

Central University of Punjab



M.Sc. Microbiology

(3+1)

Batch- 2025-2027

Department of Microbiology

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
MMIC. 400	Biochemistry	Core	3	0	0	3
MMIC. 401	Microbiology	Core	3	0	0	3
MMIC. 402	Cell and developmental Biology	Core	3	0	0	3
MMIC. 403	Molecular Genetics	Core	3	0	0	3
MMIC. 404	Microbiology Practical-I	Skill Based	0	0	8	4
Discipline Elective (opt any one)						
MMIC.516	Techniques in Microbiology	Discipline elective	3	0	0	3
MMIC. 405	Introduction to Cell and Tissue Culture	Discipline elective	3	0	0	3
XXX	Students can opt from the basket of electives offered by the allied/relevant departments such as Biochemistry, Botany, Food Science and Technology, Human Genetics and Molecular Medicine and Zoology.	Discipline elective	3	0	0	3
Total Credits						19
Individualized Education Plan/Remedial teaching			0	2	0	0

Semester – II

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Credits
MMIC.523	Immunology	Core	3	0	0	3
MMIC.524	Molecular Biology and Recombinant DNA Technology	Core	3	0	0	3
MMIC.525	Microbial Physiology and Metabolism	Core	3	0	0	3
MMIC.526	Research Methodology and Biostatistics	Compulsory Foundation	3	0	0	3

MMIC.527	Environmental Microbiology	Compulsory Foundation	3	0	0	3
MMIC.528	Microbiology Practical- II	Skill Based	0	0	6	3
Discipline Elective (opt any one)						
MMIC.529	Microbial Pathogenicity	Discipline elective	3	0	0	3
XXX	Students can opt from the basket of electives offered by the allied/relevant departments such as Biochemistry, Botany, Food Science and technology, Human Genetics and Molecular Medicine and Zoology.	Discipline Elective	3	0	0	3
Interdisciplinary course (IDC)						
XYZ	Choose from Interdisciplinary Course offered by other departments	Interdisciplinary Course (IDC)	2	0	0	2
MMIC.506	Basics of Microbiology	Interdisciplinary Course (IDC) for other department students	2	0	0	2
MMIC.507	Introduction to Immune system	Interdisciplinary Course (IDC) for other department students	2	0	0	2
Total Credit						23
Remedial teaching			0	2	0	0

Semester – III

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Credits
MMIC.535	Industrial Microbiology	Core	3	0	0	3
MMIC.536	Food and Dairy Microbiology	Core	3	0	0	3
MMIC.537	Medical Microbiology	Core	3	0	0	3
MMIC.538	Microbiology Practical –III	Skill Based	0	0	6	3
MMIC.539	Entrepreneurship in Microbiology	Compulsory foundation	2	0	0	2
Discipline Elective(opt any one) /MOOC						
MMIC.540	Microbial Biotechnology	Discipline elective	3	0	0	3
XXX	Students can opt from the basket of electives offered by the allied/relevant departments such as Biochemistry, Botany, Food Science and technology, Human Genetics and Molecular Medicine and Zoology.	Discipline elective	3	0	0	3
MMIC.599.1	Dissertation Part -I	Skill Based	0	0	8	4
Value Added Course (VAC)						
MMIC.511	Ethics for Science	VAC	2	0	0	2
XYZ	Choose from Interdisciplinary Course offered by other departments	VAC	2	0	0	2
Total Credit						23
Remedial teaching			0	2	0	0

Semester – IV

Course Code	Course Title	Course Type	Credit Hours			
MMIC.599.2	Dissertation Part -II	Skill Based	0	0	40	20
Total Credits						20

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

Microbiology programme

MOOCs: MOOCs may be taken up to 40% of the total credits (excluding dissertation credits). MOOC may be taken in lieu of any course but content of that course should match a minimum 70%. Mapping is to be done by the respective department and students may be informed accordingly.

It is mandatory for students in every PG program to complete at least one course on the SWAYAM platform accompanied by credit transfer. The students shall be responsible for payment of fees for courses on SWAYAM.

Students are encouraged to take skill-based courses on the SWAYAM PLUS platform.

Dissertation at Other Institutions: Students will have an option to carry out dissertation work in industry, national institutes, Central and State Universities. Students may also carry out dissertations in private Universities in the top 100 NIRF ranking (University Category). Each department should start efforts for roping in industries/HEIs for accepting students for dissertation/projects/internship and other academic activities for industry-academia interaction. The department may also collaborate for conducting experiments.

Group Dissertation: Group dissertation may 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.

Examination pattern and evaluation for Masters' students

Formative Evaluation: Internal assessment shall be 25 marks using any two or more of the given methods: tests, open book examination, assignments, term paper, etc. The Mid-semester test shall be of 25 marks including short answer and essay type. The number of questions and distribution of marks shall be decided by the teachers.

Summative Evaluation: The End semester examination (50 marks) with upto 100% descriptive type and up to 30% objective type shall be conducted at the end of the semester. The objective type shall include one-word/sentence answers, fill-in the blanks, MCQs', and matching. The descriptive type shall include short answer and essay type questions. The number of questions and distribution of marks shall be decided by the teachers. **Questions for exams and tests shall be designed to assess course learning outcomes along with focus on knowledge, understanding, application, analysis, synthesis, and evaluation.**

The evaluation for IDC, VAC and entrepreneurship, innovation and skill development courses shall include MST (50 marks) and ESE (50 marks). The pattern of examination for both MST and ESE shall be the same as ESE described above for other courses.

Evaluation of dissertation proposals in the third semester shall include 50% weightage by supervisor and 50% by HoD and senior-most faculty of the department. The evaluation of dissertation in the fourth semester shall include 50 marks for continuous evaluation by the supervisor for regularity in work, mid-term evaluation, report of dissertation, presentation, and final viva-voce; 50 marks (50% weightage) by an external expert shall be based

on report of dissertation (25 marks), presentation (10 marks), novelty/originality (5 marks) and final viva-voce (10 marks). The external expert may attend final viva-voce through offline or online mode.

Examination pattern

Core, Discipline Elective, and Compulsory Foundation Courses			IDC, VAC, and Entrepreneurship, Innovation and Skill Development Courses		
	Marks	Evaluation		Marks	Evaluation
Internal Assessment	25	Various methods	-	-	-
Mid-semester test (MST)	25	Descriptive	50		Descriptive (upto 100%) Objective (upto 30%)
End-semester exam (ESE)	50	Descriptive (upto 100%) Objective (upto 30%)	50		Descriptive (upto 100%) Objective (upto 30%)
Dissertation Proposal (Third Semester)			Dissertation (Fourth Semester)		
	Marks	Evaluation		Marks	Evaluation
Supervisor	50	Dissertation proposal and presentation	Supervisor/ co-supervisor(s)	50	Continuous assessment (regularity in work, mid-term evaluation) dissertation report, presentation, final viva-voce
HoD and senior-most faculty of the department	50	Dissertation proposal and presentation	External expert	50	Report of dissertation (25), presentation (10), novelty/originality (5) and final viva-voce (10)

Marks for internship shall be given by the supervisor/internal mentor and external mentor.

Some Guidelines for Internal Assessment

1. The components/pattern of internal assessment/evaluation should be made clear to students during the semester.
2. The results of the internal assessment must be shown to the students.
3. The question papers and answers of internal assessment should be discussed in the class.
4. The internal assessment shall be transparent and student-friendly and free from personal bias or influence.

Multiple Entry Multiple Exit

At the end of the first year of M.Sc. in Microbiology, if the student want to exit the programs, for the award of Post-Graduate Diploma in MSc Microbiology, the students must complete one course of 4 credits out of the following options:

1. MOOCs courses from the list with credits equivalent to four
2. Industrial training/internship/ for a period of one month.

For the lateral entry the university wide policy will be adopted

Details of syllabus
Semester – I

L	T	P	Credits
3	0	0	3

Course Code: MMIC. 400

Course Title: Biochemistry

Total Hours: 45

Course Learning Outcomes:

Students will be able to:

CLO 1: Understand the basic chemistry that governs the living organisms: nature of bonds, importance of water, and role of buffers and concepts of bioenergetics.

CLO 2: Appraise the fundamental knowledge about various biomolecules such as proteins, carbohydrates, nucleic acids and lipids.

CLO 3: Comprehend the fundamental metabolic pathways responsible for the synthesis and degradation of biomolecules.

Course Contents

Unit/Hours	Content	Mapping with CLOs
Unit I 11 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, and 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 of free energy and equilibrium constants, students applying and explaining thermodynamic principle in metabolism.	CLO 1
Unit II 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,	CLO 2

	<p>primary, secondary, tertiary, quaternary structures of proteins. Ramchandran plot. Enzymology-Historical perspective, General characterization and classification of enzymes, cofactor and coenzymes, Enzyme assays, the principle of enzyme catalysis and its kinetics, and Enzyme regulation.</p> <p>Nature of Nucleic Acids. Structure of purines, pyrimidines, nucleosides and nucleotides. Physicochemical properties of nucleic acids - Denaturation of nucleic acids. Hyperchromic effect and T_m.</p> <p>Exercise: Problem based learning for Determination of primary structure of proteins, N-terminal and C-terminal determination, Interpretation of T_m curve by students in the class.</p>	
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Unit III 11 Hours	<p>Macromolecules II: Carbohydrates, Lipids: Carbohydrates: Monosaccharide, disaccharides, oligosaccharides and polysaccharides, concepts of epimer, isomer, starch, glycogen, chitin, cellulose. Lipids: Saturated and unsaturated fatty acids, triacylglycerol, phospholipids, sphingolipids, sterols, Biological membranes.</p> <p>Exercise: Practicing nomenclature of lipid molecules according to convention, arranging them according to melting points, Recognizing aldoses, ketosis and epimers.</p>	CLO 2
Unit IV 11 Hours	<p>Metabolism: Fatty acid oxidation. Biosynthesis of fatty acids, triacylglycerols and phospholipids. Catabolism of Glycogen. Amino acid catabolism-Urea Cycle Deamination and transamination reactions. <i>De novo</i> biosynthesis of purines and pyrimidines, Ribonucleotide reductase and its role in nucleic acid metabolism.</p> <p>Exercise: Numerical approaches in calculating ATP generation from the oxidation of odd and even chain fatty acids, MMIC.599.1 MSc dissertation</p>	CLO 3

Suggested Reading:

1. Berg, J.M., Tymoczko, J.L., Gatto, Jr., G.J., and Stryer, L. (2023). *Biochemistry*, 10th Edition.
2. Geoffrey L. Zubay (2017). *Principles of Biochemistry* by Brown Co, USA.
3. MoatA.G., Foster J. W SpectorM. P. (2002) *Microbial Physiology* John Wiley & Sons.

4. Nelson D. L. and Cox M. M. (2021) *Lehninger Principles of Biochemistry* by W. H. Freeman. 8th edition
5. White, D, Drummond J. Fuqua C (2011) *The Physiology and Biochemistry of Prokaryotes* Oxford University Press.
6. Cohen G. N. (2016) *Microbial Biochemistry* Springer.
7. Ferrier D. R. (2016) *Lippincott's Illustrated Reviews: Biochemistry* Lippincott Williams & Wilkins.
8. U.Satyanarayana, U. Chakrapani (2017) *Biochemistry*, 5th Edition. Elsevier India
9. Irwin H. Segal (2010) *Biochemical Calculations* Wiley.
10. Voet, D, Voet, J.G, Pratt, C (2016) *Voet's Principles of Biochemistry*, 5th Edition. Wiley
11. Palmer, T. Horwood E (1995) *Understanding Enzymes* Wiley.
12. H. Segal and Lehninger (2007) *Biochemistry and Palmer Enzymology*

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: MMIC.401
Course Title: Microbiology

Total Hours: 45

Course Learning Outcomes (CLO):

Students will be able to:

CLO 1. Describe the microbial systematics and ultrastructure of the prokaryotes as well as its significance

CLO 2. Recall and define the basics of microbial growth and their application in day-to-day life.

CLO 3. Classify and explain the importance of fungi with emphasis on antimicrobial resistance.

CLO 4. Organize and explain the importance of algae and protozoans

Course Contents

Unit/Hours	Content	Mapping with CLOs
Unit I 12 Hours	<p>History & Scope of Microbiology: General characteristic and composition of prokaryotic and eukaryotic cells, 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.</p> <p>Microbial Taxonomy: Nomenclature, modern methods of microbial taxonomy and major characteristics used in taxonomy – morphological, physiological and metabolic, genetic and molecular taxonomy. Classification of Microorganisms: Haeckel's three kingdom concept, Whittaker's five kingdom, Bergey's Manual of Systematic Bacteriology and their economic significance.</p> <p>Exercise: Preconception/Misconception Check, One Sentence Summary, Imagine, Group discussion about emerging pathogens (SARS- CoV-2, Ebola, Marburg etc)</p>	CLO 1
Unit II 11 Hours	<p>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.</p> <p>Archaeal diversity, cell structure and model organisms: Phylogenetic diversity and key features of different phyla. General characteristics of archaeal cell structure and</p>	CLO 1 CLO 2

	<p>comparison with eubacteria. Detailed account of model archaeal organisms: <i>Methanococcus</i>, <i>Halobacterium</i>, <i>Pyrococcus</i> and <i>Sulfolobus</i>.</p> <p>Exercise: Pyramiding / Snowball Groups, Memory Matrix, Student poll, Class quiz, self- directed learning.</p>	
<p>Unit III 12 hours</p>	<p>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, Antibigrams. Antibiotic resistance in bacteria-various molecular factors that contribute to the development of resistance, Monoclonal antibodies as therapeutic agents to resistance bacteria.</p> <p>General features and classification of fungi, Introduction of fungi, Reproduction in fungi, life cycle patterns, Endophytic fungi and its importance, Economic importance of fungi and yeast.</p> <p>Pathogenic Fungi: Morphological characteristics, pathogenesis and laboratory diagnosis of following pathogenic fungi: <i>superficial mycoses</i>, <i>systemic mycoses</i>, <i>Candida albicans</i>; <i>Candida auris</i>, and <i>Cryptococcus neoformans</i></p> <p>Exercise: Asking questions, Quizzes, Presentation, unstructured interview, Students Teams.</p>	<p>CLO 3</p>
<p>Unit IV 10 Hours</p>	<p>Algae: Classification; reproduction and life cycles; algal toxins, algal bloom, algae as a source of antibiotics.</p> <p>Protozoal Pathogens: General description, life cycle, pathogenesis, diagnosis and treatment of and diseases caused by Protozoa- <i>Plasmodium spp</i>, <i>Trypanosoma spp</i>, <i>Leishmania spp</i>, <i>Entamoeba histolytica</i>.</p> <p>Exercise: Case studies, Debate, Asking questions, Objective structured practical examinations (OSPE)</p>	<p>CLO 4</p>

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 (2023) *Prescott's Microbiology*. 12th Edition, McGraw-Hill Science, USA.
3. Tortora, G.J., Funke, B.R. and Case, C.L. (2018). *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. Strelkauskas, A., Strelkauskas, J. and Moszyk-Strelkauskas, D. (2023). *Microbiology: A Clinical Approach*. Garland Science, New York, USA.
 8. James G. Cappuccino, Chad Welsh (2023) *Microbiology: A Laboratory Manual*, 11th Edition, pearson, India
 9. K.R. Aneja (2022) *Experiments in Microbiology, Plant Pathology, Tissue Culture and Microbial Biotechnology Sixth edition* New Age Intl. Publishers Ltd. - New Delhi.
 10. Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley, David A. Stahl and Thomas Brock (c 2019) *Brock Biology of Microorganisms*, 15th edition.
 11. Bryce Kendrick (2017) *The Fifth Kingdom: An Introduction to Mycology*.

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

Total Hours: 45

Course Code: MMIC. 402

Course Title: Cell and Developmental Biology

Course Learning Outcomes:

Students will be able to:

CLO 1: Demonstrate the structure and basic components of prokaryotic and eukaryotic cells.

CLO 2: Describe the cell organelles and their related functions.

CLO 3: Apply the basic core of scientific and quantitative knowledge to enhance understanding of cell structure and function at the molecular level.

CLO 4: Explain the biological processes of cell division and signal transduction pathway.

Course Contents

Unit/Hours	Content	Mapping with CLOs
Unit I 10 Hours	<p>Introduction to the Cell: Evolution of the cell. Prokaryotes and eukaryotes</p> <p>Cell Membrane Structure and Function Membrane transport of macromolecules and particles.</p> <p>Structural Organization and Function of Intracellular Organelles: Structure and function of nucleus, Ribosomes, lysosomes, peroxisomes, Golgi apparatus, endoplasmic reticulum, mitochondria and chloroplast.</p> <p>Protein Secretion and Sorting: Organelle biogenesis and protein secretion, synthesis and targeting. Intracellular traffic, vesicular traffic in the secretory pathway and protein sorting.</p> <p>Exercise: Group test reading, Debate, Brainstorming, Quiz based assessment, group discussion.</p>	CLO 1
Unit II 11 Hours	<p>The Cytoskeleton: The nature of cytoskeleton, Intermediate filaments, Microtubules, Actin filaments, Cilia and centrioles, Organization of the cytoskeleton.</p> <p>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</p> <p>Exercise: Problem based learning, Muddiest Point, Crossword Puzzle, Students teaching, paper presentation on ECM and its components.,</p>	CLO 1 CLO 2

Unit III 12 Hours	<p>Basic Concepts of Development: Molecular biology of basic cell functions and organism development. Germ Cells, Somatic cells and Stem cells and their applications, Totipotency, Induction, Competence, Determination and Differentiation, Morphogenetic gradients, Cell fate and cell lineages, and cytoplasmic determinants. Cell regeneration, and repair. Model organisms in developmental biology (<i>Drosophila</i>, <i>C. elegans</i>, <i>Xenopus</i>, mutants, transgenics and animal cloning Fertilization, Gametogenesis, Organogenesis and Metamorphosis. Homology, Hox Genes, and Developmental Integration. Programmed Cell Death.</p> <p>Exercise: Research paper presentation, Problem based learning sessions, Class quiz.</p>	CLO 3
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Unit IV 12 Hours	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. Cell Growth and cancer: Overview of the cell cycle and its control, the molecular mechanisms for regulating mitotic cell division, amitosis, Cell cycle control, Checkpoints in cell cycle regulation. Principles and types of Cancer. Genetics of cancer and roles of tumor suppressor and oncogenes, cancer therapy and resistance, Apoptotic pathway in cancer Exercise: Practical, team teaching, Quiz, Brainstorming, Presentations.	CLO 3 CLO 4
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Suggested Reading:

1. Bruce Alberts , Rebecca Heald , Alexander Johnson , David Morgan , Martin Raff, Keith Roberts, Peter Walter . (2022). 7th edition *Molecular Biology of the Cell*. Garland publishers, Oxford.
2. Alberts B, Hopkin K, Johnson AD *et al.* (2023) *Essential Cell Biology*, 6th Ed., W W Norton & Company.
3. Scott, F. and Gilbert, S.F. (2010). *Developmental Biology*. Sinauer Associates, Inc. USA.
4. George Plopper; David Sharp; Eric Sikorski (2015) *Lewin's Cell* Third edition Jones and Bartlett learning
5. Gupta, P.K. (2019). *Cytology, Genetics and Evolution*. Rastogi publications, Meerut, India.
6. Gerald Karp, Janet Iwasa, Wallace Marshall (2019). *Karp's Cell and Molecular Biology: Concepts and Experiments*. 9th edition John Wiley & Sons. Inc. New Delhi, India.
7. De Robertis, E.D.P. and De Robertis, E.M.F. (2017). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
8. Lodish, H, Birk, A, et al. (2021) *Molecular Cell Biology*. 9th ed. WH Freeman.
9. Robert A. Weinberg (2023) *The Biology of Cancer* – WW Norton & Company Third edition
10. 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: MMIC.403

Course Title: Molecular Genetics

Total Hours: 45

Course Learning Outcomes:

Students will be able to:

CLO 1: Illustrate the basic principles of inheritance at the molecular, cellular and organism levels.

CLO 2: Elaborate the concepts of hereditary information and how they work in living organisms.

CLO 3: Demonstrate the practical skills of molecular genetic analysis of genetic diseases

CLO 4: Utilize the molecular microbial genetics and to apply them to real life situations.

Course Contents

Unit/Hours	Content	Mapping with CLOs
Unit I 10 Hours	<p>Mendelian Principles: Dominance, segregation, independent assortment, Allele, multiple alleles, pseudoallele, complementation tests</p> <p>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.</p> <p>Extra- Chromosomal Inheritance: Chloroplast and Mitochondrial inheritance; Cytoplasmic inheritance.</p> <p>Exercise: Making self-pedigree tree and family history, numerical based on Mendelian laws.</p>	CLO 1
Unit II 11 Hours	<p>Gene Mapping Methods: Molecular markers: RAPD, RFLP, SSR, SNP, ISSR, and SCAR; Linkage maps, tetrad analysis in <i>Neurospora</i>, mapping with molecular markers, development of mapping population in plants.</p> <p>Human Genetics: Pedigree analysis, LOD score for linkage testing, karyotypes, genetic disorders.</p> <p>Quantitative Genetics: Polygenic inheritance, heritability and its measurements, QTL mapping.</p> <p>Exercise: Experiments, Panel discussion on inherited diseases.</p>	CLO 2 CLO 3

Unit III 12 Hours	<p>Mutations: 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.</p> <p>Recombination: Site-specific, homologous, DNA transposition, retrotransposition and non-homologous end joining (NHEJ).</p> <p>Exercise: Problem based learning, numericals for Hardy Weinberg equilibrium.</p>	CLO 3
Unit IV 12 Hours	<p>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.</p> <p>Transduction- Generalized and specialized transduction, virus life cycle and replication.</p> <p>Exercise: Research paper presentation, Problem based learning sessions, Class quiz.</p>	CLO 4

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 (2020). *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 (2014) *Molecular Genetics of Bacteria*, 4th edition; ASM Press.
5. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2017). *Molecular Biology of the Gene*. 7th Edition, Benjamin Cummings, USA.
6. Pierce, Benjamin (2021). *Genetics Essentials: Concepts and connections*. 5th edition, Macmillan international

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-single-gene-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: MMIC.521

Course Title: Techniques in Microbiology

Total Hours: 45

Course Learning outcomes:

CLO1: Perform and interpret chromatographic techniques for separation and analysis of biomolecules.

CLO2: Execute immunological assays to detect microbial antigens and antibodies.

CLO3: Demonstrate proficiency in cell biology techniques including microscopy, cell fractionation and centrifugation

CLO4: Integrate and interpret data from biochemical, immunological, and molecular experiments to draw scientifically valid conclusions

Course Contents

Unit/Hours	Content	Mapping with CLOs
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Unit I 11 Hours	<p>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.</p> <p>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.</p> <p>Exercise: Visit and demonstration of NMR, GC- MS and HPLC, Classroom Opinion Polls</p>	CLO 1
Unit II 11 Hours	<p>Immunological Techniques</p> <p>Methods for immunoglobulin determination-quantitative and qualitative antigen and antibody reactions, agglutination-precipitation, immunocytochemistry, radioimmunoassay (RIA), Enzyme Linked Immunosorbent Assay (ELISA), immunofluorescence, Immuno-Electrophoresis, immunoblotting and Flow cytometry.</p> <p>Exercise: Learning by doing small group based exercises.</p>	CLO 2

Unit III 11 Hours	<p>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). Electrophoresis: Principle and types, Colony counter, Isoelectric focussing, colorimetry, Turbidimetry.</p> <p>Exercise: Visit and demonstration of SEM, Confocal, practical for electrophoresis and centrifugation, Paper discussion.</p>	CLO 3
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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: Practical and Student-generated test questions, Problem solving.	CLO 4
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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. (2016) *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 (2016). *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. (2021) *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: MMIC.405

Course Title: Introduction to Cell and Tissue Culture

Total Hours: 45

Course Learning Outcomes:

The students will be able to:

CLO 1: Outline the background of animal tissue culture

CLO 2: Maintain cultures of animal cells and established cell lines with good viability and minimal contamination

CLO 3: Execute this knowledge in other fields and planning projects in the fields of molecular biology and biotechnology.

CLO 4: 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/Hours	Content	Mapping with CLOs
Unit I 11 Hours	Introduction to Animal Cell culture: Basics terms and definitions, historical background, Importance of animal cell culture technology, laboratory facilities-design, equipment and safety parameters, and 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.	CLO 1
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, <i>in vitro</i> 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.	CLO 2

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 patterns–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.	CLO 3
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 biological, 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 tumor spheroids (MCTS)-mono and co-cultures, re-aggregate organoid cultures, <i>in-vitro</i> drug testing. Exercise: Presentations on recent trends/breakthroughs, Case study, Team teaching.	CLO 3 CLO 4

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 (2021) *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications*. 8th Edition, Wiley-Blackwell.
4. Trent, R. J. (2012). *Molecular Medicine, Genomics to Personalized Healthcare*. Academic Press
5. John M. Davis (2011) *Animal Cell Culture: Essential Methods: 1*

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: MMIC.404

Course Title: Microbiology Practical-I

Total Hours: 120

Learning Outcomes:

The students will be able to:

CLO1. Design, create and execute the experiments pertaining to biochemistry.

CLO2. Perform and execute the experiments pertaining to microbiology

CLO.3 Design and execute the experiments pertaining to cell biology

CLO4. Plan, and execute the experiments pertaining to genetics

Course Contents

Unit/Hours	Content	Mapping with CLOs
Part A. Biochemistry 30 Hours	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.	CLO 1

<p>Part B. Microbiology 30 Hours</p>	<ol style="list-style-type: none"> 1. Use of Microscope and working in a biosafety cabinet; Preparation of growth media: Liquid and Solid media 2. Staining of bacterial cultures: Simple staining, Negative Staining, Gram Staining, Acid-Fast stain, fungal staining. 3. Effect of UV, gamma radiations, pH, disinfectants, chemicals and heavy metal ions on micro-organisms. 4. Preparation of microbiological media. Autotrophic media, minimal media, basic media, enriched media, enrichment media, differential media. Microbial growth studies. 5. Isolation of bacteria and fungi from different sources (soil, air, water) and determination of CFU. 6. Testing of Antibiotic sensitivity/resistance 7. Use of selective and/or differential media for isolation and identification of specific bacterial cultures. 8. Preparation of Media: Nutrient broth, Nutrient agar, plates, slants, soft agar; Pure culture technique: Streak plate, spread plate and pour plate methods. 9. Culturing methods of microbes – slant and stab cultures, tube culture, flask cultures, shake flask cultures. 10. Preparation of different types of culture media/observation. Blood Agar, Chocolate Agar, Mannitol salt agar, Blair Parker medium, MacConkey agar, Lowenstein-Jensen medium, Wilson Blair Bismuth sulphite medium, Biochemical media. 11. Tests for disinfectants (Phenol coefficient/RWC). 12. Biochemical tests to characterize bacterial cultures: Catalase test, Oxidase test, Methylene blue test. 	<p>CLO 2</p>
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Part C. Cell Biology 30 Hours	<ol style="list-style-type: none"> 1. Demonstration and using Microscope, 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 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 	CLO 3
Part D. Genetics 30 Hours	<ol style="list-style-type: none"> 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 <i>Drosophila melanogaster</i> as a Model organism: Identification of normal and mutant flies (<i>Drosophila melanogaster</i>), Demonstration of <i>Drosophila</i> polytene chromosomes. 	CLO 3 CLO 4

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 (2021) *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. Lewis, 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. (2020). *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

Semester II

L	T	P	Credits
3	0	0	3

Course Code:

MMIC. 523

Total Hours: 45

Course Title:

Immunology

Course Learning Outcomes:

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

CLO 1: Describe the fundamental concepts and components of human immune systems using correct scientific terminologies.

CLO 2: Understand the functioning of the immune system in the context of diseases.

CLO 3: Apply the knowledge in health and disease from an immunological perspective.

Course Contents

Unit/Hours	Content	Mapping with CLOs
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 pathways. Exercise: Concept mapping, spontaneous quizzes, role playing	CLO 1

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	CLO 1
	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	CLO 2
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	CLO 3

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. (2004). *Immunobiology: The immune system in*

- health and disease*. Blackwell Publishing, USA.
4. Delves, P.J., Roitt, I.M. and Seamus, J.M. (2017). *Roitt's Essential Immunology (Series–Essentials)*. Blackwell Publishers, USA.
 5. Elgert K.D. (2009). *Immunology: Understanding the immune system*.
 6. Paul, W.E. (2008). *Fundamental Immunology*. Raven Press, SD, USA.
 7. Tizard (2008). *Immunology: An Introduction*. Cengage Learning, Thompson, USA.
 8. David K. Male, R. Stokes Peebles, Victoria Male Immunology, International Edition, 2021 9 edition Elsevier publications

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: MMIC.524

**Course Title: Molecular Biology
and Recombinant DNA technology**

Total Hours: 45

**Course Learning Outcome **

The students will be able to:

- CLO1. Describe the molecular structure of DNA, RNA and their replication, damage and repair.
- CLO2. 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.
- CLO3. Emphasizes the concepts of central dogma of molecular biology spanning from DNA Replication, transcription and Protein Synthesis
- CLO4. Propose the applications of molecular biology to societal needs with reference to medicine, industry and agriculture.

Course Contents

Unit/Hours	Content	Mapping with CLOs
Unit I 12 Hours	<p>Genome organization: DNA structure, repetitive DNA, interrupted genes, Organelle DNA. DNA replication: Arrangement of replicons in a genome, modes of replication and keys 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. Recombination and Repair of DNA: DNA repair and recombination, DNA mismatch repair, Double Strand Break repair, recombination as a molecular biology tool,</p> <p>Exercise: Student-generated test questions, Experimental evidence, application article, Problem based learning.</p>	CLO 1, CLO3
Unit II 12 Hours	<p>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. Translation: Genetic code, prokaryotic & eukaryotic translation, the translation machinery, mechanisms of chain initiation, elongation and termination, regulation of translation, co-and post-translational modifications.</p> <p>Exercise: Asking Questions, Crossword Puzzle, Case Studies.</p>	CLO 2

<p>Unit III 10 Hours</p>	<p>Gene Regulation: Prokaryotic – lac, trp, and gal operons, Lambda gene regulation during lysogeny and lytic cycle; Eukaryotic – yeast, higher eukaryotes, hormonal regulation of genes, epigenetic regulation.</p> <p>Introduction to molecular cloning: Enzymes, vectors and hosts used in DNA technology. Cloning, genetic manipulation and over expression of recombinant Proteins: Model organisms, genetically modified plants and animals, Creating Transgenic, Knockouts, RNAi technology, CRISPR technology. Generation of transient and stable cell lines. Overexpression of recombinant proteins in E.coli under various promoters, Mammalian cell overexpression system.</p> <p>Exercise: Real time Data interpretation for different techniques, Brainstorming, online tool for cloning, Problem Solving, Team teaching, Group Text Reading</p>	<p>CLO 3</p>
<p>Unit IV 11 Hours</p>	<p>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. 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-seq. Yeast one and two hybrid system, DNA footprinting and chromatin immunoprecipitation and Chip-seq</p> <p>Exercise: Real time Data interpretation for different techniques, Discussions and Group Learning</p>	<p>CLO 4</p>

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.
8. Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick (2017) Lewin's GENES XII; 12th edition.
9. Bruce Alberts, Rebecca Heald, Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, Peter Walter. (2022). 7th edition *Molecular Biology of the Cell*. Garland publishers, Oxford.
10. Gerald Karp, Janet Iwasa, Wallace Marshall (2019). *Karp's Cell and Molecular Biology: Concepts and Experiments*. 9th edition John Wiley & Sons. Inc. New Delhi, India.
11. Brown TA Gene cloning and DNA analysis an introduction 7 edition (PB 2016)

Web Sources:

- <https://www.biointeractive.org/classroom-resources/bacterial-identification-virtual-lab>
- <https://www.youtube.com/watch?v=VgAuZ6dBOfs>
- NPTEL IIT Guwahati
https://youtube.com/playlist?list=PLwdnzlV3ogoW9QiY4FJXeliA6Q_fJkaDS&feature=shared

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: MMIC.525

Course Title: Microbial Physiology and Metabolism

Total Hours: 45

Course Learning Outcomes:

CLO1 - able to explain various anabolic and catabolic pathways, transport systems and the mechanisms of energy conservation in microbial metabolism

CLO2 - Illustrate the metabolic diversity exhibited by microorganisms, their thermodynamics and regulatory networks that support their survival and growth.

CLO3 - Grasp basic mechanisms of energy-yielding and consuming processes CLO4 - Compile the knowledge about microbial transport system, and mechanism of bacterial sporulation in a broad spectrum of micro-organism.

Course Contents

Unit/Hours	Content	Mapping with Course Learning Outcome
Unit I 10 Hours	<p>Bacterial Photosynthesis: Photosynthetic microorganisms, photosynthetic pigments, and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria.</p> <p>Exercise: Brainstorming, Discussions and Group Learning, Debates.</p>	CLO 1, CLO3

<p>Unit II 11 Hours</p>	<p>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.</p> <p>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.</p> <p>Exercise: Presentations, Debates, Quiz, Critical Thinking</p>	<p>CLO 1, CLO2</p>
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Unit III 12 Hours	<p>Bacterial Permeation: Structure and organization of membrane (Glyco-conjugants and proteins in membrane systems), fluid mosaic model of membrane. Methods of 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 <i>E. coli</i>. Transport of amino acids and inorganic ions in microorganisms and their mechanisms.</p> <p>Exercise: Student-generated test questions, Classroom Opinion Polls.</p>	CLO 4
Unit IV 12 Hours	<p>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.</p> <p>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 hydrogenomonas species. Ferrous and sulfur/sulfide oxidation by <i>Thiobacillus</i> species.</p> <p>Exercise: Concept Maps, Application Articles, Experimental evidence.</p>	CLO 4, CLO3

Suggested Reading:

1. Caldwell D.R. (1995) *Microbial Physiology and Metabolism*. Brown Publishers.
2. Moat A.G., Foster J.W. and Spector M.P. (2009). *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. (2012). *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, (2021) *Brock Biology of Microorganisms*, 16th Edition Pearson education, USA
8. Ann M. Stevens , Jayna L. Ditty , Rebecca E. Parales, Susan M. Merkel (2024) *Microbial Physiology: Unity and Diversity*, ASM press

Modes of transaction

-Lecture

- Problem solving
- Panel discussion
- Tutorial

L	T	P	Credits
3	0	0	3

Course Code: MMIC. 527

Course Title: Environmental Microbiology

Total Hours: 45

Course Learning Outcomes:

The students will be able to:

CLO 1: Categorize the composition of industrial waste water.

CLO 2: Enlist various approaches for microbiological treatment of waste water.

CLO 3: Discern various xenobiotic compounds generated by anthropogenic activities and learn about various microbiological approaches for bioremediation.

Course Contents

Unit/Hours	Content	Mapping with CLOs
Unit I 10 Hours	<p>Characteristic and composition of industrial waste water: General characteristics of industrial waste-water coming from sugar industries, tanneries, paper-pulp and alcohol industries, Concepts of C-BOD, N-BOD and COD, Oxygen-sag curve. Water borne risk to human health, Disinfection of drinking water with anti- microbial agents. Coliform test of potable water.</p> <p>Exercise: Concept mapping, Class discussion, spontaneous quizzes</p>	CLO 1
Unit II 12 Hours	<p>Microbiological approaches for waste water treatment: 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.</p> <p>Exercise: Numerical exercises for BOD, COD calculation, Interpretation for oxygen sag curve</p>	CLO 2

Unit III 12 Hours	Microbial Toxicology: General chemistry of pollutants. Particulate matter, poly-aromatic hydrocarbons, organosulfur, organophosphorus, 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	CLO 3
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Unit IV 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	CLO 3
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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. Christian RA , Jariwala, Namrata D, Karia, GL (2023) *Wastewater treatment: concepts and design approach* third edition PHI Learning Private Limited
4. Lawrence, P., Wacekett, C. and Douglas Hershberger. (2014) *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.
8. Buckley R. G. (2019) *Environmental Microbiology*, CBS publication

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: MMIC.526

Course Title: Research Methodology and Biostatistics

Total Hours: 45

Course Learning Outcomes:

Student will be able to:

CLO 1: Illustrate various aspects of research methods, ethics, technical and scientific writings and literature search.

CLO 2: Develop and formulate research questions and ideas and develop skill in understating the results published in the research paper

CLO 3: Recognize the concept of biosafety, biological risks and their importance in laboratories and research.

CLO 4: Demonstrate various bioinformatics tools and techniques to analyse data and to perform the interaction studies.

CLO 5: Design, plan and execute the experimental study.

CLO 6: Utilise various tools to collect and present data.

CLO 7: Demonstrate the outcome of results using statistical approaches in testing hypotheses, analyzing experimental data and interpreting the results.

Course Contents

Unit/Hours	Content	Mapping with CLOs
Unit I 10 Hours	<p>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.</p> <p>Exercise: Research presentation and poster preparation. Plagiarism and open access publishing.</p>	CLO 1 CLO2

Unit II 11 Hours	<p>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/safety and Ethical considerations in rDNA and genetic engineering. 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).</p> <p>Exercise: Paper discussion (research paper versus review article), case studies on patent filing.</p>	CLO 2 CLO 3
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Unit III 12 Hours	<p>Biostatistics: Differences between parametric and non-parametric statistics, Univariate and multivariate 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. 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), Standard errors of regression coefficients and types of correlation coefficient.</p> <p>Exercise: Problem solving, numerical, Training Games for Learners, Student- generated test questions.</p>	CLO 5 CLO 6 CLO 7
Unit IV 12 Hours	<p>Bioinformatics: Organization, management and analysis of biological data, use of computers in data analysis, biological databases - DNA sequence databases and protein sequence databases, BLAST, FASTA, multiple sequence alignment, primers in biology (design and types of primers) genome projects (human, <i>Arabidopsis</i> and other genome projects), NCBI, UCSC, BV-BRC and other database searches. Indian Biological Data Centre (IBDC) and its repositories: Indian Nucleotide Data Archive (INDA), Indian Proteome Databank (IPD), Indian Metabolome Data Archive (IMDA), Indian Structure Data Archive (ISDA), Indian Biological Images Archive (IBIA), Indian Crop Phenome Database (ICPD); DBT-Centre for Microbial Informatics.</p> <p>Exercise: Hands on training on bioinformatics tools,</p>	CLO 4

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. 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. Zvelebil, M. and Baum, J. (2007). *Understanding Bioinformatics*, Garland Science, New York, USA.
13. Mount, D. (2012). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor Laboratory Press.
14. Oregano, C., Jones, D., Thornton, J. (2005). *Bioinformatics: Genes, Proteins and Computers* (Advanced Texts). Taylor and Francis Publishers.
15. Norman, G. and Streiner, D. (2014). *Biostatistics: The Bare Essentials*, Decker Inc. USA, 4th edition.
16. Rao Nageswara G. (2018) *Biostatistics & Research Methodology*, 1st Ed. PharmaMed Press
17. Samuels, M.L., Witmer, J., Schaffner, A. (2016). *Statistics for the Life Sciences*. , 5th edition, Prentice Hall publishers.
18. Emden, H.F. (2019). *Statistics for Terrified Biologists*. Blackwell Publishers.
19. Thomas, C. George (2020). *Research Methodology and Scientific Writing*. 2nd Edition. ; Ane Books pvt. Ltd.
20. Bryant, John A. & Velle, Linda LA (2019). *Introduction to bioethics*, 2nd Edition.

Web-links

- <https://www.cdc.gov/>

- <https://www.who/>
- [http://dbtindia.gov.in/regulations-guidelines/regulations/biosafety- programme](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: MMIC.529

Course Title: Microbial Pathogenicity

Total Hours: 45

Course Learning Outcomes (CLO):

The students will be able to:

CLO1. Describe virulence determinants – colonization, toxins, enzymes and invasiveness with varied examples from different pathogens.

CLO2. Illustrate molecular Koch's postulates and multiplicity of virulence factors and coordinated regulation of virulence genes type 1-IV secretion systems, importance of biofilms and quorum sensing

CLO3. Discuss about the emerging and reemerging pathogens.

CLO4. Discussion and evaluation of various tools and techniques used to study the epidemiology and diagnosis of various diseases.

Course Contents

Unit/Hours	Content	Mapping with CLOs
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Unit I 11 Hours	Introduction and Techniques to Study Bacterial Pathogenesis: Host defense mechanisms such as Phagocytosis, opsonization and complement, Non-specific, innate and adaptive host defense. 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	CLO 1
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 pathogenicity. 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	CLO 2

Unit III 10 Hours	Emerging and Re-emerging Pathogens: Illustrate emerging and re-emerging pathogens using <i>V. cholerae</i> 0139, X-MDR <i>M. tuberculosis</i> , <i>Helicobacter pylori</i> , <i>Enterohaemorrhagic E. coli</i> (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	CLO 3
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	CLO 4

	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	
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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 (2019) Fourth edition *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 (2015) *Textbook of Diagnostic Microbiology*. 5th edition 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.
8. Reba Kanungo (2022) *Ananthanarayan and Paniker's Textbook of Microbiology*, 12th Edition Universities Press(India)Pvt.Ltd.
9. Abigail A. Salyers, Brenda A. Wilson , Dixie D. Whitt , Malcolm Winkler (2011) *Bacterial Pathogenesis: A Molecular Approach*.

Web Sources <https://www.cdc.gov/>
[https://www.who./](https://www.who/)

Modes of transaction:

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

L	T	P	Credits
0	0	6	3

Course Code: MMIC.528

Course Title: Microbiology Practical-II

Total Hours: 90

Learning Outcomes:

The students will be able to:

CLO1. Outline the basic molecular biology, cell culture and immunological techniques and correlate them with their fundamental concepts in the subject

CLO2. Assess the use of molecular biology, cell culture and immunological techniques in health and diseases,

CLO3. 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.

CLO4. Conduct and examine the experiments pertaining to the theory papers of environmental microbiology.

CLO5. Apply these observations and scientific ideas in the real life microbiology associated tribulations.

Course Contents Unit/Hours	Content	Mapping with
Part A. Immunology and research Methodology 30 Hours	<ol style="list-style-type: none">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 antibodies and antigen.12. Dot Immunoblot assay (DIBA).13. ELISA14. Polyacrylamide gel electrophoresis and Western blotting.15. Demonstration of Flow Cytometry.16. Immunohistochemistry: H & E staining,	CLO 1 CLO2 CLO3

	Fluorescent staining,	
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Part B. Molecular Biology 30 Hours	<ol style="list-style-type: none"> 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. 	CLO 1 CLO2 CLO3
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<p>Part C. Environmental Microbiology/Microbial Physiology & Metabolism 30 Hours</p>	<ol style="list-style-type: none"> Physical analysis of sewage/industrial effluent by measuring total solids, total dissolved solids and total suspended solids. Determination of indices of pollution by measuring BOD/COD of different effluents. Bacterial reduction of nitrate from ground waters Isolation and purification of degradative plasmid of microbes growing in polluted environments. Recovery of toxic metal ions of an industrial effluent by immobilized cells. Utilization of microbial consortium for the treatment of solid waste [Municipal Solid Waste]. Biotransformation of toxic chromium (+ 6) into non-toxic (+ 3) by <i>Pseudomonas</i> species. Tests for the microbial degradation products of aromatic hydrocarbons /aromatic compounds. Microbial response to stress/antimicrobial agent, biofilm growth Microbial dye decolorization/adsorption. Isolation of Photosynthetic bacteria Glucose uptake by <i>E. coli</i> / <i>Saccharomyces cerevisiae</i> [Active and Passive diffusion] Effect of UV, gamma radiations, pH, disinfectants, chemicals and heavy metal ions in spore germination of <i>Bacillus</i> SP. Determination of Iron Oxidation Rate of <i>Thiobacillus ferrooxidans</i>. Determination of Sulfur Oxidation Rate of <i>Thiobacillus thiooxidans</i>. Microbial cell permeability alteration analysis, leakage of cellular contents Estimation of calcium ions present in sporulating bacteria by EDTA method. Demonstration of utilization of sugars by oxidation and fermentation techniques. 	<p>CLO4 CLO5</p>
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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 Benson's *Microbiological Applications Lab Manual*, 2016.
4. James G. Cappuccino & Natalie Sherman (2014) *Microbiology: A Laboratory Manual*, 10th Edition 2014
5. Aneja KR (2014) *Laboratory Manual of Microbiology and Biotechnology*.
6. Alberts, B. Bray, D. Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell*. Garland publishers, Oxford.
7. Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.
8. Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology*. CRC Press, Taylor and Francis Group, UK.
9. Michael J. Leboffe (2011) *A Photographic Atlas for the Microbiology laboratory*.
10. *Laboratory protocols in Applied Life Sciences* (2014). Taylor & Francis Group, LLC
11. James G. Cappuccino & Natalie Sherman (2014) *Microbiology: A Laboratory Manual*, 10th Edition 2014
12. Aneja KR (2014) *Laboratory Manual of Microbiology and Biotechnology*.
13. Alberts, B. Bray, D. Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell*. Garland publishers, Oxford.

14. 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./](https://www.who/)

L	T	P	Credits
2	0	0	2

Course Code: MMIC.506

Course Title: Basics in Microbiology (IDC)

Total Hours: 30

Course Learning Outcomes:

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

CLO 1: Impart a foundation of microbiology to the students from different backgrounds.

CLO 2: Understand the nutritional and growth requirements for different bacteria.

CLO 3: Acquire a broad understanding of different groups of microorganisms important in health, diseases and industry.

CLO 4: Outline the various methods for the control of microorganisms.

Course Contents

Unit/Hours	Content	Mapping with CLOs
Unit I 7 Hours	<p>Introduction to Microbiology: Scope and history of Microbiology, Classification of Bacteria, Fungi, Protozoa, Algae, and viruses.</p> <p>Basic principles and techniques used in bacterial classification. Phylogenetic and numerical taxonomy. General characteristics, structure and classification of plant animal and bacterial viruses.</p> <p>Exercise: Spontaneous quiz on identification of</p>	CLO 1

	microorganism based on given characteristic	
Unit II 8 Hours	<p>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</p> <p>Exercise: Data Interpretation of different growth curve, classifying microorganism based on nutritional requirements</p>	CLO 2
Unit III 8 Hours	<p>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.</p> <p>Exercise: Groupwise discussion on therapeutic approaches against pathogenic microorganism</p>	CLO 3
Unit IV 7 Hours	<p>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.</p> <p>Exercise: Case studies and hands-on experiments.</p>	CLO 4

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

L	T	P	Credits
2	0	0	2

Course Code: MMIC. 507

Course Title: Introduction to Immune system (IDC)

Course Learning Outcomes:

Total Hours: 30

The students will be able to:

CLO 1: Develop an awareness about the various components of the human immune system.

CLO 2: Delineate the human immune response as it defends the host against pathogens and malignancies.

CLO 3: Examine diseases associated with deficient or abnormal immune responses.

CLO 4: Understand the immunological basis of therapeutics and diagnostics.

Course Contents

Unit/Hours	Content	Mapping with CLOs
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	CLO 1

Unit II 8 Hours	<p>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.</p> <p>Exercise: Panel discussion about evasion mechanism employed by pathogens</p>	CLO 2
Unit III 7 Hours	<p>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.</p> <p>Exercise: Case studies on immune disorders, Presentations</p>	CLO 3
Unit IV 8 Hours	<p>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</p>	CLO 4

Suggested Reading:

1. Abbas. (2021 8). *Cellular and Molecular Immunology*. 10th Edition 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

Semester – III

L	T	P	Credits
3	0	0	3

Course Code: MMIC.535**Course Title: Industrial Microbiology****Total Hours: 45****Course Learning Outcomes**

Student will be able to:

CLO 1: Understand the principles of upstream and downstream processes in fermentation technology

CLO 2: Production and purification of Alcohol, Antibiotics, Acid and enzymes through large scale processes.

CLO 3: Apply the knowledge of industrial microbiology in large-scale production of recombinant proteins.

CLO 4: Production and purification of vitamins and microbe based products.

Course Contents

Unit/Hours	Content	Mapping with Course Learning Outcome
Unit I 12 hours	<p>Introduction: Scope and historical development; Sources of industrially important microbes, strain development, types of fermentation and fermenters, process optimization, and In situ Fermentation cleaning and sterilization, Types of fermentation systems; Bioreactor designs and operations. Single use bioreactor. Sterilization testing of fermentor.</p> <p>Downstream processing of microbial products: Filtration, centrifugation, cell disruption, liquid-liquid extraction, chromatography, membrane processes, drying (lyophilization and spray drying), and crystallization.</p> <p>Exercise: Case studies, industry visits,</p>	CLO1

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 Production of distilled beverages or liquors, 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. Exercise: Panel Discussion, Industry visits, hands-on experiments, Concept Mapping	CLO2
Unit III (11 hours)	Development and production of microbial products: Organic Metabolites-Ethanol, Acetone; Citric acid, Acetic acid, Lactic acid, Amino acids; Enzymes- Amylases, Glucose Isomerase, Proteases,; Vitamins- Vitamin B12, Riboflavin, B carotene; Antibiotics: beta-Lactam antibiotics; Amino acid and peptide antibiotics; Carbohydrate antibiotics; Tetracycline; Nucleoside antibiotics; Aromatic antibiotics. Recombinant biomolecules and therapeutic proteins. Exercise: Discussions and Group Learning, Concept Mapping.	CLO2 and CLO3
Unit IV (10 hours)	Application of Microbial Products: Mushroom production Biopolymers-xanthan gum and PHA's (Bioplastics), Bioethanol, Biobutanol, Biodiesel, Biohydrogen production by using microorganisms. Biofertilizers. Single cell protein, Fermentation economics. Exercise: Problem based learning, Quiz, Critical Thinking, Brainstorming. Industrial visits.	CLO 4

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
8. Debabrata Das, Soumya Pandit (2021) *Industrial Biotechnology* CRC Press

Modes of transaction:

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

L	T	P	Credits
3	0	0	3

Course Code: MMIC.536

**Course Title: Food and Dairy
Microbiology**

Total Hours: 45

Course Learning Outcomes (CLO):

The students will be able to:

CLO1. Describe the food borne disease caused by bacteria and fungi and explain the environmental factor responsible for food spoilage.
 CLO2. Explain and assess the microbiology of different types of food and food products.
 CLO3. Develop and review industrial aspects of food and dairy microbiology. CLO4. Explain about the food preservation methods, quality testing and different regulatory bodies.

Course Contents

Unit/Hours	Content	Mapping with CLOs
Unit I 11 Hours	History of Food Microbiology and Microbial Growth in Food: History of Microorganisms in Food, Historical Developments, Food Preservation, Food Spoilage, Food Poisoning. Taxonomy, Role, and Significance of Microorganisms in Foods. Intrinsic and Extrinsic Parameters of Foods That Affect Microbial Growth. 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. Exercise: Training Games for Learners, Problem-solving Activities for Learners	CLO 1
Unit II 13 Hours	Microorganisms in Food: Food borne diseases- Bacterial food borne diseases- (Staphylococcal intoxication, Botulism, Salmonellosis, Shigellosis, EHEC E. coli infection, <i>Listeria monocytogenes</i> infection, <i>Clostridium perfringens</i> gastroenteritis, <i>Bacillus cereus</i> gastroenteritis; Food-borne fungi- Mycotoxins in 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,	CLO 1 CLO 2
Unit III 11 Hours	Fermented Foods and Beverages: Global dietary culture and history of traditional fermented foods and alcoholic beverages; Classification of global fermented foods and beverages. Types of fermentation: spontaneous/natural, back-slopping and starter culture. 'Ethno-microbiology' concept of fermented foods. Indian fermented food products and beverages. Fermented foods and beverages of the world. Culture dependent and culture independent methods. Health benefits	CLO 3

	of fermented foods. Application of multi omics in fermented foods and beverages. 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: Codex Alimentarius, FDA (Food and Drug Administration), HACCP (Hazard Analysis and critical control points), FSSAI (Food Safety and Standards Authority of India). Probiotics, Prebiotics, Synbiotics, Paraprobiotics, Postbiotics. Exercise: Discussions and Group Learning, Concept Mapping	CLO 4

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. Foster W.M (2020) *Food Microbiology* CBS publications
7. Doyle, M. P. and Beuchat, L. R., (2007) *Food Microbiology- Fundamentals and Frontiers*, ASM Press.
8. Elmer H. Marth, James Steele, (2001) *Applied Dairy Microbiology*, Second Edition, CRC Press.
9. Tamang, J.P., (2015) *Health Benefits of Fermented Foods and Beverages*. CRC Press.
10. Tamang, J.P., (2016) *Ethnic Fermented Foods and Alcoholic Beverages of Asia*. Springer.
11. Tamang, J.P., (2020) *Ethnic Fermented Foods and Beverages of India: Science History and Culture*. Springer.

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: MMIC.537

Course Title: Medical Microbiology

Total Hours: 45

Course Learning Outcomes (CLO):

The students will be able to:

CLO1: Describe and explain the concept of various cellular processes during disease development.

CLO2: Describe and evaluate the relevance of microbes and diseases caused by pathogenic bacteria.

CLO3: Describe and explain the virus structure, pathogenesis and review the emerging viral diseases.

CLO4: Comprehend the clinical diagnostics and treatment of the different diseases caused by viruses.

Course Contents

Unit/Hours	Content	Mapping with course learning outcomes
Unit I 12 Hours	<p>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.</p> <p>Exercise: Quiz, Critical Thinking, Brainstorming</p>	CLO 1

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; <i>Staphylococcus</i> , <i>Streptococcus</i> , <i>Enterococcus</i> , <i>Escherichia coli</i> , <i>Neisseria</i> , <i>Klebsiella</i> , <i>Salmonella</i> , <i>Shigella</i> , <i>Vibrio</i> , <i>Campylobacter</i> , <i>Pseudomonas</i> , <i>Acinetobacter</i> , <i>Yersinia</i> , <i>Treponema</i> , <i>Haemophilus</i> , <i>Bordetella</i> , <i>Bacillus</i> , <i>Clostridium</i> , <i>Corynebacterium</i> , <i>Mycobacterium</i> , <i>Actinomyces</i> , <i>Nocardia</i> , <i>Fusobacterium</i> , <i>Listeria</i> , <i>Rickettsiae</i> , <i>Chlamydiae</i> , <i>Spirochetes</i> . Nosocomial Infections and their treatment. Exercise: Case Studies, Paper discussion, application Articles.	CLO 2
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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	CLO 3
Unit IV 11 Hours	Oncogenic Viruses: 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	CLO 4

	<p>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.</p> <p>Exercise: Case Studies, Discussions and Group learning</p>	
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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./](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

Total Hours: 90

Course Code: MMIC.538

Course Title: Microbiology Practical

–III

Learning Outcomes:

The students will be able to:

CLO1. Conduct and examine the experiments pertaining to the theory papers of industrial and food and dairy microbiology.

CLO2. Apply these observations and scientific ideas in the real life microbiology associated tribulations.

CLO3. Plan experiments related to clinical microbiology and virology which will enhance their laboratory skills, and scientific knowledge.

CLO4. Distinguish between various types of microbial media, culturing methods,

CLO5. Inspect and isolate the microbes from the day to day sources.

Course Content

Unit/Hours	Content	Mapp ing with CLOs
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Industrial and Food & Dairy Microbiology 60 Hours	<ol style="list-style-type: none"> 1. Isolation of industrially important microorganisms for microbial processes (citric / actic/ alpha amylase) and improvement of strain for increased yield by mutation. 2. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microorganisms for design of a sterilizer. 3. [a]Determination of growth curve of a supplied microorganism and also determines substrate degradation profile.[b]Compute specific growth rate (m), growth yield (Y) from the above. 4. Extraction of Citric acid/Lactic acid by salt precipitation. 5. Product concentration by vacuum concentrator 6. . Cell disruption for endoenzymes by sonication. 7. Microbiological examination of fresh and canned foods, mushrooms, spoiled foods and fruits, milk and milk products 8. Microbiological quality testing of milk (MBRT test). 9 Isolation of toxin producing organisms and estimation of their toxins in different foods 10 Extraction of Mycotoxins from contaminated food. <ol style="list-style-type: none"> 11. Isolation of bacterial and fungal probiotics 12. Development of probiotics <i>in vitro</i>. 13. To study various food preservation methods. 14. Standard method for bacteriological water analysis: Presumptive, confirmatory and completed test. 15. Microbial growth studies. 16. Isolation of industrially important microorganisms for microbial processes (citric / lactic/ alpha amylase) and improvement of strain for increasing yield by mutation. 17. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microorganisms for design of a sterilizer. 18. Monitoring of dissolved oxygen during aerobic fermentation 19. Biomass production (Baker's yeast and <i>Spirulina</i>). 20. Production of beverages (alcohol and wine). 21. Estimation of the fermentation products by titration Method 22. Isolation of food poisoning bacteria from contaminated foods, Dairy products 23. Production of fermented milk by <i>Lactobacillus acidophilus</i>. 	CLO 1 CLO2
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Bacteriology & Virology 30 Hours	<ol style="list-style-type: none"> 1. Methods for studying microbial respiration 2. Preparation of different types of culture media/observation. Blood Agar, Chocolate Agar, Mannitol salt agar, Blair Parker medium, MacConkey agar, Lowenstein-Jensen medium, Wilson Blair Bismuth sulphite medium, Biochemical media. 3. Tests for disinfectants (Phenol coefficient/RWC) 4. Study of normal micro-biota of mouth; isolation, identification and preservation of microorganisms 5. Study of normal micro-biota of skin; isolation identification and preservation of microorganisms 6. Identification and Biochemical tests of respiratory tract bacterial pathogen using avirulent strain of MTCC Culture of <i>Streptococci/ Klebsiella pneumoniae</i>. 7. Identification and Biochemical tests of gastrointestinal bacterial infection using avirulent strain of MTCC Culture of <i>Salmonella</i> /<i>Shigella</i> spp. 8. Laboratory examination and identification and biochemical tests of pus specimens using avirulent strain of MTCC Culture for <i>Staphylococcus aureus</i>, <i>Streptococcus pyogenes</i> and <i>Pseudomonas aeruginosa</i>. 9. 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. 10. Determination of MIC values for antimicrobial chemicals 11. Identification of pathogenic bacteria (any three of <i>E. coli</i>, <i>Salmonella</i>, <i>Pseudomonas</i>, <i>Staphylococcus</i>, <i>Bacillus</i>) based on cultural, morphological and biochemical characteristics. 12. Biochemical, enzymatic and serological tests (Coagulase, Catalase, WIDAL, VDRL tests). 13. PCR based diagnosis. 14. Estimation of infectivity titer of a virus sample using Plaque assay. 15. Production of a purified virus stock and its quantitation. 	CLO 3 CLO 4 CLO 5
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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. Lewis, 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
3	0	0	3

Course Code: MMIC.540

Course Title: Microbial Biotechnology

Total Hours: 45

Course Learning Outcomes (CLO):

The students will be able to:

CLO1. Review and explain the use of microbes in the pharmaceutical industry. CLO2. Discuss and evaluate the role of microbial nanotechnology.

CLO3. Describe about the beneficial microbes for health and sustainable development of agriculture

CLO4. Discuss about the various regulatory practices of quality control and quality assurance

Course Contents

Unit / hours	Content	Mapping with CLOs
Unit I 10 Hours	<p>Microbes in Pharmaceutical Products: Macromolecular, cellular and synthetic drug carriers. Immobilization procedures for pharmaceutical applications. Biosensors in pharmaceuticals. Production and application of microbial enzymes in pharmaceuticals. 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.</p> <p>Exercise: Pro-Con Grids, Buzz Group Discussion.</p>	CLO 1
Unit II 11 Hours	<p>Microbial Nanotechnology: Microbial synthesis of Nanoparticles. Synthesis of nanodrugs – metal nanoparticles and drug delivery vehicles – Nanoshells – Tectodentrimers Nanoparticle drug systems – Diagnostic applications of nanotechnology. Nanobiofertilizers for sustainable development of agriculture.</p> <p>Exercise: Quiz, Brainstorming, Problem based learning sessions, Case studies</p>	CLO 1 CLO 2
Unit III 12 Hours	<p>Beneficial Microbes and their applications: Biofertilizers- <i>Rhizobium</i>, <i>Azospirillum</i>, <i>Azotobacter</i>, <i>Gluconacetobacter</i>, <i>Azorhizobium</i>, phosphobacteria - <i>mycorrhizae</i> - Blue Green Algae and <i>Azolla</i>. Massproduction of biofertilizers and composting, Designer Microbes and Health: Gut microbiota and diseases, approaches for engineering gut microbiota, therapeutic uses of gut microbiota, Bacteriophages in control of bacteria. Microbial biosensors and its applications.</p> <p>Exercise: Students seminars, Brainstorming, Case studies, Industry visits.</p>	CLO 3
Unit IV 12 Hours	<p>Regulatory Approvals and Clinical Trials: Good laboratory practice (GLP), Current Good</p>	CLO 4

	<p>Manufacturing Practice (CGMP), different phases of clinical trials, difference between biologics, biosimilar and bio-better, development of biosimilars and generic biomolecules, analysis of process economics, Design and layout of sterile product manufacturing unit, Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification.</p> <p>Exercise: Problem based learning sessions, Case studies, Group discussion</p>	
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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 *Quinolone 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, Merckel Dekker (2019) *Good Manufacturing Practices for Pharmaceuticals* New York.

Modes of transaction

- Lecture
- Problem Solving
- Self-Learning

L	T	P	Credits
2	0	0	2

Course Code: MMIC.539

Course Title: Entrepreneurship in Microbiology

Total Hours: 30

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

CLO 1: Understand the fundamentals of microbiology and its applications in various industries.

CLO 2: Develop an entrepreneurial mindset and learn how to identify opportunities for microbial-based innovations. To gain insights about entrepreneurial behavior and skills.

CLO 3: Gain practical knowledge of business development, marketing, and intellectual

property protection in the microbial sector.

CLO4: Acquire skills for designing and presenting a comprehensive business plan for microbial entrepreneurship.

Course Content

Unit/Hours	Content	Mapping with CLOs
Unit I (6 hours)	Basics of microbiology and microbial diversity, Definition and scope of microbial entrepreneurship, Overview of the microbial industry landscape, Case studies of successful microbial entrepreneurs, Microbial applications in healthcare, agriculture, energy, and biotechnology, Current trends and emerging technologies in microbial research Exercise: Oral presentation on recent development, online training, Group discussion.	CLO 1
Unit II (8 hours)	Building an effective entrepreneurial team, Leadership skills for managing a microbial startup, Ethical considerations and social responsibility in microbial entrepreneurship, Components of a comprehensive business plan, Writing and presenting a business plan for microbial entrepreneurship, Feedback and refinement of business plans Exercise: Industry visits, seminar and interaction with entrepreneurs	CLO2, CLO3
Unit III (8 hours)	Ideation techniques for microbial entrepreneurship, Evaluating market potential and feasibility, Assessing intellectual property and regulatory considerations, formulating a business strategy for microbial innovations, Product development and prototyping, Funding options and financial management for microbial startups Exercise: Problem-solving Activities for Learners, Case Studies in Lesson Plans, industry visits.	CLO 4
Unit IV (8 hours)	Managing intellectual property in the microbial industry; Market research and target audience identification; Branding, positioning, and pricing strategies; Sales channels and distribution networks Exercise: Case Studies, Asking Questions, industry visits.	CLO 4

Modes of transaction:

- Lecture
- Demonstration
- Industrial visit

Suggested Reading:

1. Craig Shimasaki (2020) *Biotechnology Entrepreneurship Leading, Managing and Commercializing Innovative Technologies Second Edition* 9780128155851, Academic Press Inc
2. Natarajan Amaresan, Dhanasekaran Dharumadurai, Olubukola Oluranti Babalola (2022) *Agricultural Microbiology Based Entrepreneurship Making Money from Microbes* ISBN 978-981-19- 5746-8;
3. Natarajan Amaresan, Dhanasekaran Dharumadurai, Olubukola Oluranti Babalola (2022) *Industrial Microbiology Based Entrepreneurship Making Money from Microbes* ISBN 978-981-19- 6663-7
4. Bioentrepreneurship- Development *A resource book by Biotech consortium India Limited, (2020) New Delhi*
<https://www.biotech.co.in/sites/default/files/2020-01/Bioentrepreneurship-Development.pdf>
5. Dr. Peter Kolchinsky (2005) *The Entrepreneur's Guide to a Biotech Startup* 4th edition. https://www.racap.com/media/Perspectives/EGBS4_Kolchinsky.pdf?v=FgFxfEBdEZ-v0OVuiQJT_pkkTnG0F2GXL8T2Gu4KEHI

L	T	P	Credits
0	2	0	2

Course Code: MMIC.511**Course Title: Ethics for Science (VAC)****Total Hours: 30****Course Learning Outcomes:**

Students from inter-disciplinary background will be able to:

- CLO 1: Illustrate the basic good practices to be followed in research and overall as a student.
- CLO 2: Formulate Classify the principles of ethics in research which will help them to understand the set of conduct norms applied in science.
- CLO 3: Interpret the ethical issues involved in human, animals and plants research.
- CLO 4: Judge the misconduct, fraud and plagiarism in research.

Course Content

Unit/Hours	Content	Mapping with Course Learning Outcome

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.	CLO 1 CLO 2
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	CLO 2 CLO 3
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 <i>In-vitro</i> fertilization. Ethical issues in MTP and Euthanasia. Types of consents and Human Genome project. Exercise: Critical Thinking, Discussions and Group Learning	CLO 3
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.	CLO 4

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: MMIC.599.1

Course Title: Dissertation Part I

Total Hours: 120

Course Learning Outcomes

The students will be able to:

CLO1. Organize extensive review of literature.

CLO2. Apply various search engines and websites to identify the area of their research interest.

CLO3. Formulate the hypothesis and work plan with scientifically sound (and achievable) objectives backed by a comprehensive and detailed methodology.

Content:

Students will prepare a research proposal based on the literature review and extensive student-supervisor interactions involving discussion, meetings and presentations. Each student will submit a research/dissertation proposal of the research work planned for MSc. dissertation with origin of research problem, literature review, hypothesis, objectives and methodology to carry out the planned research work, expected outcome and bibliography.

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

Dissertation-One (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: MMIC.599.2

Course Title: Dissertation Part II

Total Hours: 600

Course Learning Outcomes:

The students will be able to:

CLO1. Organize extensive review of literature.

CLO2. Apply various search engines and websites to identify the area of their research

interest.

CLO3. Formulate the hypothesis and work plan with scientifically sound (and achievable) objectives backed by a comprehensive and detailed methodology. CLO4. Compile the data obtained from the experimental plan.

CLO5. Analyze the results in light of established scientific knowledge to arrive at cogent conclusions.

CLO6. Demonstrate their substantial research-based capabilities.

Students will carry out their research work under the supervision of a faculty member. Students will interact with the supervisor through meetings and presentations on a regular basis. After completion of the research work, students will complete the dissertation under the guidance of the supervisor. The dissertation will include literature review, hypothesis, objectives, methodology, result, discussion and bibliography.

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