. Madigan,M.T., Martinko, J.M., Bender, K., and Buckley, D. (2011) Brock Biology of Microorganisms, 13th Ed., Pearson Education, USA.

4. Jawetz, Melnick, & Adelberg (2016) *Medical Microbiology* by Carroll KC, Hobdon JA, Miller S, Morse SA, Mietzner TA. Lange Publication.
5. Locht C and Simonet M, Caister (2012) *Bacterial Pathogenesis: Molecular and Cellular Mechanisms* by Academic Press.
6. Persing DH, Tenover FC, Hayden R, Leven M, Miller MB, Nolte FS, Tang YW, Belkum AAV. (2016) *Molecular Microbiology: Diagnostic Principles and Practice.* American Society for Microbiology Press.
7. Nelson KE and Williams CM (2019) *Infectious Disease Epidemiology: Theory and Practice.* Jones and Bartlett.
8. World Organization for Animal Health: "*Manual of Diagnostic Tests and Vaccines for Terrestrial Animals"* Volumes I & II, 6th Edition, 2010.
9. Rao, Juluri R, Fleming, Colin C., Moore, John E., (2006) *Molecular Diagnostics: current technology and Applications.* Horizon Bioscience, U. K.
10. Dimmock N., Easton A., Leppard K (2016) *Introduction to Modern Virology*. Blackwell Publishing.
11. Wanger, K. Hewiett M., Bloom D., Camerini D. (2007). *Basic Virology* Blackwell Publishing.
12. Cann AJ (2015) *Principles of Molecular Virology*. Elsevier Academic Press.
13. Flint S. J., L.W. Enquist, V.R. Racaniello, A.M. Skalka (2015) *Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses.* 4th edition. ASM Press.

Web Sources

https://www.cdc.gov/
https://www.who./

Modes of transaction

-Lecture
-Problem Solving
-Self-Learning
-Inquiry training
-Co-operative learning
-Team teaching

L	T	P	Credits
0	0	6	3

Course Code: MIC.554
Course Title: Microbiology Practical –III

Total Hours: 90

Learning Outcomes:

The students will be able to:

- Conduct experiments pertaining to the theory papers of industrial and environmental microbiology and food and dairy microbiology.
- Apply these observations and scientific ideas in the real life microbiology associated tribulations.

Course Contents

1. Microbiological examination of fresh and canned foods, mushrooms, spoiled foods and fruits, milk and milk products
2. Microbiological quality testing of milk (MBRT test)
3. Isolation of toxin producing organisms and estimation of their toxins in different foods
4. Extraction of Mycotoxins from contaminated food.
5. Isolation of bacterial and fungal probiotics
6. Development of probiotics *in vitro.*
7. To study various food preservation methods.
8. Standard method for bacteriological water analysis: Presumptive, confirmatory and completed test.
9. Microbial growth studies.
10. Isolation of industrially important microorganisms for microbial processes (citric / lactic/ alpha amylase) and improvement of strain for increasing yield by mutation.
11. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microorganisms for design of a sterilizer.
12. Extraction of Citric acid/Lactic acid by salt precipitation.
13. Monitoring of dissolved oxygen during aerobic fermentation
14. Biomass production (Baker's yeast and *Spirulina*).
15. Production of beverages (alcohol and wine).
16. Estimation of the fermentation products by titration Method
17. Isolation of food poisoning bacteria from contaminated foods, Dairy products
18. Production of fermented milk by *Lactobacillus acidophilus*.
19. Physical analysis of sewage/industrial effluent by measuring total solids, total dissolved solids and total suspended solids.
20. Determination of indices of pollution by measuring BOD/COD of different effluents.
21. Bacterial reduction of nitrate from ground waters
22. Isolation and purification of degradative plasmid of microbes growing in polluted environment.
23. Recovery of toxic metal ions of an industrial effluent by immobilized cells.
24. Utilization of microbial consortium for the treatment of solid waste [Municipal Solid Waste].
25. Biotransformation of toxic chromium (+ 6) into non-toxic (+ 3) by *Pseudomonas* species.

26. Tests for the microbial degradation products of aromatic hydrocarbons /aromatic compounds.
27. Reduction of distillery spent wash (or any other industrial effluent) BOD by bacterial cultures.
28. Microbial dye decolorization/adsorption.

Practical may be modified depending on available faculties/facilities.

Modes of transaction

-Lecture cum demonstration
-Problem Solving
-Self-Learning
-Inquiry training
-Experimentation

Evaluation Criteria for Practical Courses: Students are evaluated for a total of 100 marks with following distribution:

Continuous assessment- 50 Marks:

Maintaining the lab records/notebooks: 15 Marks

Surprise test/quiz/objective type test during the semester: 15 Marks

Good laboratory Practices, Designing and execution of experiments: 10 Marks

Attendance during day to day practical: 10 Marks

Final Practical Examination- 50 Marks:
Minor Experiment (10 Marks), Major Experiment (to be performed, 20 Marks) and viva-voce (20 Marks)

Suggested Reading:

1. Michael J. Leboffe (2011) *A Photographic Atlas for the Microbiology laboratory*.
2. Prakash S. Bisen (2014) *Laboratory Protocols in Applied Life Sciences*. Taylor & Francis Group, LLC
3. John Harley (2016) *Laboratory Exercises in Microbiology*, 10th Edition by John Harley
4. Benson's Microbiological *Applications Lab Manual*, 2016.
5. James G. Cappuccino &Natalie Sherman (2014) *Microbiology: A Laboratory Manual,* 10th Edition 2014
6. Aneja KR (2014) *Laboratory Manual of Microbiology and Biotechnology*.
7. Alberts, B. Bray, D. Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell.* Garland publishers, Oxford.
8. Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.
9. Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology*. CRC Press, Taylor and Francis Group, UK.

L	T	P	Credits
2	0	0	2

Course Code: MIC.555

Course Title: Ecology, Evolution and Developmental Biology

Total Hours: 30

Learning Outcomes: The students will be able to:

- Illustrate the ecological processes and evolutionary theories.
- Identify their shortcomings while practicing and revising the topics related to ecology and evolution.
- Learn about the origin of life and development of plants and animals, with a particular emphasis on the molecular genetic basis for developmental events.
- Solve the exercises, mock tests and practice test from the previous year's examinations.
- Manage the time to attempt the questions in various competitive examinations.
- Minimize the technical difficulties associated with competitive examinations.

Course Contents

Unit I **7 Hours**

Principles of Ecology

Biotic and abiotic interactions, concept of habitat and niche, characteristics of a population, life history strategies, concept of metapopulation, species interactions, levels of species diversity and its measurement, ecological succession, Indian ecosystems, altruism and evolution-group selection, kin selection, reciprocal altruism, use of space and territoriality; mating systems, parental investment and reproductive success; parental care, habitat selection.

Exercise: Student-generated test questions, Quiz, Problem based learning

Unit II **7 Hours**

Origin of Life: Lamarckism, Darwinism, Concepts of variation, adaptation, struggle, Mendelism, Spontaneity of mutations, Theories of phyletic gradualism vs. punctuated equilibria, Modern evolutionary synthesis. Origin of basic biological molecules, Abiotic synthesis of organic monomers and polymers, Concept of Oparin and Haldane model, Origin of eukaryotic cells, Evolution of unicellular eukaryotes, Anaerobic metabolism, Photosynthesis and aerobic metabolism.

Exercise: Critical Thinking, Problem Solving, debates

Unit III **8 Hours**

Basic Concepts of Development: Totipotency, Commitment, Specification, Induction, Competence, Determination and Differentiation, Morphogenetic gradients, Cell fate and cell lineages, Stem cells, Genomic equivalence and cytoplasmic determinants. Model organisms in Developmental biology (*Drosophila, C. elegans, Xenopus*). Production of gametes, Cell surface molecules in sperm-egg recognition in animals; Embryo-sac development and double fertilization in plants, Zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals. Embryogenesis and establishment of symmetry in plants, Seed formation.
Exercise: Case Studies in Lesson Plans, Problem-solving Activities for Learners

Unit IV **8 Hours**

Morphogenesis and organogenesis in animals and plants: Cell aggregation and differentiation in *Dictyostelium*, axes and pattern formation in *Drosophila,* Organogenesis: vulva formation, eye lens induction, limb development and regeneration in vertebrates; Metamorphosis. Shoot, root and leaf development; floral meristems and development in plants. Cell-Cell Communication and Signaling. Apoptosis, Caspases, Importance of programmed cell death (PCD) in animal/plant development. Medical implications of developmental biology: genetic errors/ teratogenesis/ stem cell therapy.
Exercise: Student-generated test questions, Quiz, Problem based learning

Suggested Reading:

1. Darwin, C.R. (2013). *On the origin of species by means of natural Selection, or preservation of favoured races in the struggle for life*. Hurst Publishers, UK.
2. Dawkins, R. (1996). *The Blind Watchmaker*, W.W. Norton & Company Jones and Bartlett Publishers.
3. Futuyma, D.J. (2009). *Evolution*. Sinauer Associates Inc. USA.
4. Hake, S. and Wilt, F. (2003). *Principles of Developmental Biology*. W.W. Norton & Company, New York, USA.
5. Hall, B.K. and Hallgrimsson, B. (2013). *Strickberger's Evolution.* Jones and Bartlett Publishers, India.
6. Lewin, R. (2004). *Human Evolution - An Illustrated Introduction.* Wiley-Blackwell, USA.
7. Scott, F. and Gilbert, S.F. (2016). *Developmental Biology*. Sinauer Associates, Inc. USA.
8. Slack, J.M.W. (2005). *Essential Developmental Biology*, Wiley-Blackwell, USA.
9. Green, D. R. & Reed J. C. (2010). *Apoptosis: Physiology and Pathology*. Cambridge press, UK.
10. Sadler, T.W., Tosney, K., Chescheir, N.C., Imseis, H., Leland, J. and Sadler- Redmond, S., L. (2016). *Langman's Medical Embryology (Longmans Medical Embryology).* Lippincott Williams and Wilkins.
11 .Schaefer, B.D. (2014). *Medical Genetics: An integrated Approach.* McGraw Hill Education, New Delhi.

Modes of transaction:

-Lecture

-Demonstration

-Lecture cum demonstration

-Problem solving

-Self-learning

Course Code: MIC.556

L	T	P	Credits
3	0	0	3

Course Title: Genetic Engineering and Recombinant DNA Technology

Total Hours: 45

Learning Outcomes:

The students will be able to:

- Apply the versatile tools and techniques of genetic engineering in basic and applied fields of biological research.
- Identify the application of basic molecular biology in manipulating and modifying genetic material, cells and organisms.
- Utilize the acquired knowledge in a setting of Medical Biotechnology, Industrial Biotechnology, and Agricultural Biotechnology.

Course Contents

Unit I **11 Hours**

Tools of Genetic Engineering: Restriction enzymes, Enzymes in genetic engineering, Cloning vectors, Expression vectors & their biology (Plasmid Vectors, Vectors based on Lambda Bacteriophage, Cosmids, M13 Vectors, Expression Vectors, Vectors for Cloning Large DNA Molecules), Transformation and transfection. Selection, genomic and cDNA library construction & DNA-sequencing techniques, Site-directed mutagenesis. **Cloning and Expression Systems**: Artificial chromosome vectors (YACs, BACs), Animal virus derived vectors. Cloning in *E. coli*, Gram-positive bacteria, *Streptomycetes, Saccharomyces Cerevisiae,Pichia pastoris*, Insect Cells and Mammalian Cells. Expression system, Fusion proteins, Transcriptional & Translational Fusions, Adding Tags and Signals.

Exercise: Real time Data interpretation for different techniques, Problem Solving, Debates

Unit II **12 Hours**

Genetic Manipulation and Over expression of Recombinant Proteins: Basics of different types of PCR**,** Model organisms, genetically modified plants and animals, Creating Transgenics, Knockouts, Knockdowns, RNAi technology, CRISPR technology. Generation of Transient and stable cell lines.

Functional genomics: Forward and reverse Genetics. Overexpression and tagging of recombinant proteins in *E.coli*, driven by lac, T7 and Tet-regulatable promoters, Expression in *B. subtilis*. Overexpression systems in *S.cerevisiae, P.pastoris, S.pombe* and *K.lactis.* Baculovirus overexpression system. Mammalian cell overexpression system.
Exercise: Real time Data interpretation for different techniques, Brainstorming

Unit III **12 Hours**

Transcriptional Analysis of Gene Expression and Transcriptomics: Gene expression analysis by Northern Blotting, RT-PCR, EST analysis and the use of reporter genes. Enzymatic and bioluminescent reporters. Reporters used in protein localization and trafficking studies. Promoter analysis – deletion analysis and linker scanning analysis coupled to reporter assays, mapping transcriptional start sites by S1 nuclease mapping, primer extension studies or 5' RACE. Transcriptome analysis by DD-PCR and EST analysis, DNA microarrays (cDNA arrays and oligo arrays), Serial Analysis of Gene Expression (SAGE), RNA-sequences.
Exercise: Real time Data interpretation for different techniques, Discussions and Group Learning

Unit IV **12 Hours**

Techniques and Applications of Recombinant DNA Technology: Analysis of protein-DNA and protein-protein interactions, protein engineering and proteome analysis: Gel retardation assay, DNA footprinting by DNase I and chemical methods, yeast one-hybrid assay, ChIP- chip, ChIP-seq. Yeast two hybrid, three-hybrid, split hybrids and reverse hybrid. Co-immunoprecipitation, pull-down, far-western. Use of GFP and its variants in FRET analysis, use of BiFC. Phage display. Insertional and deletion mutagenesis. Site directed mutagenesis by conventional and PCR-based methods. Proteome analysis by 2D gel electrophoresis coupled to mass spectrometric analysis. Principles and used of MALDI-TOF and LC-MS platforms. PMF verses MS/MS. Protein arrays and their applications. Vaccines, Metabolic Engineering and Protein Engineering: Enzymes, Antibiotics, Therapies for Genetic Diseases, Bioremediation. Biosafety and Ethical considerations in rDNA and genetic engineering.
Exercise: Thought experiments, Problem based learning, Real time Data interpretation for different techniques

Suggested Reading:

1. Glick BJ, Patten CL. (2017) Molecular Biotechnology: Principles and Applications of Recombinant DNA. 5 th edition, American Society for Microbiology
2. Kurnaz IA. (2015) *Techniques in Genetic Engineering.*1st edition, CRC Press.

3. Primrose SB, Twyman R. (2006) *Principles of Gene Manipulation and Genomics*. 7th edition, Wiley-Blackwell.
4. Green MR, Sambrook J. (2012). *Molecular cloning: A laboratory manual*. 4th edition, Cold Spring Harbor Laboratory Press, New York.
5. Andreas Hofmann, Samuel Clokie (2018) ,Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8th edition Cambridge University Press

Modes of transaction

-Lecture
-Problem Solving
-Self-Learning
-Inquiry training

Web Sources

https://www.addgene.org/educational-resources/
http://www.mrrottbiology.com/genetic-engineering--biotechnology.html

L	T	P	Credits
3	0	0	3

Course Code: MIC.557
Course Title: Pharmaceutical Microbiology

Total Hours: 45

Learning Outcomes:
The students will be able to:

- Describe the diverse methods of pharmaceutical Microbiology to treat the microbial human diseases.
- Explain the general principles to prevent and treat human diseases.
- Apply these techniques in various applied fields of biological research.

Course Contents

Unit I **10 Hours**

Microorganisms in Pharmaceutical Industry: Antibiotics and synthetic antimicrobial agents. Aminoglycosides, β lactams, tetracyclines, ansamycins, macrolide antibiotics. Antifungal antibiotics, antitumor substances. Peptide antibiotics, Chloramphenicol, Sulphonamides and Quinolinone antimicrobial agents. Chemical disinfectants, antiseptics and preservatives.
Exercise: Quiz, Brainstorming, Problem based learning sessions, Case studies

Unit II **11 Hours**

Mechanism of Action of Antibiotics: Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis). Molecular principles of drug targeting. Drug delivery system in gene therapy Bacterial resistance to antibiotics. Mode of action of bacterial killing by quinolinones. Bacterial resistance to quionolinones. Mode of action of non–antibiotic antimicrobial agents. Penetrating defenses – How the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport system and drug diffusion).
Exercise: Pro-Con Grids, Buzz Groups, Quescussion

Unit III **12 Hours**

Microbes in Pharmaceutical Products: Microbial contamination and spoilage of pharmaceutical products (sterile injectables, non injectables, ophthalmic preparations and implants) and their sterilization. Manufacturing procedures and in process control of pharmaceuticals. Other pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase). Vaccines and adjuvant- Traditional vaccine preparations, attenuated, dead or inactivated bacteria, Attenuated and inactivated viral vaccines, Toxoids, antigen-based and other vaccine preparations. New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines. Vaccine clinical trials.
Exercise: Students seminars, Brainstorming, Case studies, Industry visits.

Unit IV **12 Hours**

Regulatory Practices and Quality Assurance: Biosensors and applications in Pharmaceuticals. Financing R&D capital and market outlook. IP, BP, USP. Government regulatory practices and policies, FDA perspective. Reimbursement of drugs and biologicals, legislative perspective. Rational drug design. Immobilization procedures for pharmaceutical applications (liposomes). Macromolecular, cellular and synthetic drug carriers. Biosensors in pharmaceuticals. Application of microbial enzymes in pharmaceuticals.
Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in the pharmaceutical industry. Regulatory aspects of quality control. Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization) Chemical and biological indicators. Design and layout of sterile product manufacturing unit. (Designing of Microbiology laboratory) Safety in microbiology laboratory.
Exercise: Problem based learning sessions, Case studies, Group discussion

Suggested Reading:

1. W. B. Hugo & A. D. Russell (2004) *Pharmaceutical Microbiology*. Blackwell Scientific Publications.

2. Frederick Kavanagh *Analytical Microbiology* Academic Press New York.
3. David C. Hooper, John S. Wolfson *Quinolinone antimicrobial agents*. ASM Washington DC.
4. Murray S.Cooper *Quality control in the Pharmaceutical Industry*. Academic Press New York.
5. H. J. Rehm & G.Reed, *Biotechnology*. VCH Publications, Germany.
6. S. P. Vyas & V.K.Dixit (2017) *Pharmaceutical Biotechnology*. CBS Publishers & Distributors, New Delhi.
7. Sydney H. Willig, Murray M. Tuckerman, William S. Hitchings, Mercel Dekker (2019)*Good Manufacturing Practices for Pharmaceuticals* New York.
8. Gregory Gregoriadis *Drug Carriers in biology & Medicine*. Academic Press New York.

Modes of transaction

-Lecture
-Problem Solving
-Self-Learning

L	T	P	Credits
0	0	0	1

Course Code: MIC.558
Course Title: Entrepreneurship in Microbiology

Total Hours: 15

Learning Outcomes: On the completion of this course, students will be able

- To develop understanding about problems and prospects in entrepreneurship.
- To gain insights about entrepreneurial behaviour and skills.
- To develop understanding about writing business plan/project proposals & managing start-up issues.

Unit I **4 Hours**

Entrepreneurial Structure; Nature, Characteristics, functions and its role in economic development. Entrepreneurship- problems and prospects in India. Entrepreneurial Behaviour and Skills.

Exercise: Oral presentation on recent development, online trainings, Group discussion.

Unit II **4 Hours**

Role of industries/entrepreneur's associations and self-help groups. Funding opportunities for start-ups. Basic start-up problems. Preliminary contracts with the vendors, suppliers, bankers, principal customers. Contents of business plan/ project proposal.

Exercise: Teacher guided student evaluation, industry visits, interaction with entrepreneurs.

Unit III **4 Hours**

Agriculture Microbiology products production

Biofertilizers: Introduction, types, characteristics and production technology of biofertilizers such as Rhizobium, Azotobacter, Azospirillum, Phosphate solubilizing microbes, Cyanobacteria, Azolla, Mycorrhizae and their production technology.

Biopesticides: Definition and types, importance of Biopesticides in agriculture, characteristics and Production technology of Biopesticides.

Exercise: Training Games for Learners, Problem-solving Activities for Learners, Case Studies in Lesson Plans, industry visits.

Unit IV **4 Hours**

Biofuel Processes and Enzyme Technology.

Biofuels: Introduction, characteristics, types and production technology of biofuel produced by microorganisms.

Enzymes: Introduction, overview of various enzymes & their products produced using microorganisms. Production Technology: Raw materials, microorganisms, production process, recovery, and applications of industrially important enzymes.

Exercise: Case Studies, Asking Questions, industry visits

Modes of transaction:

-Lecture

-Demonstration

- Industrial visit

Suggested Reading:

1. Craig Shimasaki (2020), Biotechnology Entrepreneurship: Leading, Managing and commercializing Innovative Technologies 2nd Edition
2. Paul S. Teng. (2008) Bioscience Entrepreneurship In Asia: Creating Value with Biology Publisher: World Scientific Publishing Company,
3. Holger Patzelt Thomas Brenner (2008), Handbook of Bioentrepreneurship Springer
4. Françoise Simon and Glen Goei (2017), Managing Biotechnology: From Science to Market in the Digital Age Wiley and sons
5. Martin Grossmann (auth.) (2003) Entrepreneurship in Biotechnology: Managing for Growth from Start-Up to Initial Public Offering: Physica-Verlag Heidelberg
6. Ram Sarup Singh Reeta Rani Singhania, Ashok Pandey Christian Larroche (2019) Biomass, Biofuels, Biochemicals 1st Edition Advances in Enzyme Technology Elsevier publication.

L	T	P	Credits
0	2	0	2

Course Code: MIC.504

Course Title: Ethics for Science (VAC)

Total Hours: 30

Learning Outcomes:

Students from inter-disciplinary background will be able to:

- Illustrate the basic good practices to be followed in research and overall as a student.
- Formulate Classify the principles ethics in research which will help them to understand the set of conduct norms applied in science.
- Interpret the ethical issues involved in human, animals and plants research.
- Judge the misconduct, fraud and plagiarism in research.

Unit I **6 Hours**

Introduction and Basic Principles of Ethics: Ethical theories, Ethical considerations during research, Data Manipulations. Ethical review procedure and committees.

Exercise: Problem based learning, Real time Data to use the ethics and biosafety principles.

Unit II **8 Hours**

Ethics in Basic and Applied Sciences: Ethics in cloning, recombinant technology, Genetically Engineered Organisms and r-DNA based products. Animal Testing. Animal Rights, Perspectives and Methodology.

Exercise: Paper discussion, Student Presentations

Unit III **8 Hours**

Principles of Ethics in Clinical and Medical Sciences: Code of Ethics in Medical/clinical laboratories. Healthcare rationing, Ethical Issues of Xeno-transplantation, Ethics involved in embryonic and adult stem cell research, Ethics in assisted reproductive technologies: animal and human cloning and *In-vitro* fertilization. Ethical issues in MTP and Euthanasia. Types of consents and Human Genome project.

Exercise: Critical Thinking, Discussions and Group Learning

Unit IV **8 Hours**

Ethics in Research: Intellectual property rights (IPRs), Patents copyrights. Fair use and plagiarism. Collaboration in research: authorship, resources

sharing and mentoring, publications, conflict of interest, collaboration between academia and industry. Scientific misconduct.
Exercise: Problem based learning, Brainstorming, Case Studies

Suggested Reading:

1. Clarke, A (2012). *Genetic Counseling: Practice and Principles*. Taylor & Francis
2. Fleming, D.O. and Hunt, D.L. (2006). *Biological Safety: Principles and Practices*. American Society for Microbiology, USA.
3. Mahop, M.T. (2010). *Intellectual Property, Community Rights and Human Rights: The Biological and Genetic Resources of Developing Countries.* Routledge.
4. Rockman, H.B. (2004). *Intellectual Property Law for Engineers and Scientists*. Wiley-IEEE Press, USA.
5. Shannon, T.A. (2009). *An Introduction to Bioethics*. Paulist Press, USA.
6. Thompson J and Schaefer, B.*D (2013).Medical Genetics: An Integrated Approach*. McGraw Hill.
7. Vaughn, L. (2009). *Bioethics: Principles, Issues, and Cases*. Oxford University Press, UK.
8. WHO. (2005). *Laboratory Biosafety Manual*. World Health Organization.
9. Ethical guidelines for biomedical research on human participants, ICMR.

Weblinks:

- https://www.cdc.gov/
- https://www.who./
- http://dbtindia.gov.in/regulations-guidelines/regulations/biosafety-programme
- https://pubmed.ncbi.nlm.nih.gov/
- https://main.icmr.nic.in/sites/default/files/guidelines/ICMR_Ethical_Guidelines_2017.pdf

Modes of transaction

-Lecture
-Demonstration
-Self-learning
-Group discussion

L	T	P	Credits
0	0	8	4

Course Code: MIC. 599
Course Title: Research Proposal

Total Hours: 120

Learning Outcome:

The students will be able to:

- Organize extensive review of literature.
- Apply various search engines and websites to identify the area of their research interest.
- Formulate the hypothesis and work plan with scientifically sound (and achievable) objectives backed by a comprehensive and detailed methodology.

Students can opt for dissertation work in industry, national institutes or Universities in the top 100 NIRF ranking. Group dissertation can be opted, with a group consisting of a maximum of four students. These students may work using a single approach or multidisciplinary approach. Research projects can be taken up in collaboration with industry or in a group from within the discipline or across the discipline.

Evaluation Criteria

Research Proposal (Third Semester)		
	Marks	Evaluation
Supervisor	50	Dissertation proposal and presentation
HoD and senior-most faculty of the department	50	Dissertation proposal and presentation

Modes of transaction

-Self-Learning
-Group discussion
-Problem solving
- Seminars
-Experimentation

Semester IV

L	T	P	Credits
0	0	40	20

Course Code: MIC.600
Course Title: Dissertation

Total Hours: 600

Learning Outcomes:
The students will be able to:

- Organize extensive review of literature.
- Apply various search engines and websites to identify the area of their research interest.
- Formulate the hypothesis and work plan with scientifically sound (and achievable) objectives backed by a comprehensive and detailed methodology.
- Compile the data obtained from the experimental plan.
- Analyze the results in light of established scientific knowledge to arrive at cogent conclusions.
- Demonstrate their substantial research-based capabilities.

Evaluation Criteria

Dissertation (Fourth Semester)		
	Marks	Evaluation
Supervisor	50	Continuous assessment (regularity in work, mid-term evaluation) dissertation report, presentation, final viva-voce
External expert, HoD and senior-most faculty of the department	50	Dissertation report (30), presentation (10), final viva-voce (10)

Modes of transaction

-Self-Learning
-Group discussion
- Experimentation
- Internship
-Industrial Training