Central University of Punjab



M.Sc. Microbiology (Research) (2+2)

Academic Session 2026-2028

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 outline for 2+2 MSc in Microbiology by Research (NCrF)

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.526	Research Methodology and Biostatistics	Core	3	0	0	3
MMIC.404	Microbiology Practical-I	Skill Based	0	0	8	4
Discipline Elective (opt any one)						
MMIC.540	Microbial Biotechnology	Discipline elective	3	0	0	3
MMIC.529	Microbial Pathogenicity	Discipline elective	3	0	0	3
Total Credits						**19**
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	Medical Microbiology	Core	3	0	0	3
MMIC.403	Molecular Genetics	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.536	Food Microbiology	DEC	3	0	0	3
XXX	Choose any DEC from allied departments	DEC	3	0	0	3
Interdisciplinary course (IDC)						
XYZ	Choose from Interdisciplinary Course offered by other departments or Choose any MOOC	IDC	2	0	0	2
MMIC.506	Basics of Microbiology	IDC	2	0	0	2
MMIC.507	Introduction to Immune system	IDC	2	0	0	2
MMIC. 508	Microbiology in the Indian Scenario	IDC	2	0	0	2
Value Added Course (VAC)						
MMIC. 511	Ethics For Scienc	VAC	2		0	2
Total Credit						**25**
Remedial teaching			0	2	0	**0**

Semester – III

S. No.	Course Code	Course Title	Course Type	L	T	P	Cr
1	MMIC.599.1	Dissertation Part-I	**Skill Based**	**0**	**0**	**40**	**20**
		Total		**0**	**0**	**40**	**20**

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

Post-Graduate Diploma will be awarded after the end of the first year of M.Sc. Microbiology program

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 (descriptive) 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 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, Innovation and Skill Development Courses	
	Marks	Evaluation	Marks	Evaluation
Internal Assessment	25	Various methods	-	-
Mid-semester test (MST)	25	Descriptive	50	Descriptive (up to 100%) Objective (up to 30%)
End-semester exam (ESE)	50	Descriptive (up to 100%) Objective (up to 30%)	50	Descriptive (up to 100%) Objective (up to 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, primary, secondary, tertiary, quaternary structures of proteins. Ramchandran plot. Protein purification; Liquid chromatography; Gas chromatography, Affinity Chromatography, Gel Filtration, Ion Exchange Chromatography, HPLC. **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. **Nature of Nucleic Acids.** Structure of purines, pyrimidine, nucleosides and nucleotides. Physicochemical properties of nucleic acids - Denaturation of nucleic acids. Hyperchromic effect and Tm. **Exercise:** Problem based learning for Determination of primary structure of proteins, N-terminal and C-terminal determination, Interpretation of Tm curve by students in the class.	**CLO 2**

Unit III **11 Hours**	**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. **Exercise:** Practicing nomenclature of lipid molecules according to convention, arranging them according to melting points, Recognizing aldoses, ketosis and epimers.	**CLO 2**
Unit IV **11 Hours**	**Metabolism:** Fatty acid oxidation. Biosynthesis of fatty acids, triacylglycerols and phospholipids. Catabolism of Glycogen. Amino acid catabolism- Urea Cycle Deamination and transamination reactions. *De novo* biosynthesis of purines and pyrimidines, Ribonucleotide reductase and its role in nucleic acid metabolism. **Exercise:** Numerical approaches in calculating ATP generation from the oxidation of odd and even chain fatty acids	**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. Moat A.G., Foster J. W Spector M. 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. Satyanarayana U., Chakrapani U. (2017) *Biochemistry,*5th Edition. Elsevier India
9. Irwin H. Segel (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. Segal H. 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
-Co-Instructor Model

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:

CLO1. Describe the microbial systematics and ultrastructure of the prokaryotes as well as its significance
CLO2. Explain and apply the basics of microbial growth, classification and the importance of viruses, fungi and algae
CLO3. Bacteria permeation and sporulation.
CLO4. Bacterial Photosynthesis and chemolithotroph bacteria

Course Contents

Unit/Hours	Content	Mapping with CLOs
Unit I **12 Hours**	**History & Microbial Taxonomy:** Golden era of microbiology, scope of microbiology; Methods of microbial taxonomy – morphological, physiological and metabolic, Polyphasic approach and Molecular techniques. Bergey's Manual of Systematic Bacteriology and its significance. **Morphological features and ultrastructure of bacteria**: Detailed structure of gram negative and gram-positive bacterial cell wall, function and its significance. Outer membrane lipopolysaccharide (LPS) and its importance. Cell wall synthesis and its inhibitors. Microbial cell appendages and surface structures. **Archaeal diversity, cell structure and model organisms:** Phylogenetic diversity and key features of different phyla. General characteristics of archaeal cell structure and comparison with eubacteria. Detailed account of model archaeal organisms: *Methanococcus, Halobacterium, Pyrococcus* and *Sulfolobus*. **Exercise:** Preconception/Misconception Check, One Sentence Summary, Imagine, Class quiz, self-directed learning	**CLO 1**
Unit II 11 Hours	**Growth and cell division:** Measurement of growth, growth physiology, cell division, growth yields, growth kinetics, steady state growth and continuous growth. Microbial stress response to different environmental conditions. **General features and classification of viruses, fungi & algae:** Nomenclature and classification of virus, morphology and ultrastructure; Viral genomic organization, structure, and replication (RNA & DNA viruses); cytopathic effects. Prion and viroids. **Fungi**: classification & reproduction in fungi, Economic importance of fungi and yeast. **Algae** classification; reproduction, algal bloom and algal toxins. **Exercise:** Pyramiding /Snowball Groups, Memory Matrix, Student poll, Class quiz, self-directed learning. Group discussion about emerging pathogens (SARS-CoV-2, Ebola, Marburg etc)	**CLO 1** **CLO 2**

Unit III 12 hours	**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, role of permeases in transport, different permeases in *E. coli*. Transport of amino acids and inorganic ions in microorganisms and their mechanisms. **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. **Exercise:** Asking questions, Quizzes, Presentation, unstructured interview, Students Teams.	**CLO 3**
Unit IV 10 Hours	**Bacterial Chemolithotrophy:** Physiological groups of chemolithotrophs, ammonia oxidation by members of Genus Nitroso group, nitrite oxidation by Nitro group of genera. Oxidation of molecular hydrogen by hydrogeno-monas species. Ferrous and sulfur/sulfide oxidation by *Thiobacillus* species. **Bacterial Photosynthesis:** Photosynthetic microorganisms, photosynthetic pigments, and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria. Aerobic and Anaerobic respiration. **Exercise:** Case studies, Debate, Asking questions, Objective structured practical examinations (OSPE)	**CLO 4**

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. Cappuccino, J.G. and Sherman, N. (2004). *Microbiology-A Laboratory Manual*. Benjamin Cummings, USA.
6. James G. Cappuccino, Chad Welsh (2023) *Microbiology: A Laboratory Manual,* 11th Edition, pearson, India
7. Aneja K.R. (2022) *Experiments in Microbiology, Plant Pathology, Tissue Culture and Microbial Biotechnology Sixth edition* New Age Intl. Publishers Ltd. - New

Delhi.
8. 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.
9. 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

M**odes of transaction**

-Lecture
- Problem solving
-Panel discussion
- Group discussion
- Co-Instructor Model

L		P	Credits
3		0	3

Course Code: MMIC. 402

Course Title: Cell and Developmental Biology

Total Hours: 45

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	**Introduction to the Cell:** Evolution of the cell. Prokaryotes and eukaryotes Cell **Membrane Structure and Function** Membrane transport of macromolecules and particles. **Structural Organization and Function of Intracellular Organelles**: Structure and function of nucleus, Ribosomes,lysosomes, peroxisomes, Golgi apparatus, endoplasmic reticulum, mitochondria and chloroplast. **Protein Secretion and Sorting:** Organelle biogenesis and protein secretion, synthesis and targeting. Intracellular traffic, vesicular traffic in the secretory pathway and protein sorting. Sub-cellular Fractionation: Isolation and purification of cell organelles and macromolecular complexes from homogenization, centrifugation and density gradient techniques. **Exercise:** Group test reading, Debate, Brainstorming, Quiz based assessment, group discussion.	**CLO 1**
Unit II 11 Hours	**The Cytoskeleton:** The nature of cytoskeleton, Intermediate filaments, Microtubules, Actin filaments, Cilia and centrioles, Organization of the cytoskeleton. **Cell communication and cell signaling:** Cell adhesions, Cell junctions and the extracellular matrix, Cell-cell adhesion and communication, Cell matrix adhesion, Collagen the fibrous protein of the matrix, Non-collagen component of the extracellular matrix **Exercise:** Problem based learning, Muddiest Point, Crossword Puzzle, Students teaching, paper presentation on ECM and its components.	**CLO 1** **CLO 2**

Unit III **12 Hours**	**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 (*Drosophila, C. elegans, Xenopus,* mutants, transgenics and animal cloning Fertilization, Gametogenesis, Organogenesis and Metamorphosis. Homology, Hox Genes, and Developmental Integration. Programmed Cell Death. **Exercise:** Research paper presentation, Problem based learning sessions, Class quiz.	**CLO 3**
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**

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
- Co-Instructor Model

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	**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, plagiarism and open access publishing. An overview of AI knowledge; Applications of AI tools in research; Ethical considerations associated with the use of AI in academic research. **Exercise:** Research presentation and poster preparation. Plagiarism and open access publishing.	**CLO 1 CLO 2**
Unit II 11 Hours	**Bioethics and Biosafety:** Good Laboratory Practices, Sterilization techniques, Cell and tissue culture techniques: Plants and animals. Biosafety for human health and environment. Biosafety issues for using cloned genes in medicine, gene editing, 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 projects. Intellectual property rights (IPRs), Patents copyrights and Fair use. **Exercise:** Paper discussion (research paper versus review article), case studies on patent filing.	**CLO 2 CLO 3**

Unit III 12 Hours	**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. **Exercise:** Problem solving, numerical, Training Games for Learners, Student- generated test questions.	**CLO 5** **CLO 6** **CLO 7**
Unit IV 12 Hours	**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, *Arabidopsis* 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. **Exercise:** Hands on training on bioinformatics tools, Quiz, Brainstorming.	**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. Orengo, 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
- 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
-Co-Instructor Model

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. Various techniques for microbial study

Course Contents

Unit / hours	Content	Mapping with CLOs
Unit I **10 Hours**	**Microbes in Pharmaceutical Products:** Immobilization procedures for pharmaceutical applications. 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. Difference between biologics, biosimilar and bio-better, development of biosimilars and generic biomolecules, bio-manufacturing, **Exercise:** Pro-Con Grids, Buzz Group discussion.	**CLO 1**
Unit II **11 Hours**	**Microbial Nanotechnology:** Microbial synthesis of Nanoparticles. Synthesis of nanodrugs – metal nanoparticles and drug delivery vehicles – Nanoshells – Tectodentrimers Nanoparticle drug systems – Diagnostic applications of nanotechnology. Nanobio fertilizers for Sustainable development of agriculture. **Exercise:** Quiz, Brainstorming, Problem based learning sessions, Case studies	**CLO 1** **CLO 2**
Unit III **12 Hours**	**Beneficial Microbes and their applications:** Biofertilizers- *Rhizobium, Azospirillum, Azotobacter, Gluconacetobacter, Azorhizobium,* phosphobacteria **–** *mycorrhiza* Blue Green Algae and *Azolla***.** Mass Production 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. **Development and production of microbial products:** Amino acids; Enzymes-Amylases, Proteases,; Vitamins- Vitamin B12, Riboflavin,; Antibiotics: beta-Lactam antibiotics; Amino acid and peptide antibiotics; Carbohydrate antibiotics; Tetracycline; Nucleoside antibiotic. **Exercise:** Students seminars, Brainstorming, Case studies, Industry visits.	**CLO 3**

Unit IV 12 Hours	**Different techniques in microbial biotech** Different types of Microscopy and its application in microbial study (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 focusing (IEF), colorimetry, turbidimetry. Types, importance of Biosensors. **Exercise:** Problem based learning sessions, Case studies, Group discussion Visit and demonstration of SEM, Confocal, practical for electrophoresis and centrifugation.	**CLO 1**

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. Celis, J.E. (2006). *Cell biology: A laboratory handbook*, Vol 1, 2, 3. Academic Press, UK.
4. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. John Wiley &Sons. Inc. New Delhi, India.
5. Watson, J.D., Baker, T. A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2014). *Molecular Biology of the Gene*. 7th Edition, Benjamin Cummings, USA.
6. Hugo W. B. & Russell A. D. (2004) Pharmaceutical Microbiology. Blackwell Scientific Publications.
7. Frederick Kavanagh Analytical Microbiology Academic Press New York. YEAR MISSING
8. David C. Hooper, John S. Wolfson Quinolinone antimicrobial agents. ASM Washington DC.
9. Murray S.Cooper Quality control in the Pharmaceutical Industry. Academic Press New York. Rehm H. J. & Reed G., Biotechnology. VCH Publications, Germany.
10. Vyas S. P. & Dixit V.K. (2017) Pharmaceutical Biotechnology. CBS Publishers & Distributors, New Delhi.
11. Sydney H. Willig, Murray M. Tuckerman, William S. Hitchings, Mercel Dekker (2019) Good Manufacturing Practices for Pharmaceuticals New York.

Modes of transaction

-Lecture
-Problem Solving
-Self-Learning
-Group discussion
-Co-Instructor Model

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/hour	**Content**	**Mapping with CLOs**
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	**CLO 2**

	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	
Unit III 10 Hours	Emerging and Re-emerging Pathogens: Illustrate emerging and re-emerging pathogens using V. cholerae 0139, X-MDR, M. tuberculosis, Helicobacter pylori, Entero- haemorrhagic E. coli (EHEC), Bird/swine flu, MERS-CoV, SARS-CoV-, EBOLA, 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, phagetyping,; Molecular typing: RAPD, rep (REP, ERIC, BOX)-PCR, IS based typing, PFGE, AFLP, MLST, VNTR and whole genome sequence; Rapid diagnostic principles: Nucleic acid probes in diagnostic microbiology, nucleic acid amplification methods, Real-time PCR, Lateral flow assays, diagnostic sequencing and mutation detection, automated instruments for detection / diagnosis of Infectious agents. Exercise: Discussions and Group Learning, Paper discussion, hands-on training	**CLO 4**

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./

Modes of transaction:

-Lecture
-Demonstration
-Lecture cum demonstration
-Inquiry training
-Group discussion
-Co-Instructor Model

L	T	P	Credits
0	0	8	4

Course Code: MMIC.404 Practical-I
Course Title: Microbiology

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**
Part B. Microbiology 30 Hours	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. Isolation of bacteria and fungi from different sources (soil, air, water) and determination of CFU. 5. Use of selective and/or differential media for isolation and identification of specific bacterial cultures. 6. Pureculture techniques: Streak plate, spread plate and pour plate methods. 7. Tests for disinfectants (Phenol coefficient/RWC). 8. Biochemical tests to characterize bacterial cultures: Catalase test, Oxidase test, Methylene blue test. 9. Microbial response to stress/antimicrobial agent, biofilm growth 10. Microbial dye decolorization/adsorption. 11. Isolation of Photosynthetic bacteria. 12. Glucose uptake by E. coli / *Saccharomyces cerevisiae* [Active and Passive diffusion] 13. Effect of UV, gamma radiations, pH, disinfectants, chemicals and heavy metal ions in spore germination of *Bacillus* sp. 14. Microbial cell permeability alteration analysis, leakage of cellular contents Estimation of calcium ions present in sporulating bacteria by EDTA method. 15. Demonstration of utilization of sugars by oxidation and fermentation techniques.	**CLO 2**

Part C. Cell Biology 30 Hours	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 staining and Temporary staining for epithelial cells and blood cells. 5. Cell counting using various staining techniques 6. Preparations of temporary mount and study the different stages of Mitosis (Onion root tip). 7. Study of polyploidy in onion root tip colchicine treatment. 8. Study of structure of cell organelles through electron micrographs 9. To demonstrate the presence of nucleus, mitochondria and other cell organelles using vital stains. 10. Depicting nature of cellular membranes: Osmosis, Hypertonicity, Hypotonicity, Isotonicity	**CLO 3**
Part D. Research Methodology 30 Hours	1. To analyse cell viability by dye exclusion method. 2. Media preparation for animal cell culture. 3. Growth and maintenance of cell lines. 4. To analyse cytotoxicity of a treatment in a given cell line and calculating LD50 dose16S rRNA gene sequence analysis. 5. Literature Reviews & Academic Searching: Tools like Google Scholar and PubMed and Reference management tools. 6. Submission of gene sequences to GenBank and Sequence Read Archive (SRA). 7. Primer designing using Primer-BLAST 8. Determination of genes mapped within a specific chromosomal locus using GeneLoc integration resource and gene orthologue prediction using Ensembl. 9. Protein-protein interactions using STRING; Introduction to KEGG and Metacyc databases. 10. PCR based site directed mutagenesis, blue white screening 11. In silico cloning using Vector Builder and analysis of sequence using EMBOSS and other tools	**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 K.R. (2014) *Laboratory Manual of Microbiology and Biotechnology*.
7. Alberts, B. Bray, D. Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell.* Garland publishers, Oxford.
8. Celis, J.E. (2006). *Cell biology: A laboratory handbook,* Academic Press, UK.
9. Karp, G. (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
Course Title: Immunology
Total Hours: 45

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 and articulate the functioning of the immune system in the context of diseases.
CLO 3: Apply the immunological techniques in health and diseases.
CLO 4: Apply the knowledge in health and disease from an immunological perspective and diagnostics.

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/CLO4**

	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, discussion	
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/CLO4**
Unit IV 12 Hours	**Diagnostic Immunology**: 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. **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
-Co-Instructor Model

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**	**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, NHEJ **Exercise:** Student-generated test questions, Experimental evidence, application article, Problem based learning.	**CLO 1, CLO3**
Unit II **12 Hours**	**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. **Exercise:** Asking Questions, Crossword Puzzle, Case Studies.	**CLO 2**

Unit III **10 Hours**	**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. **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. **Exercise:** Real time Data interpretation for different techniques, Brainstorming, online tool for cloning, Problem Solving, Team teaching, Group Text Reading	**CLO 3**
Unit IV **11 Hours**	**Polymerase chain reaction (PCR):** Principle, types and applications, PCR based markers: RAPDs, SSRs, SNPs, ISSRs, and SCARs etc, DNA fingerprinting, and Restriction mapping, SSCP DNA sequencing technology. **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, **Exercise:** Real time Data interpretation for different techniques, Discussions and Group Learning	**CLO 4**

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 Robert F. Weaver (2011)Molecular Biology McGraw-Hill Education; 5th edition.
7. Jocelyn E.Krebs , Elliott S.Goldstein , Stephen T.Kilpatrick (2017) Lewin's GENES XII; 12th edition.
8. 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.
9. 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.
10. 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
-Co-Instructor Model

Tools used

Study Videos, Google Classroom/Drive

L	T	P	Credits
3	0	0	3

Course Code: MMIC.525

Course Title: Medical Microbiology

Total Hours: 45

Course Description

This course provides advanced knowledge of pathogenic microorganisms of medical importance, host–pathogen interactions, clinical manifestations of infectious diseases, laboratory diagnosis, antimicrobial therapy, and prevention strategies. The course emphasizes bacteriology, virology, mycology, parasitology, emerging infections, and infection control practices.

Course Learning Outcomes (CLO):

The students will be able to:

CLO1: Explain principles of medical microbiology, infection processes, and host-pathogen interactions.
CLO2: Describe the etiology, pathogenesis, clinical features, and laboratory diagnosis of bacterial infections.
CLO3: Explain viral diseases, mechanisms of viral pathogenesis, and diagnostic approaches.
CLO4: Describe medically important fungi and parasites, their pathogenesis, diagnosis, and treatment.
CLO5: Interpret clinical microbiology laboratory reports, antimicrobial susceptibility patterns, and infection control measures.

Course Contents

Unit/Hours	**Content**	**Mapping with course learning outcomes**

Unit I **11 Hours**	**Hospital Infection Control & Public Health Microbiology:** Nosocomial infections and common agents, Sterilization and disinfection in hospitals, Biomedical waste management (overview), Infection prevention strategies: hand hygiene, PPE, isolation, Surveillance of antimicrobial resistance, Outbreak investigation (basic approach).Principles of infection: colonization, invasion, dissemination, Virulence factors: toxins, enzymes, adhesins, biofilms; Host defense mechanisms, Pathogenesis and mechanisms of tissue damage. **Mechanism of Antibiotic and Resistance:** Mode of action of antibiotics and chemotherapeutic drugs: inhibitors of cell wall synthesis, Protein Synthesis, Nucleic Acid Synthesis and Metabolism, Antibiotic sensitivity assays, Antibiograms. Antibiotic resistance in bacteria-various molecular factors that contribute to the development of resistance, Monoclonal antibodies as therapeutic agents to resistance bacteria **Exercise:** Quiz, Critical Thinking, Brainstorming, case-based discussion on infection transmission and specimen selection. Case study on hospital outbreak and infection control plan.	**CLO1**
Unit II **12 Hours**	**Introduction and Biology of Pathogenic Bacteria:** Morphological characteristics, pathogenesis and laboratory diagnosis including rapid methods of following pathogenic bacteria; Gram-positive (e.g. *Staphylococcus, Streptococcus, Corynebacterium, Bacillus, Clostridium, Listeria*); Gram-negative (*Enterobacteriaceae, Vibrio cholerae, Pseudomonas & other NF, Acinetobacter, Haemophilus, Bordetella, helicobacter*); Acid-fast & atypical bacteria (e.g. *Mycobacterium, mycoplasma, Chlamydia, Rickettsia, Treponema*); Common Bacterial Infections by Site: Respiratory Tract Infections (Upper & Lower); Skin and Soft Tissue Infections (SSTI); Urinary Tract Infections (UTIs); Gastrointestinal (GI) Tract Infections (Food Poisoning); Sexually Transmitted Infections (STIs); Nervous System Infections (CNS); Bloodstream Infections (Systemic): Factors Influencing Site-Specific Infections **Exercise:** Case Studies, Paper discussion, application Articles, Problem-based diagnosis using clinical case scenarios.	**CLO2**

Unit III **11 Hours**	**Medical Virology, Pathogenesis & Emerging Viral Disease:** Viral pathogenesis: latency, oncogenesis, immune invasion. Important human viral infections: **Emerging Viral Diseases** & Respiratory Viruses (influenza, RSV, and adenovirus). Coronavirus, hepatitis virus, arbovirus, rabies and encephalitis viruses, and viral hemorrhagic fevers (Ebola, Marburg), Flaviviruses. Oncogenic viruses, diagnostic virology: virus isolation (cell culture), serology, molecular diagnosis, and rapid antigen detection tests. Viral chemotherapy: mechanisms and resistance, Recent advances in the development of antiviral vaccines. **Exercise/Activity:** Seminar on viral outbreaks and pandemic preparedness, inquiry training, extempore of recent pathogenic events, Student-generated test questions.	**CLO3**
Unit IV **11 Hours**	**Pathogenic fungi, parasitology & infection control:** morphological characteristics, pathogenesis, and laboratory diagnosis of the following pathogenic fungi: superficial, cutaneous, subcutaneous, and systemic mycoses; opportunistic fungal infections, *Candida albicans* and *Candida auris, Cryptococcus neoformans, Aspergillus, dermatophytes, and mucormycosis* agents *(Rhizopus and Mucor). Diagnosis:* KOH mount, culture, antigen tests, molecular tests, antifungal agents, and resistance. **Protozoal Pathogens:** General description, life cycle, pathogenesis, diagnosis, and treatment of diseases caused by protozoa: Entamoeba histolytica, Giardia, and Trichomonas; Hemoprotozoa: Plasmodium, Leishmania, and Trypanosoma; Helminths: Taenia, Ascaris, Ancylostoma, and Wuchereria. Diagnosis: microscopy, antigen tests, serology, molecular methods. **Exercise:** Case Studies, Discussions and Group Learning,	**CLO4, CLO5**

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 (2023) *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.
14. Ananthanarayan and Paniker (2022). Textbook of Microbiology, Universities Press.
15. Greenwood, D., Slack, R., and Peutherer, J. (2018). Medical Microbiology, Churchill Livingstone.
16. Bailey & Scott (2022). Diagnostic Microbiology, Elsevier.
17. Koneman, E.W. (2017). Color Atlas and Textbook of Diagnostic Microbiology, Lippincott.
18. Mandell, Douglas and Bennett (latest edition). Principles and Practice of Infectious Diseases (Reference).

Web Sources

https://www.cdc.gov/ https://www.who./
ICMR antimicrobial resistance surveillance reports
NPTEL / SWAYAM Medical Microbiology modules

Modes of transaction

-Lecture with clinical case examples
-Problem based learning and case discussion solving
-Self-Learning, research paper presentation
-Inquiry training
-Co-operative learning
- Demonstration of diagnostic algorithms
-Visit to clinical microbiology lab/hospital (optional)
-Team teaching
-Co-Instructor Model

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**	**Classical Genetics, Extensions of Mendelian Principles and Population Genetics:** Mendelian concepts, laws & Principles**,** dominance, segregation, independent assortment, Allele, multiple alleles, pseudoallele, complementation tests & allelism. Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex-influenced characters. **Population Genetics:** Hardy-Weinberg equilibrium and assumptions, Allele/genotype frequency calculations, Genetic drift, selection, mutation, gene flow, Founder effect and bottleneck effect **Exercise:** Making self-pedigree tree and family history, numerical based on Mendelian laws and Hardy-Weinberg equilibrium.	**CLO 1**
Unit II **12 Hours**	**Gene Mapping, Cytoplasmic Inheritance, and Quantitative Genetics:** Linkage maps & recombination frequency, tetrad analysis in *Neurospora*, mapping with molecular markers, development of mapping populations in plants. **Extra-chromosomal inheritance:** Chloroplast, cytoplasmic, and mitochondrial inheritance. **Quantitative Genetics:** Polygenic inheritance, heritability, its measurements, and QTL mapping. **Human Genetics:** Pedigree analysis, LOD score for linkage testing, karyotypes, molecular basis of genetic disorder and diagnosis, autosomal disorders, and sex-linked disorders, and BRCA1 and BRCA2 mutations. Genetic diagnosis: PCR-based testing, sequencing overview, prenatal diagnosis, ethical issues, and genetic counseling basics. **Exercise:** Experiments, quizzes, research paper presentations, case-based discussions, and panel discussions on inherited diseases.	**CLO 2/** **CLO 3**

Unit III **11 Hours**	**Molecular basis of Mutations:** Types of mutations: point, frameshift, nonsense, missense, silent, Spontaneous vs induced mutations, Chemical and physical mutagens, Mutant types: lethal, conditional, biochemical, Loss-of-function vs gain-of-function mutations, Germinal vs somatic mutations, Insertional mutagenesis and transposon mutagenesis, Forward genetics vs reverse genetics approaches**.** Chromosomal Alterations: Structural changes: deletion, duplication, inversion, translocation, Numerical changes: aneuploidy, polyploidy, Genetic consequences and clinical significance. **Exercise:** Problem-based learning on mutation/repair case studies.	**CLO 3**
Unit IV **12 Hours**	**Microbial Genetics**: Microbes as tools for genetic studies. Organization of genetic material in bacteria and viruses, Gene transfer mechanisms; **Horizontal gene transfer:** Natural transformation and competence (Gram + and Gram –), conjugation and transduction. Lambda phage: structure, genetic makeup and life cycle (lytic and lysogeny); Mobile genetic elements: plasmids, transposons, integrons, Antibiotic resistance gene transfer and microbial evolution. **Exercise:** Research paper presentation, Problem based learning sessions, Class quiz. Case-based discussions (HGT, MDR evolution, cancer genetics)	**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 G.B., Mason K.A., Losos J.B., Singer S.S. (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-singlegene-disorder
https://www.biointeractive.org/classroom-resources/analyzing-pedigrees

Modes of transaction

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

Tools used

Videos, Google Drive

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:

CLO1: Explain microbial diversity and ecological interactions in air, soil, and aquatic ecosystems.

CLO2: Describe the role of microorganisms in biogeochemical cycles and ecosystem functioning.

CLO3: Evaluate microbial processes involved in water quality, wastewater treatment, and public health.

CLO4: Apply microbial approaches in bioremediation and management of pollutants.
CLO5: Interpret environmental monitoring data using microbiological and molecular tools.

Course Contents

Unit/Hours	Content	Mapping with CLOs
Unit I **10 Hours**	**Environmental Niches and Microbial Ecology:** Concept and scope of environmental microbiology, Microbial habitats: soil, water, air, extreme environments, Microbial diversity: bacteria, archaea, fungi, algae, protozoa in ecosystems; Microbial interactions: mutualism, commensalism, parasitism, competition, syntrophy; Microbial communities and biofilms: formation, structure, and significance. Factors influencing microbial distribution: temperature, pH, nutrients, oxygen, salinity **Exercise/Activity:** Case discussion on microbial communities in extreme habitats. Short quizzes, · Concept mapping and classroom discussion	**CLO 1**
Unit II 12 Hours	**Microorganisms in Biogeochemical Cycles:** Concept of nutrient cycling and microbial contribution, Carbon cycle: decomposition, methanogenesis, methane oxidation; Nitrogen cycle: nitrogen fixation, nitrification, denitrification, anammox; Sulfur cycle: sulfate reduction, sulfur oxidation, microbial sulfur metabolism; Phosphorus cycle and microbial solubilization: Microbial role in mineralization and humus formation. Microbial indicators of ecosystem health. **Exercise/Activity:** Diagram-based learning and cycle mapping. Short assignments on ecosystem case examples.	**CLO 2**
Unit III 12 Hours	**Water Microbiology and Wastewater Treatment:** Microbiology of freshwater and marine environments, Waterborne risk to human pathogens and microbial contamination sources, Indicator organisms: coliforms, fecal coliforms, enterococci, Water quality standards and microbial risk assessment. Drinking water disinfection and purification: antimicrobial agents, filtration, chlorination, ozonation, and UV treatment. Wastewater characteristics: BOD, COD, DO, oxygen sag curve, Sewage microbiology, Wastewater treatment processes: Primary treatment, Secondary treatment (activated sludge, trickling filters, oxidation ponds), Anaerobic digestion and biogas production, and tertiary treatment and nutrients removal, Removal of volatile organic matter, Bioaccumulation/biosorption of heavy metals from industrial effluents. **Exercise/Activity:** Numerical problems on BOD/COD and interpretation of oxygen sag curve.	**CLO 3**

Unit IV 11 Hours	**Bioremediation, Pollution and Environmental Monitoring:** Types of environmental pollution: air, soil, water, Xenobiotics: pesticides, organophosphates and organohalides compounds, hydrocarbons, plastics, heavy metals, bioconcentration, biomagnification, biotransformation and biodegradation. Microbial degradation of hydrocarbons and industrial pollutants, Bioremediation strategies: Natural attenuation, Bioaugmentation, Biostimulation, Phytoremediation and rhizoremediation. Biosorption and bioaccumulation of heavy metals, **Microbial toxicology:** General chemistry of pollutants, PM, PAHs, fog, smog, acid rain, Dose-response relationship and determination of LD50, Ames test, genotoxicity, Microbial tolerance and resistance to heavy metals, antibiotics, pesticides. Environmental monitoring tools: Culture-based methods, Molecular tools (PCR, metagenomics overview), Biosensors and microbial indicators, Environmental impact assessment (EIA) and biosafety issues of GMOs. **Exercise/Activity:** Group presentation on a real bioremediation case study, Research paper discussion and case-based learning, One-minute concept presentation and quizzes	**CLO 4, CLO5**

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 (2007). *A Manual of Environmental Microbiology*. 2nd Edition. ASM Publications.
6. Mitchell, R. and Gu, J.D. (2010). Environmental Microbiology. Wiley-Blackwell.
7. Ian Pepper, Charles Gerba, Terry Gentry (2015) *Environmental Microbiology* 3rd Edition; Academic Press.
8. N.S. Subba Rao. N.S. (2020). *Bio-fertilizers in Agriculture and Forestry*. CBS Publisher and Distributor.
9. Buckley R. G. (2019) Environmental Microbiology, CBS publication
10. Atlas, R.M. and Bartha, R. (2018). Microbial Ecology: Fundamentals and Applications. Pearson
11. Dubey, R.C. (2020). A Textbook of Environmental Microbiology. S. Chand.

Web Sources:

https://swayam.gov.in/

WHO Water Quality Guidelines

CDC Environmental Health resources

US EPA microbial water standards

Central Pollution Control Board

Modes of transaction:

-Lecture

-Demonstration

-Lecture cum demonstration

-Inquiry training

-Group discussion

-Field visits

-Co-Instructor Model

L	T	P	Credits
3	0	0	3

Course Code: MMIC.536 Course Title: Food Microbiology
Total Hours: 45

Course Learning Outcomes (CLO):

The students will be able to:

The student will able to

CLO 1: Learn the principles and scope microorganism food industry and in food systems
CLO 2: Analyze microbial growth, survival, and death in foods under intrinsic, extrinsic, and implicit factors
CLO 3: Describe methods for detection and control of microorganisms, including thermal death parameters (D, Z, F values)
CLO 4: Identify major foodborne pathogens and toxins and explain their mechanisms of pathogenicity and transmission
CLO 5: Explain fermentation processes and their applications in traditional and industrial foods and microbial diversity
CLO 6: Evaluate physical, chemical, and biological methods for controlling microorganisms, and food safety systems (HACCP, GMP) and regulatory frameworks, including FSSAI

Course Contents

Unit/Hours	Content	Mapping with CLOs
Unit I **11 Hours**	**Fundamentals of Food Microbiology and Microbial Behavior** Food Microbiology: Past and Present; Microbial growth, survival, and death in foods; Classical microbiology and its limitations in microbial detection; Factors influencing microbial growth: intrinsic, extrinsic, implicit factors; Spores and their significance; Detection and enumeration of microbes in food; Rapid and automated microbial methods; Physical and chemical destruction of microorganisms; Thermal death concepts: D-value, Z-value, F-value. **Exercise**: Problem-based learning, quizzes, critical thinking exercises, brainstorming sessions, student presentations, and literature survey of recent research articles	**CLO 1** **CLO 2**
Unit II 13 Hours	**Foodborne Pathogens, Toxins and Spoilage** Foodborne bacteria and illnesses: *Bacillus cereus, Campylobacter* sp.*, Clostridium botulinum, Clostridium perfringens,* Shiga toxin-producing *Escherichia coli, Listeria monocytogenes, Salmonella* sp.*, Shigella* sp.*, Staphylococcus aureus, Vibrio* sp.*, Yersinia enterocolitica*; Foodborne Fungi and Mycotoxins- Major mycotoxin producers (e.g., *Aspergillus*, *Fusarium*, *Penicillium*); Types of mycotoxins (aflatoxins, ochratoxins, etc.); Health impacts and control strategies; Microbial spoilage of foods- Spoilage microorganisms in different food systems, Biochemical mechanisms of spoilage, Shelf-life and quality deterioration. **Exercise**: Problem-based learning, quizzes, critical thinking exercises, brainstorming sessions, student presentations, and literature survey of recent research articles	**CLO 3** **CLO 4**

Unit III **11 Hours**	**Fermented Foods and Microbial Diversity** Ethnic fermented foods and beverages of India; Ethnic fermented foods and beverages of the world; Ethno-microbiology concept - Types of fermentation: spontaneous, back-slopping, starter culture; Microbiome assembly in fermented foods; Techniques to study microbial diversity; Denaturant gradient gel electrophoresis/temperature gradient gel electrophoresis (DGGE/TGGE); Meta-omics approaches; High-throughput sequencing (HTS); 16S/18S/ITS amplicon sequencing; Metagenomics; Genome-resolved metagenomics; Metagenome-assembled genomes (MAGs); Pangenomics. **Exercise**: Problem-based learning, quizzes, critical thinking exercises, brainstorming sessions, student presentations, and literature survey of recent research articles.	**CLO 5**
Unit IV **10 Hours**	**Control of Microorganisms and Food Regulatory Systems** Chemical antimicrobials; Biologically based preservation and probiotics; Antimicrobials from lactic acid bacteria (LAB); Physical methods of food preservation; Non-thermal processing technologies; Food Safety Systems & Regulatory Frameworks: International regulatory bodies (FDA, USDA, CDC); national authority (FSSAI); food safety laws (FSMA); probiotic guidelines (ICMR-DBT); food safety management systems (HACCP, GMP) and their implementation. Concepts of prebiotics, synbiotics and paraprobiotics. **Exercise**: Problem-based learning, quizzes, critical thinking exercises, brainstorming sessions, student presentations, and literature survey of recent research articles.	**6**

Suggested Reading:

1. Matthews, K. R., Kniel, K. E., & Critzer, F. J. (2025). *Food microbiology: an introduction*. John Wiley & Sons.
2. Ray, B. and Bhunia, A. (2013). *Fundamental Food Microbiology*, 5th revised edition. CRC press Inc.
3. Frazier, W.C. and Westhoff, D.C. (2013). *Food Microbiology*. 5th Ed. Tata McGraw Hill.
4. Doyle, M.P. and Buchanan, R.L. (2012). *Food Microbiology*, ASM Press, Washington.
5. Jay, J.M., Loessner, M.J. and Golden, D.A. (2005) *Modern Food Microbiology*, 7th ed. Springer-Verlag New York

6. Richard K. Robinson, (2002) *Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products*, Wiley-Blackwell; 3rd Edition.
7. Foster W.M (2020) Food Microbiology CBS publications
8. Doyle, M. P. and Beuchat, L. R., (2007) *Food Microbiology- Fundamentals and Frontiers*, ASM Press.
9. Elmer H. Marth, James Steele, (2001) *Applied Dairy Microbiology*, Second Edition, CRC Press.
10. Tamang, J.P., (2015) *Health Benefits of Fermented Foods and Beverages*. CRC Press.
11. Tamang, J.P., (2016) *Ethnic Fermented Foods and Alcoholic Beverages of Asia*. Springer.
12. Tamang, J.P., (2020) *Ethnic Fermented Foods and Beverages of India: Science History and Culture*. Springer.
13. Cocolin, L., & Ercolini, D. (Eds.). (2007). Molecular Techniques in the Microbial Ecology of Fermented Foods. Springer Science & Business Media.
14. Louw, N. L., Lele, K., Ye, R., Edwards, C. B., & Wolfe, B. E. (2023). Microbiome assembly in fermented foods. *Annual Review of Microbiology,* 77(1), 381-402.
15. Yap, Min, Danilo Ercolini, Avelino Álvarez-Ordóñez, Paul W. O'Toole, Orla O'Sullivan, and Paul D. Cotter. "Next-generation food research: use of meta-omic approaches for characterizing microbial communities along the food chain." *Annual Review of Food Science and Technology* 13, no. 1 (2022): 361-384.

Modes of transaction:

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

L	T	P	Credits
0	0	6	3

Course Code: MMIC.528, Practical-II
Course Title: Microbiology
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 Medical Microbiology 30 Hours	1. Double immunodiffusion test using specific antibody and antigen. 2. To perform immunoelectrophoresis using specific antibodies and antigen. 3. Dot Immunoblot assay (DIBA). 4. ELISA 5. Polyacrylamide gel electrophoresis and Western blotting. 6. Demonstration of Flow Cytometry. 7. Immunohistochemistry: H & E staining, Fluorescent staining. To perform Total Leukocyte Count/Differential Leukocyte count of the given blood sample. 8.Separation of serum from blood. 9. To isolate mononuclear cells from peripheral blood various lysis and separation methods. 10. Lymphocyte proliferation assay. 11. Study of normal micro-biota of mouth; isolation, identification of normal micro-biota of skin; and preservation of microorganisms 12. Identification and Biochemical tests of respiratory tract bacterial pathogen using avirulent strain of MTCC Culture of Streptococci/ *Klebsiella pneumoniae*; gastrointestinal bacterial infection using avirulent strain of MTCC Culture of *Salmonella*/ *Shigella* spp. 13. Laboratory examination and identification and biochemical tests of pus specimens using avirulent strain of MTCC Culture for *Staphylococcus aureus*, *Streptococcus pyogenes* and *Pseudomonas aeruginosa*. 14. 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. 15. Determination of MIC values for antimicrobial chemicals 16. Biochemical, enzymatic and serological tests (Coagulase, Catalase, WIDAL, VDRL tests).	**CLO 1 CLO2 CLO3**

Part B. Molecular Biology and Genetics 30 Hours	1. Isolation of genomic DNA 2. DNA amplification by Polymerase Chain Reaction (PCR). 3. Preparation of competent cells, ligation and E.coli chemical transformation, plating, colony selection, trans conjugation and transduction of DNA 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. Learning the genetic basis of blood group typing. 9. Identification of inactivated X chromosome as Barr body and drumstick 10. To demonstrate and understand the principle of Hardy-Weinberg equilibrium. Calculation of genotypic and allelic frequencies for a specific trait in a random sample. 11. Techniques for screening and isolation of bacterial cultures with specific phenotypic/genotypic characteristics. 12. Differentiating genetic variants (species/strains) using RFLP. 13. Studying *Drosophila melanogaster* as a Model organism: Identification of normal and mutant flies (*Drosophila melanogaster*), Demonstration of Drosophila polytene chromosomes.	**CLO 1** **CLO2** **CLO3**
Part C. Environmental Microbiology 30 Hours	1. Physical analysis of sewage/industrial effluent by measuring total solids, total dissolved solids and total suspended solids. 2. Determination of indices of pollution by measuring BOD/COD of different effluents. 3. Bacterial reduction of nitrate from ground waters 4. Isolation and purification of degradative plasmid of microbes growing in polluted environments. 5. Recovery of toxic metal ions of an industrial effluent by immobilized cells. 6. Utilization of microbial consortium for the treatment of solid waste [Municipal Solid Waste]. 7. Biotransformation of toxic chromium (+ 6) into non-toxic (+ 3) by *Pseudomonas* species. 8. Tests for the microbial degradation products of aromatic hydrocarbons /aromatic compounds.	**CLO4** **CLO5**

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./

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 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 wi CLOs
Unit I **7 Hours**	**Introduction to Microbiology:** Scope and history Microbiology, Classification of Bacteria, Fungi, Protozo Algae, and viruses. **Basic principles and techniques us in bacterial classification.** Phylogenetic and numeric taxonomy. General characteristics, structure a classification of plant animal and bacterial viruses. **Exercise:** Spontaneous quiz on identification microorganism based on given characteristic	**CLO 1**
Unit II **8 Hours**	**Microbial Growth, and Nutrition:** Microbial growt Bacterial generation time. Monoauxic, Diauxic a synchronized growth curves. Factors affecting microb growth. Principles of microbial nutrition- Chemoautotroph chemo-heterotrophs, photoautotrophs and phot heterotrophs. Types of growth media, pure culture metho Culture maintenance and preservation **Exercise:** Data Interpretation of different growth curv classifying microorganism based on nutrition requirements	**CLO 2**
Unit III **8 Hours**	**Pathogens:** Medically important bacteria. Retrovirus Viroids, Prions and emerging viruses such as HIV, Avian a swine flu viruses and SARS-CoV-2. Medically importa fungi and protozoans. **Beneficial applications of microbe** Human Microflora, Pre and Probiotics, Industria important microbes. **Exercise:** Group wise discussion on therapeutic approach against pathogenic microorganism	**CLO 3**
Unit IV **7 Hours**	**Control of Microorganism:** Control of Microorganism physical and chemical agents. Narrow and broad-spectru antibiotics, Mode of action of Antimicrobial agen Antibiotic resistance mechanisms. **Exercise:** Case studies and hands-on experiments.	**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)

Total Hours: **30**

Course Learning Outcomes:

The students will be able to:

CLO 1: Develop 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	**Function of immune system:** Discriminate between self and non-self. A functional immune system confers a state of health through effective elimination of infectious agents (bacteria, viruses, fungi, and parasites) and through control of malignancies by protective immune surveillance. **Exercise:** Panel discussion about evasion mechanism employed by pathogens	**CLO 2**
Unit III 7 Hours	**Immunodeficiency and dysfunction as the basis of disease**: Immune Deficiency and Immune dysfunction. Allergies, Types of hypersensitivity reactions. Immunity to microbes (bacteria, fungi, virus and protozoans), tumors and AIDS. **Exercise:** Case studies on immune disorders, Presentations	**CLO 3**
Unit IV 8 Hours	**Immunological Processes and Therapeutics:** Hybridoma technology and vaccine, natural, synthetic and genetic, development of vaccine. Methods for immunoglobulin determination-quantitative and qualitative antigen and antibody reactions, agglutination-precipitation, immunofluorescence ELISA and Flow cytometry. **Exercise:** Problems on data interpretation for ELISA, Flow Cytometry, antigen-antibody reactions	**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

L	T	P	Credits
2	0	0	2

Course Code: MMIC. 508
Course Title: Microbiology in the Indian Scenario (IDC)
Total Hours: 30

Course Learning Outcomes:

The students will be able to:
CLO 1: Describe early concepts of microorganisms and health in ancient Indian knowledge systems
CLO 2: Analyze the contributions of key Indian microbiologists in shaping microbiological science
CLO 3: Summarize the development of microbiology education, research institutions, and scientific
CLO 4: Explain key applications of microbiology in healthcare, agriculture, and food systems
CLO 5: Evaluate the role of microbiology in sustainable development and emerging research areas in India

Unit 1 (5 hours)	**Microbiology in Ancient Indian Knowledge Systems:** Microbiology in Indian Vedic Knowledge, Ancient Bacteriology, History of development of microbiological science in ancient India to modern India.	**CLO1**
Unit 2 (5 hours)	**The torch bearers of Indian Microbiology** Contribution of Indian scientists to Microbiology in the pre-independence and post-independence.	**CLO2**

Unit 3 (10 hours	**Microbiology Education and Research in India** First colleges and universities in India which started teaching Microbiology as a separate subject, Microbiological societies and associations, Indian journals in Microbiology, Indian patents in Microbiology, Microbial Culture Collections in India	**CLO3**
Unit 4 (12 hours)	**Applications and Progress of Microbiology in India** Latest trends and researches or Microbiology in India, Recent Developments in the Basic Research, Diagnostics and Vaccines, Role of Microbiology for Sustainable Development in India, "Ethno-microbiology" of ethnic Indian fermented foods and alcoholic beverages, Indian gut microbiome.	**CLO4 CLO5**

Suggested Readings

1. Lal, R., Singh, B., Sar, P., & Phale, P. (2022). Microbiology in India: status, challenges and scope. *Environmental Microbiology*, 24(6), 2607-2611.
2. Kuhad, U., Goel, G., Maurya, P. K., & Kuhad, R. C. (2021). Sukshmjeevanu in Vedas: The forgotten past of microbiology in Indian vedic knowledge. Indian *Journal of Microbiology*, 61, 108-110.
3. Kaur, H., & Gupta, B. M. (2009). Indian contribution in Immunology and Microbiology 1999–2008: A scientometric analysis. DESIDOC *Journal of Library & Information Technology*, 29(5), 36-43.
4. Dhawan, P., & Gupta, V. (2024). Role of Microbiology for Sustainable Development in India. In Role of Science and Technology for Sustainable Future: Volume 1: Sustainable Development: A Primary Goal (pp. 119-132). Singapore: Springer Nature Singapore.
5. Singh, S. K. (2021). Microbial Culture Collections in India: Historical Perspectives and Future Prospects. Progress in Mycology: An Indian Perspective, 143-160.
6. Mukherjee, S., Sain, S., Ali, M. N., Goswami, R., Chakraborty, A., Ray, K., & Chatterjee, G. (2022). Microbiological properties of Beejamrit, an ancient Indian traditional knowledge, uncover a dynamic plant beneficial microbial network. *World Journal of Microbiology and Biotechnology, 38(7), 111.*
7. Tamang, J. P. (2022). "Ethno-microbiology" of ethnic Indian fermented foods and alcoholic beverages. *Journal of Applied Microbiology*, 133(1), 145-161.

Web Sources:

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

Modes of transaction

-Lecture
-Problem Solving
-Inquiry training
-Team teaching

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 *In-vitro* 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.	**CLO4**

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	40	20

Course Code: MMIC.599.1 **Total Hours: 600**

Course Title: Dissertation Part I

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