Scheme and Syllabus of Examination

University Teaching Department

(w.e.f. 2025-26 onwards)

M.Sc. Microbiology

BASED ON

National Education Policy (NEP)- 2020

Department of Biotechnology

Guru Jambheshwar University of Science & Technology, Hisar-125 001, Haryana

MSc Microbiology

Semester-I						
Sr. No.	**Course Code**	**Title**	**Type**	**L**	**P**	**Credit**
1	U25MMI101T	Principles of Microbiology	DSC-1	4		4
2	U25MMI102T	Principles of Biochemistry	DSC-2	4		4
3	U25MMI103T	Microbial Physiology and Metabolism	DSC-3	4		4
4	U25MMI111T	Microbial Genetics	DEC -1	4		4
5	U25MMI104P	Biochemistry Lab	DSC-4		6	3
6	U25MMI105P	Microbiology Lab	DSC -5		6	3
7		To be opted from the pool of VAC	VAC			2
					Total	**24**
Semester-II						
1	U25MMI201T	Molecular Biology	DSC-6	4		4
2	U25MMI202T	Immunology	DSC -7	4		4
3	U25MMI203T	Industrial Microbiology	DSC -8	4		4
4	U25MMI211T	Instrumentation Techniques	DEC -2	4		4
5	U25MMI204P	Industrial Microbiology Lab	DSC-9		6	3
6	U25MMI205P	Immunology & Instrumentation Techniques Lab	DSC-10		6	3
7	U25MMI201S	Seminar	S-1	2		2
8	U25MMI201I	Internship*				4
					Total	**28**
***Internship of 4 credits of 4 weeks (120 Hrs.) duration after 2nd semester is mandatory for each student either for enhancing the employability or for developing research aptitude**						
Semester-III						
1	U25MMI301T	Recombinant DNA Technology	DSC-11	4		4
2	U25MMI302T	Microbial Enzyme Technology	DSC-12	4		4
3	U25MMI303T	Food Microbiology	DSC-13	4		4
4	U25MMI311T	Bioinformatics	DEC -3	4		4
5		To be opted from the pool of OEC	OEC			**2**
6	U25MMI304P	Recombinant DNA Technology and Bioinformatics Lab	DSC-14		6	3
7	U25MMI305P	Food Microbiology and Enzyme Technology Lab	DSC-15		6	3
					Total	**24**
Semester-IV						
1	U25MMI401T	Soil and Environmental Microbiology	DSC-16	4		4
2	U25MMI402T	Plant-microbe Interactions	DSC-17	4		4
3	U25MMI403T	Nano particles in Microorganisms and biosystems	DSC-18	4		4
4	U25MMI411T	Medical Microbiology	DEC -4	4		4
5	U25MMI404P	Soil and Environmental microbiology Lab	DSC-19		6	3
6	U25MMI405P	Nanoparticles in Microorganisms and medical Microbiology Lab	DSC-20		6	3
7		To be opted from the pool of SEC	SEC	2		2
					Total	**24**

OR

Semester-IV: Scheme of Semester IV when a student opts for Dissertation Work or Project Work

Sr. No.	Course Code	Title	Type	L	P	Credit
1	U25MMI401T	Soil and Environmental Microbiology	DSC-16	4		4
2	U25MMI411T	Medical Microbiology	DEC -4	4		4
3		To be opted from the pool of SEC	SEC	2		2
4		To be opted from the pool of EEC	EEC	2		2
5	U25MMI401D	**Dissertation work/ Project work**	DW/PW		12	12
					Total	24

List of VAC, OEC, SEC & EEC offered by Microbiology

Sr. No.	Course Code	Title	Type	L	P	Credit
1.	U25VAC130T	Environmental Microbiology	VAC	2		2
2.	U25OEC330T	Principles of Nano Science and Technology	OEC	2		2
3.	U25SEC430T/ U25SEC404T	Bio-entrepreneurship, Intellectual Property Rights & Biosafety	SEC	2		2
4.	U25EEC430T/ U25EEC404T	Research methodology	EEC	2		2

SEMESTER I

U25MMI101T: PRINCIPLES OF MICROBIOLOGY

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce fundamental concepts and historical developments in microbiology and microbial cell structure.*
- *To provide a comprehensive understanding of microbial diversity, taxonomy, and classification systems.*
- *To explain principles of microbial growth, nutrition, and methods of culturing and preserving microbes.*
- *To familiarize students with methods of microbial control and key features of viruses and viral diseases*

COURSE OUTCOMES

- *Describe microbial cell structures and classify major groups of microorganisms based on their characteristics.*
- *Distinguish microbial taxa using traditional and modern classification approaches, including extremophiles and unculturable microbes.*
- *Analyze microbial growth patterns and nutritional types, and demonstrate methods for culture maintenance.*
- *Evaluate microbial control strategies and viral replication mechanisms, including emerging viral threats.*

UNIT I [15 Lectures]

Introduction to Microbiology: Introduction to microbiology and microorganisms, Historical development and scope of Microbiology, Ubiquitous nature of microorganisms, Impact of microorganisms on human life, Structure of prokaryotic and eukaryotic cell, Differences between Eubacteria, Archaebacteria and Eukaryotes, Salient features of different groups of microorganisms such as bacteria, fungi, protozoa and algae including their morphological features, mode of reproduction and cell cycle.

UNIT II [15 Lectures]

Microbial Diversity and Classification: Microbial taxonomy and evolution of diversity, Classification of microorganisms, criteria for classification, New approaches of bacterial classification, Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore-forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, thermophiles and unculturable microbes; Eukaryotes: algae, fungi and protozoa.

UNIT III [15 Lectures]

Microbial Growth & Nutrition: The definition of microbial growth, Growth in batch culture, Mathematical representation of bacterial growth, Bacterial generation time, Specific growth rate, Monoauxic, Diauxic and synchronized growth curves, Measurement of microbial growth, Factors affecting microbial growth. Culture collection and maintenance of microbial cultures, Principles of microbial nutrition- Chemoautotrophs, chemoheterotrophs, photoautotrophs and photoheterotrophs.

UNIT IV [15 Lectures]

Control of Microorganisms: Control of Microorganisms by physical and chemical agents- Antiseptics and disinfectants, Narrow and broad-spectrum antibiotics, Antifungal drugs, Mode of action of antimicrobial agents; Antibiotic resistance mechanisms.

Viruses: General characteristics, structure, and classification of plant, animal and bacterial viruses,

Replication of viruses- Lytic and lysogenic cycle in bacteriophages. A Brief account of Retroviruses, Viroids, Prions and viruses including HIV, SARS, Avian flu, Swine flu, Ebola, COVID-19.

Recommended Textbooks and References:

1. *Pelczar, M.J., Reid, R.D. & Chan, E. C. Microbiology (5th Ed.). New York: McGraw-Hill. 2001.*
2. *Matthai, W., Berg, C.Y. & Black, J.G. Microbiology, Principles and Explorations. Boston, MA: John Wiley & Son. 2005.*
3. *Willey, J.M., Sherwood, L., Woolverton, C.J., Prescott, L.M. & Willey, J.M., Prescott's Microbiology. New York: McGraw-Hill. 2011.*
4. *Madigan, MT, Bender, K.S., Buckley, D.H., Sattley, W. M. & Stahl, D.A., Brock Biology of Microorganisms (15th Ed.). Pearson/ Benjamin Cummings. 2018.*
5. *Pommerville, J.C., Alcamo's Fundamentals of Microbiology (10th Ed.) Jones and Bartlett Learning. 2013.*
6. *Sequeira, M., Kapoor, K.K., Yadav, K.S. & Tauro, P., An Introduction to Microbiology (3rd Ed.). New Age International Publishers. 2019.*

U25MMI102T: PRINCIPLES OF BIOCHEMISTRY

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce the chemical and structural foundations of biomolecules essential for life.*
- *To provide an overview of the major metabolic pathways and their regulation.*
- *To develop an understanding of biomolecular structure-function relationships and interactions.*
- *To explore the roles of coenzymes and vitamins in metabolism and physiological processes.*

COURSE OUTCOMES

- *Explain the structure and functions of biomolecules and their role in life processes.*
- *Analyze metabolic pathways of carbohydrates, proteins, lipids, and nucleotides.*
- *Apply concepts of biomolecular interactions and metabolic integration.*
- *Evaluate regulatory mechanisms and biochemical roles of vitamins and coenzymes*

UNIT I [15 Lecture]

Chemical Basis of Life: Chemical basis of life: Miller-Urey experiment, Abiotic formation of amino acid oligomers, Composition of living matter; Water – properties of water, Essential role of water for life on earth.

Biomolecules: An introduction, General structure and Important features of biomolecules, Fundamental principles governing structure of biomolecules, Importance of covalent and non-covalent bonds.

Glycobiology: Structure and function of biologically important mono, di and poly-saccharides, glycoproteins and glycolipids. Stereoisomers, Epimers, Anomers and mutarotation. Metabolism of Carbohydrates-Glycolysis, Feeder pathways, Anaplerotic and Cataplerotic reactions, Citric acid cycle, Gluconeogenesis and their regulations, Glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, Role of epinephrine, glucagon and insulin in glycogen metabolism; Glyoxylate cycle and Pentose phosphate pathways.

UNIT II [15 Lecture]

Structure and Functions of Proteins: Structure and Classification of amino acids, Structural organization of proteins, Forces stabilizing protein structure, Ramachandran plot, Structure-function relationships in some model proteins like haemoglobin and chymotrypsin. Protein folding: Anfinsen's Dogma, Levinthal paradox, Cooperativity in protein folding

Amino acid metabolism: A brief account of amino acid biosynthesis and degradation, Urea cycle and its regulation. Chemical synthesis of peptides and small proteins. Protein sequencing by Edman's Degradation technique

UNIT III [15 Lecture]

Structure and Functions of Lipids: Structure of fatty acids, Classification of lipids, Structure and functions of major lipid subclasses- Acylglycerols, Phospholipids, Glycolipids, Sphingolipids, Waxes, Terpenes and Sterols.

Lipid Metabolism: Fatty acids biosynthesis (saturated and unsaturated) and its regulations, Fatty acid degradation (Both odd and even carbon fatty acids) with regulations, Ketone bodies synthesis and Breakdown. Biosynthesis of TAG, Phospholipids and Glycolipids. Overview of Mevalonate pathway.

UNIT IV [15 Lecture]

Structure and Metabolism of Nucleic acids: Structure of purines, pyrimidines, nucleosides and nucleotides. Structure, types and biological role of RNA and DNA. Different forms of DNA, Forces stabilizing nucleic acid structure Properties of DNA: UV absorption and Hyperchromicity, Tm, Denaturation of DNA. De novo synthesis and degradation of purines and pyrimidines, Role of ribonucleotide reductases, Salvage pathway.

Central Metabolism: Logic and integration of central metabolism; Entry/ exit of various biomolecules from central pathways; Principles of metabolic regulation; Steps for regulation.

Vitamins and Coenzymes: Structure and biochemical roles of fat and water-soluble vitamins and their coenzymes

Recommended Textbooks and References:

1. *Stryer, L. (2019). Biochemistry. (9th ed.) New York: Freeman.*
2. *Lehninger, A. L. (2021). Principles of Biochemistry (8th ed.). New York, NY: Worth.*
3. *Voet, D., & Voet, J. G. (2018). Biochemistry (5th ed.). Hoboken, NJ: J. Wiley & Sons.*
4. *Dobson, C. M. (2003). Protein Folding and Misfolding. Nature, 426(6968), 884-890.doi:10.1038/nature02261.*
5. *Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.*
6. *Appling, D. R., Anthony-Cahill, S. J., & Mathews, C. K. (2018). Biochemistry: Concepts and Connections (2nd ed.). Pearson Education.*
7. *Mathews, C. K., van Holde, K. E., Ahern, K. G., & Fischer, W. M. (2000). Biochemistry (4th ed.). Prentice Hall (Pearson Education).*

U25MMI103T: MICROBIAL PHYSIOLOGY AND METABOLISM

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To impart knowledge of cellular structures and transport mechanisms in prokaryotes and fungi.*
- *To explore the processes and regulatory mechanisms of microbial differentiation and sporulation.*
- *To understand microbial metabolic pathways involved in fermentation, photosynthesis, and energy generation.*
- *To examine aerobic and anaerobic respiration in bacteria, including electron transport and oxidative phosphorylation.*

COURSE OUTCOMES

- *Identify and describe structural and functional components of prokaryotic and fungal cells.*
- *Explain mechanisms of bacterial differentiation and sporulation under varying environmental conditions.*
- *Compare metabolic pathways in diverse microbial groups involved in fermentation and photosynthesis.*
- *Analyze aerobic and anaerobic respiration in bacteria, including electron transport chains and energy generation systems.*

UNIT I [15 Lectures]

Cellular Organization of Microorganisms: Structure, function, biosynthesis and assembly of various cellular components of Prokaryotes- Capsule and slime layers, peptidoglycan, outer membrane, cytoplasmic membrane, flagella, axial filaments, pili and fimbriae, nuclear material, and storage molecules. Bacterial Permeation-Transport of solutes across the membrane. Chemotaxis. Cell cycle of *E. coli,* and Yeast *S. cerevisiae.* Structure of fungal cell.

UNIT II [15 Lectures]

Differentiation in Bacteria: Endospore and cyst-forming bacteria. Molecular architecture of spores, induction and stages of sporulation cycle. Influence of different factors on sporulation. Cytological and macromolecular changes during sporulation. Spore germination and out-growth. Differentiation in *Caulobacter* and myxobacteria. Sporulation in fungi-biochemical and macromolecular changes.

UNIT III [15 Lectures]

Fermentation and Energy Generation: Metabolism of lactic acid bacteria, coliforms, yeast, clostridia, and propionic acid bacteria. Metabolism of methanogens.

Bacterial Photosynthesis: Photosynthetic bacteria, photosynthetic pigments, and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria, Carbon dioxide fixation pathways. Cyanobacterial photosynthesis.

UNIT IV [15 Lectures]

Bacterial Respiration: Bacterial aerobic respiration, components of electron transport chain, free energy changes and electron transport, oxidative phosphorylation and theories of ATP formation, inhibition of electron transport chain. Electron transport

chain in some chemolithotrophic bacteria such as nitrifiers and Sulphur oxidizers. Oxidation of molecular hydrogen by *Hydrogenomonas* species. Bacterial anaerobic respiration- Nitrate and sulphate as electron acceptors. Electron transport chains in some anaerobic bacteria. Catalase, Superoxide dismutase, mechanism of oxygen toxicity.

Recommended Textbooks and References:

1. *Madigan, MT, Bender, K.S., Buckley, D.H., Sattley, W.M. & Stahl, D.A., Brock Biology of Microorganisms (15th Ed.). Pearson/ Benjamin Cummings. 2018.*
2. *Singh, R.P., Microbiology. Kalyani Publisher. 2009.*
3. *Caldwell, D.R., Microbial Physiology and Metabolism, Brown Publishers. 1995.*
4. *Moat, A.G. & Foster, J. W. , Microbial Physiology. Wiley., NY.1999.*
5. *Brun, Y.V. & Shimkets L.J., Prokaryotic Development. ASM Press, Wisconsin. 2000.*
6. *Doelle, H.W., Bacterial Metabolism. Academic Press, NY. 1969.*
7. *Gottschalk, G., Bacterial Metabolism.Springer Verlag, Berlin. 1979.*
8. *Sokatch, J.R., Bacterial Physiology and Metabolism. Academic Press, NY. 1969.*
9. *Srivastava, B., Microbial Physiology and Metabolism, LAP Lambert Academic Publishing, USA. 2011.*
10. *Warner B. Bair, W.R., Tortora, G.J., Funke, B.R., Case, C.L. & Weber, D., Microbiology an Introduction (13th Ed.). Pearson. 2018.*

U25MMI111T: MICROBIAL GENETICS

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	**4**	**30**	**70**	**100**	**3h**
Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.					

COURSE OBJECTIVES

- *To understand the principles of bacterial genetics, including mutation types, mutagenesis techniques, genetic complementation, and gene cloning strategies.*
- *To explore the molecular mechanisms of horizontal gene transfer in bacteria through conjugation, transduction, and transformation, and apply these for genetic mapping.*
- *To examine the regulatory mechanisms of gene expression in bacteriophages, with emphasis on lytic and lysogenic cycles and the genetic control of lysogeny.*
- *To analyze the mechanisms of transposition and operon-based gene regulation, and appreciate the role of model organisms in advancing microbial genetic research.*

COURSE OUTCOMES

- *Analyze bacterial inheritance and mutagenesis by employing mutation detection, complementation, and gene replacement techniques.*
- *Demonstrate gene transfer mechanisms in bacteria and bacteriophages, and construct genetic maps using conjugation, transformation, and transduction.*
- *Interpret the molecular regulation of lytic and lysogenic bacteriophage life cycles, with emphasis on lambda phage gene expression and immunity.*
- *Evaluate transposition mechanisms, gene regulation systems in bacteria, and the utility of model organisms in advanced genetic studies.*

UNIT I [15 Lectures]

Genetic analysis in microbes: Importance and applications of mutation analysis in microbiology. Mechanisms of inheritance in prokaryotes. Types of mutations: spontaneous and induced. Isolation and selection of microbial mutants. Methods of mutant enrichment. Reversions and suppressor mutations. Complementation tests, recombination tests, and gene replacement strategies in bacteria. Gene cloning using complementation and marker rescue in microbial systems.

UNIT II [15 Lectures]

Bacterial gene transfer and genome mapping: Fertility factors in bacteria. Types of plasmids: self-transmissible and mobilizable. Molecular basis and mechanisms of conjugation: roles of genes and proteins. Regulation of conjugation. Hfr strains and their use in chromosomal mapping. Chromosomal transfer via integrated plasmids and prime factors. Transfer systems in Gram-positive bacteria.

Gene transfer via phages and transformation: Lytic phages (T4, T7) – replication and gene regulation. Phage genetics – recombination, complementation, and rII experiments. Natural competence and DNA uptake systems in Gram-positive and Gram-negative bacteria. Regulation of competence in *Bacillus subtilis*. Importance and methods of artificial competence.

Transduction: Generalized and specialized transduction; phages involved (T4, lambda). Bacterial gene mapping via transduction.

UNIT III [15 Lectures]

Lysogenic phages and gene regulation: *Lambda* phage gene and promoter organization. Lytic cycle: regulation of gene expression – early, middle, and late stages. Establishment and maintenance of lysogeny. Regulatory roles of cI, cII, and cIII proteins. Lambda immunity and superinfection exclusion. Induction mechanisms – regulatory roles of cI and cro repressors in the lytic–lysogenic switch.

Bacterial gene regulation: Positive and negative control of gene expression, attenuation mechanisms. Case studies: *lac*, *trp*, *gal*, *ara*, and *tol* operons.

UNIT IV [15 Lectures]

Transposable elements in microbes: Discovery and classes of bacterial transposons. Regulation and consequences of transposition in microbial genomes. Experimental assays: suicide vectors and mating-out assays. Mechanisms of transposition with genetic evidence. Conjugative transposons and their impact. Applications in transposon mutagenesis.

Model microorganisms in genetics: Overview of model systems used in microbial and genetic studies – *Escherichia coli*, *Saccharomyces cerevisiae*, *Caulobacter crescentus*, *Bacillus subtilis*, and applications of these models in functional genomics and gene regulation studies.

Recommended Textbooks and References:

1. *Maloy, S. R., Cronan, J. E., & Freifelder, D. (1994). Microbial Genetics (2nd ed.). Jones & Bartlett Learning.*
2. *Streips, U. N., & Yasbin, R. E. (Eds.). (2002). Modern Microbial Genetics (2nd ed.). Wiley-Liss Publishers.*
3. *Trun, N., & Trempy, J. (2004). Fundamental Bacterial Genetics (1st ed.). Wiley-Blackwell Publishing.*
4. *Snyder, L., Peters, J. E., Henkin, T. M., & Champness, W. (2013). Molecular Genetics of Bacteria (4th ed.). ASM Press.*
5. *Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2021). Brock Biology of Microorganisms (16th ed.). Pearson.*
6. *Willey, J. M., Sandman, K., & Wood, D. (2022). Prescott's Microbiology (11th ed.). McGraw-Hill Education.*

U25MMI104P: BIOCHEMISTRY LAB

Couse Credits	Internal Marks	External Marks	Total Marks	Examination hours
3	25	50	75	4h

COURSE OBJECTIVES

1. *To impart hands-on skills in preparing laboratory solutions and biochemical buffers.*
2. *To develop proficiency in analytical techniques for biomolecule quantification and separation.*
3. *To train students in enzyme purification, characterization, and analysis of kinetic parameters.*
4. *To enable identification and structural analysis of nucleic acids and proteins using experimental tools.*

COURSE OUTCOMES

1. *Prepare laboratory reagents, buffers, and working solutions accurately, and demonstrate understanding of biochemical principles through validation experiments.*
2. *Apply spectroscopic and chromatographic techniques for quantitative analysis and separation of biomolecules.*
3. *Execute multistep enzyme purification protocols and assess enzyme characteristics using kinetic and electrophoretic methods.*
4. *Identify nucleic acids and proteins using experimental evidence, and analyze structural transitions in DNA through denaturation-renaturation studies.*

List of Experiments

1. Preparation of various stock solutions and working solutions.
2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.
3. Extraction and estimation of protein content by Bradford Assay and Lowry Method.
4. Separation and identification of amino acids by paper chromatography.
5. Separation and identification of amino acids /lipids using Thin-Layer Chromatography (TLC).
6. Determination of DNA melting temperature (Tm) and experimental verification of hyperchromicity upon denaturation.
7. Estimation of malondialdehyde (MDA) as a marker of lipid peroxidation.
8. Determination of Na^+, K^+, Ca^{2+} in biological fluids using AAS.
9. Estimation of glucose (GOD-POD) and urea in serum.
10. Estimation of reducing sugars by DNS method.
11. Isolation of casein from milk and its quantification
12. Isolation of gluten and gliadin from wheat.

Recommended Textbooks and References:

1. *Sawhney, S.K. & Singh, R., Introductory Practical Biochemistry, Narosa Publishing House. 2009.*
2. *Plummer, D., An Introduction to Practical Biochemistry (3rd Ed.). McGraw Hill Education.2017.*
3. *Sadasivam, S., Biochemical Method (3rd Ed.). New Age International Pvt Ltd Publishers. 2018.*
4. *Jayaraman, J., Laboratory Manual in Biochemistry. New Age International Private Limited. 2011.*

U25MMI105P: MICROBIOLOGY LAB

Couse Credits	Internal Marks	External Marks	Total Marks	Examination hours
3	25	50	75	4h

COURSE OBJECTIVES

- *To train students in fundamental microbiological techniques and lab safety.*
- *To develop skills in culturing, staining, and identifying microorganisms.*
- *To enable quantitative analysis of microbial growth and antimicrobial effects.*
- *To introduce methods for isolation and preservation of useful microbes.*

COURSE OUTCOMES

- *Demonstrate aseptic techniques, media preparation, and microbial culture handling with appropriate safety measures.*
- *Perform staining, microscopy, and microbial identification using standard microbiological methods.*
- *Analyze bacterial growth patterns, enumerate microbial populations, and interpret antimicrobial sensitivity results.*
- *Isolate, maintain, and assess functional characteristics of beneficial microorganisms such as Rhizobium.*

List of Experiments:

1. Sterilization, disinfection and safety in microbiological laboratory.
2. Media Preparation for cultivation of microorganisms.
3. Isolation of bacteria in pure culture by streak plate method.
4. Study of colony and growth characteristics of some common bacteria: *Bacillus, E. coli, Staphylococcus* etc.
5. Preparation of bacterial smear and Gram's staining
6. Light compound microscope and its handling
7. Microscopic observation of bacteria (Gram +ve bacilli and cocci, Gram –ve bacilli), cyanobacteria, algae, and fungi.
8. Calibrations of microscopic measurements (Ocular, stage micrometers)
9. Measuring dimensions of fungal spores
10. Simple and differential staining (Gram staining).
11. Spore staining, capsule staining and negative staining.
12. Enumeration of bacteria: standard plate count.
13. Growth curve of bacteria in batch culture.
14. Antimicrobial sensitivity test and demonstration of drug resistance.
15. Maintenance of stock cultures: slants, stabs and glycerol stock cultures.
16. Determination of phenol co-efficient of antimicrobial agents.
17. Determination of Minimum Inhibitory Concentration (MIC)
18. Isolation of Rhizobium from root nodules

Recommended Textbooks and References:

1. *Cappuccino, J.G., & Welsh, C., Microbiology: a Laboratory Manual. Benjamin-Cummings Publishing Company. 2016.*
2. *Collins, C.H., Lyne, P.M., Grange, J.M., & Falkinham III, J. Collins and Lyne's Microbiological Methods (8th Ed.). Arnolds. 2004.*
3. *Tille, P.M., Bailey & Scott's Diagnostic Microbiology (14th Ed.). Elsevier. 2017.*
4. *Kapoor, K.K. & Paroda, S., Experimental Soil Microbiology. CBS Publishers. 2007.*
5. *Garg, F.C., Experimental Microbiology. CBS Publishers & Distributors. 2005.*

SEMESTER II

U25MMI201T: MOLECULAR BIOLOGY

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h
Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.					

COURSE OBJECTIVES

- *To introduce the chemical structure and organization of genetic material.*
- *To explain DNA replication, repair, and genome editing mechanisms.*
- *To describe transcription and post-transcriptional regulation processes.*
- *To familiarize students with translation, protein modifications, and DNA-binding motifs*.

COURSE OUTCOMES

- *Explain the structure, properties, and organization of genetic material in prokaryotes and eukaryotes.*
- *Describe DNA replication, repair mechanisms, and genome editing technologies.*
- *Illustrate transcription processes and post-transcriptional regulation in cells.*
- *Analyze translation, post-translational modifications, and DNA-binding protein motifs.*

UNIT I [15 Lecture]

The Nature of Genetic material: Chemical structure and base composition of nucleic acids, Properties of DNA; Forces stabilizing nucleic acid structure; Super coiled DNA; Renaturation and denaturation of DNA. Tm and Cot curves, Structure and types of RNA, Direct and Indirect evidence of DNA and RNA as genetic material; Organization of prokaryotic and eukaryotic genomes-chromatin arrangement, nucleosome formation, satellite DNA.

UNIT II [15 Lecture]

DNA replication: General features of DNA replication, Semi-conservative mode of replication; Prokaryotic and eukaryotic DNA replication: Mechanism of DNA replication, Enzymes and accessory proteins involved, Replication errors, Relationship between DNA replication and cell cycle, DNA copy number maintenance. Replication in phages-Lytic and Lysogenic cycle, Reverse transcription.

Recombination and Repair of DNA: DNA damage and repair, Single strand and Double strand break repair mechanisms: Nucleotide excision repair, base excision repair, mismatch repair, Homologous and Non-Homologous End Joining Repair mechanism

UNIT III [15 Lecture]

Transcription: Mechanism of transcription in prokaryotes and eukaryotes, Structure and assembly of prokaryotic and eukaryotic RNA polymerases, promoters and enhancers, Transcription factors as activators and repressor, Transcription- initiation, elongation and termination, Regulation of transcription.

Post-transcriptional Processes: Co- and post-transcriptional modifications, Posttranscriptional processing of tRNA, rRNA and mRNA (5' capping, 3' polyadenylation and splicing)

UNIT IV [15 Lecture]

Genetic code: Genetic code and its general features, Deciphering of genetic code, Wobble hypothesis, mitochondrial genetic code.

Translation: Translational mechanism in prokaryotes and eukaryotes. Ribosome composition and assembly, Regulation of translation, Antibiotic inhibitors and translation, non-ribosomal polypeptide synthesis. Post translational modification, Transport, Folding and Protein targeting.
Gene Regulation: Prokaryotic – lac, trp, gal and ara operons
DNA Binding Protein Motifs: Zinc finger, Leucine zipper, Helix-turn-helix and other motifs

Recommended Textbooks and References:

1. Adams, R.L.P., Knowler, J.T. & Leader, D.P., The Biochemistry of Nucleic Acids (11th Ed.), Chapman and Hall, New York. 1992.
2. Kreb, J.E. & Goldstein, E.S., Lewin's GENE XII, Jones and Bartlett Publishers. 2017.
3. Karp, G., Iwasa, J. & Marshall, W., Karp's Cell and Molecular Biology (9th Ed.). John Wiley & Sons. 2020.
4. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. & Martin, K.C., Molecular Cell Biology (8th Ed.). W. H. Freeman & Co. 2016.
6. Buchanan, B.B., Gruissem, W. & Jones, R.L., Biochemistry and Molecular Biology of Plants. Wiley. 2015.
7. Watson, J.D., Baker T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R., Molecular Biology of the Gene (7 Ed.). Pearson Pub. 2013.
8. Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the cell (6th Ed.). Garland Science.

U25MMI202T: IMMUNOLOGY

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h
Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.					

COURSE OBJECTIVES

- *Introduce structural and functional components of the immune system, focusing on innate and adaptive mechanisms.*
- *Explain lymphocyte development, antigen recognition, and molecular basis of immune responses.*
- *Familiarize students with immunological techniques used in diagnostics, vaccine development, and research.*
- *Explore the immune basis of diseases like hypersensitivity, autoimmunity, immunodeficiency, and tumor immunity, along with therapies.*

COURSE OUTCOMES

- *Explain the roles of innate and adaptive immune components in host defense.*
- *Describe B and T cell responses and the molecular basis of antigen recognition and presentation.*
- *Apply immunological techniques to detect and analyze antigen-antibody interactions.*
- *Evaluate immune disorders and propose strategies for immunotherapy and disease management.*

UNIT I [15 Lecture]

Innate Immunity: Components of innate and acquired immunity; Important organs and cells of immune responses, complement and inflammatory responses; Pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); Interferon, Inflammation, ADCC, Acute Phase protein, Innate immune response; Mucosal immunity; Immune dysfunction and its consequences; Antigens - immunogens, Haptens, adjuvant; Antigenic determinants.

UNIT II [15 Lecture]

Immune Responses Generated by B and T Lymphocytes: Immunoglobulins-basic structure, classes and subclasses of immunoglobulins; Hybridoma technology and its application; Multigene organization of immunoglobulin genes; B cell receptor; Immunoglobulin superfamily; Principles of cell signalling; Basis of self, non-self-discrimination; Kinetics of immune response, memory; Generation of antibody diversity. Processing and presentation of antigen: Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens, Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing.

UNIT III [15 Lecture]

Antigen-antibody Interactions: Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques- RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immune electron microscopy; Surface Plasmon resonance, Biosensor assays for assessing ligand –receptor interaction, CMI techniques-lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis, microarrays, transgenic mice, gene knock outs.

Vaccine and its type, Active and passive immunization; live, killed, attenuated, subunit vaccines; recombinant DNA and protein-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines. Success stories in vaccinology e.g. Hepatitis, Polio, Small pox, DPT.

UNIT IV **[15 Lecture]**

Clinical Immunology Immunity to Infection: Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Cytokines-properties, receptors and therapeutic uses; Tumor immunology –Tumor antigens; Immune response to tumor and tumor evasion of the immune system, Cancer immunotherapy; Immunodeficiency Primary immune deficiencies, Acquired or secondary immune deficiencies.

Recommended Textbooks and References:

1. *Abbas, A. K., Lichtman, A. H., & Pillai, S. (2023). Cellular and Molecular Immunology (11th ed.). Elsevier.*
2. *Murphy, K., Weaver, C. (2016). Janeway's Immunobiology (9th ed.). Garland Science.*
3. *Parham, P. (2020). The Immune System (5th ed.). Garland Science.*
4. *Owen, J. A., Punt, J., Stranford, S. A., & Jones, P. P. (2013). Kuby Immunology (7th ed.). W.H. Freeman and Company.*
5. *Male, D., Brostoff, J., Roth, D. B., & Roitt, I. (2012). Immunology (8th ed.). Elsevier.*
6. *Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2017). Roitt's Essential Immunology (13th ed.). Wiley-Blackwell.*
7. *Paul, W. E. (Ed.). (2012). Fundamental Immunology (7th ed.). Lippincott Williams & Wilkins.*

U25MMI203T: INDUSTRIAL MICROBIOLOGY

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce fundamental concepts of industrial fermentation and microbial strain development.*
- *To impart knowledge of fermenter design and production processes for key primary and secondary metabolites.*
- *To provide understanding of upstream and downstream processing techniques in industrial biotechnology.*
- *To develop awareness of waste treatment technologies and sustainable biotechnological approaches for environmental management*

COURSE OUTCOMES

- *Describe industrial fermentation processes, classify fermentation systems, and explain microbial growth kinetics with examples.*
- *Analyze fermenter design requirements and evaluate production strategies for selected industrial metabolites and bioproducts.*
- *Apply upstream and downstream processing techniques for optimized bioprocess operations and product recovery.*
- *Assess waste treatment methods and bioremediation strategies for sustainable management of industrial and environmental waste*

UNIT I [15 Lectures]

Introduction to Fermentation Technology: Fermentation- Overview, Introduction to fermentation processes, industrially important microorganisms-Isolation, screening, and preservation of industrially important microorganisms, Strain improvement for increased yield and other desirable characteristics; Principles of overproduction of primary and secondary metabolites with relevant examples, Culture collection, cataloguing of cultures.

Fermentation Systems: Batch and Continuous system, Fed batch culture, multistage systems, Feedback systems, Solid substrate fermentation. Instrumentation and control of fermentation processes, Monod kinetics of microbial growth, growth and non-growth associated product formation, product formation kinetics.

UNIT II [15 Lectures]

Fermenter Design: Bioreactor configuration, design features, Criteria in Fermenter design, Requirement for aeration and mixing, Energy Transfer. Other fermenter designs- Tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors, trickle flow reactors.

Production and Recovery of Primary and Secondary Metabolites: Industrial Alcohol, Beer, Wine, Citric Acid, Acetic acid, Baker's Yeast, Single Cell Protein, Amino acids-Lysine & Glutamic acid production, Industrial enzymes- Proteases, Antibiotics- Penicillin, vaccines (BCG& Covid-19), vitamins (B12), Bioinsecticides, Biopolymers and steroids.

UNIT III [15 Lectures]

Fermentation Upstream Processing: Media for industrial fermentation, Criteria used in media formulation, fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down;

measurement and control of bioprocess parameters.

Downstream Processing: Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: Liquid-liquid extractions, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.

UNIT IV [15 Lectures]

Waste Treatment: Waste Treatment systems, Aerobic and anaerobic waste treatment systems for waste treatment in a fermentation industry, Treatment of sewage (primary, secondary and tertiary treatments), treatment of industrial effluents (distillery, textile, pulp and paper), methods to detect various pollutants (metals, sediments, toxin and organic matters). Solid waste types, composting, landfill development, incineration methods, composting and sustainable agriculture, biogas production, plastic degrading microorganisms as a tool for bioremediation, challenges in waste management.

Recommended Textbooks and References:

1. *Stanbury, P.F., Hall, S., Whitaker, A., Principles of Fermentation Technology (3rd Ed.). Butterworth Heinemann Ltd., Elsevier. 2016.*
2. *Ward, O.P., Fermentation Biotechnology - Principles, Process and Products. Prentice Hall Publishing, New Jersey. 1999.*
3. *Rehm, H.J., Reed, G.B., Puehler, A. & Stadler, Biotechnology, Vol. 1-8, VCH Publication. 1993.*
4. *Prescott, S.C. & Dunn, G.C., Prescott and Dunn's Industrial Microbiology (4th Ed.). CBS Publication, New Delhi. 1992*
5. *Demain, A.I. & Davies, J. E., Manual of Industrial Microbiology and Biotechnology (2nd Ed.), ASM Press, Washington D.C. 1999.*
6. *Glazer, A.N. & Nikaido, H., Microbial Biotechnology: Fundamentals of Applied Microbiology. WH Freeman & Company, New York. 1998.*
7. *Cruger, W. & Kruger, A., Biotechnology -A Textbook of Industrial Microbiology (2nd Ed.). Panima Publishing Corporation, New Delhi. 2002.*
8. *Clarke, W., Industrial Microbiology. CBS Publisher and Distributors PVT. LTD New Delhi. 2016.*

U25MMI211T: INSTRUMENTATION TECHNIQUES

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h
Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.					

COURSE OBJECTIVES

- *To introduce key spectroscopy and microscopy techniques used in biological research.*
- *To explain methods for determining macromolecular structures.*
- *To teach separation and analysis techniques for biomolecules.*
- *To familiarize students with radioactive and emerging biotechnological tools.*

COURSE OUTCOMES

- *Describe principles and biological applications of spectroscopy and microscopy techniques.*
- *Interpret macromolecular structure data using crystallography and magnetic resonance methods.*
- *Apply chromatography, centrifugation, and electrophoresis techniques for biomolecule separation and analysis.*
- *Evaluate the use of radioactive methods, nanobodies, and emerging technologies in biotechnology research.*

UNIT I [15 Lectures]

Spectroscopy: Various theories exploring the concept of light: Corpuscular theory, Wave theory, Electromagnetic theory, Planck's concept and modern theory. Basic concepts, principles and biological applications of different types of spectroscopies: absorption spectroscopy, Visible and UV Spectroscopy and its applications; fluorescence spectroscopy, phosphorescence, Infrared and Raman spectroscopy, Optical Rotatory Dispersion (ORD), Circular Dichroism (CD), LCMS, GCMS.

UNIT II [15 Lectures]

Microscopy: Basics of microscopy: image formation, magnification, resolution, biological applications and instrumentation of various kinds of microscopy: Optical Microscopy, Fluorescence, Confocal microscopy, Electron Microscopy: SEM & TEM, Probe Microscopy: Atomic Force Microscopy

Macromolecular Structure Determination: Basics of X-ray Crystallography, its biological applications and interpretations. Basics of Magnetic resonance spectroscopy: Nuclear Magnetic Resonance (NMR) & Electron Spin Resonance (ESR/EMR).

UNIT III [15 Lectures]

Separation Techniques I (Chromatography): Basics principles and applications of various chromatography methods: Partition and Absorption chromatography, Gel filtration chromatography, Ion exchange chromatography and Affinity chromatography, Gas Chromatography, High Performance Liquid Chromatography

Separation Techniques II (Centrifugation & Electrophoresis): Basics of centrifugation-based methods: viscosity, diffusion, sedimentation equilibrium, dialysis, Centrifugation Types: Differential and Density gradient centrifugation, Analytical and Preparative ultracentrifugation.

Electrophoretic mobility and affecting factors, Principle and biological applications of different types of electrophoresis: Polyacrylamide gel electrophoresis, SDS-PAGE, Gradient gel, Agarose Gel Electrophoresis, 2D Electrophoresis, Iso-electric focusing.

UNIT IV **[15 Lectures]**

Radioactive Methods: Basics of radioactive isotopes and radioactive decay, Safety precautions during handling, Principle & applications of GM counter, Solid Scintillation counters & Liquid Scintillation counters, Autoradiography

Other Emerging Techniques: Theory, principle and applications of PSA cum Zeta sizer, Flow Cytometry, DSC-TGA, Nanobodies as an analytical tool for protein-based studies and molecular imaging.

Recommended Textbooks and References:

1. Banwell, C., Fundamentals of Molecular Spectroscopy (4 th Ed.) McGraw Hill. 2017.

2. Lakowicz, J. & Joseph, R., Principles of Fluorescence Spectroscopy (3 rd Ed.) Springer. 2006. 3. Valeur, B., Molecular Fluorescence: Principles and Applications (2nd Ed.) Wiley. 2013.

4. Rupp, B., Biomolecular Crystallography: Principles, Practice and Application to Structural Biology (1st Ed.). Garland Science. 2009.

5. Wilson, K. & Walker, L., Principles and Techniques in Practical Biochemistry (5th Ed.). Cambridge University Press. 2000.

6. Dash, U.N., Textbook of Biophysical Chemistry. Macmillan Publishers India. 2006.

7. Cantor, C.R. Schimmel, P.R., Biophysical Chemistry: Part 2: Techniques (1 st Ed.). W.H Freeman and Co. 2008.

8. Campbell, I.D., Biophysical Techniques. Oxford: Oxford University Press. 2012.

9. Serdyuk, I.N., Zaccai, N.R., & Zaccai, G., Methods in Molecular Biophysics: Structure, Dynamics, Function. Cambridge: Cambridge University Press. 2007.

10. Chakravarty, R., Goel, S. & Cai, W., Nanobody: The "Magic Bullet" for Molecular Imaging? Theranostics, 4(4), 386-398. doi:10.7150/thno.8006. 2014.

U25MMI204P: INDUSTRIAL MICROBIOLOGY LAB

Couse Credits	Internal Marks	External Marks	Total Marks	Examination hours
3	25	50	75	4h

COURSE OBJECTIVES

- *To introduce methods of sterilization, safety, and isolation of industrially important microbes.*
- *To train in microbial production of industrial products like alcohol, acids, and enzymes.*
- *To develop proficiency in fermentation assays and quality analysis of fermentation products.*
- *To apply microbiological techniques in wastewater treatment and environmental monitoring.*

COURSE OUTCOMES

- *Apply sterilization techniques and safety protocols in industrial microbiology labs.*
- *Isolate and screen microorganisms for production of industrial enzymes and metabolites.*
- *Perform fermentation processes and analyze key biochemical parameters.*
- *Evaluate wastewater and soil samples for pollutants using standard microbiological methods.*

List of Experiments:

1. Sterilization, general methods and safety in Industrial microbiology laboratory.
2. Industrially important microorganisms: Isolation and screening- Isolation of yeast, lactic acid bacteria, Acetobacter; Isolation of Amylase producers from soil, Isolation of Cellulase producing organisms, Isolation of Protease producers from soil.
3. Production of Industrial alcohol.
4. Production of Lactic acid.
5. Production of Grape wine
6. Production of cellulase.
7. Production of Citric acid
8. Analytical assays in fermentations: Estimation of Ethanol, lactic acid, sugars, total acids, volatile fatty acids, protein assay etc
9. Analysis of BOD, COD, DO in wastewater.
10. Estimation of hardness in water sample.
11. Treatment of sewage and wastewater (visit).
12. Estimation of Heavy metals in soil/water sample.

Recommended Textbooks and References:

1. *Kulandaivel, S. & Janarthanan, S., Practical Manual on Fermentation Technology, IK Books. 2012.*
2. *Mathur, N., & Singh, A., Industrial Microbiology: A Laboratory Manual. Aavishkar. 2007*

U25MMI205P: IMMUNOLOGY & INSTRUMENTATION TECHNIQUES LAB

Couse Credits	Internal Marks	External Marks	Total Marks	Examination hours
3	25	50	75	4h

COURSE OBJECTIVES

- *Understand experimental approaches for immunization, antigen preparation, and immune cell handling.*
- *Learn core immunological techniques for antibody detection, purification, and cellular assays.*
- *Gain hands-on experience in advanced diagnostic tools like ELISPOT and flow cytometry.*
- *Acquire practical skills in nanobody synthesis, characterization, and spectroscopic analysis*

COURSE OUTCOMES

- *Perform immunological techniques including ELISA, immunodiffusion, and immunoblotting to detect and analyze antigen-antibody interactions.*
- *Isolate, purify, and preserve immune cells and immunoglobulins using standard laboratory protocols.*
- *Demonstrate proficiency in advanced immunological assays such as FACS and ELISPOT for cell-based analysis.*
- *Apply spectroscopy, microscopy, and nanotechnology-based instrumentation techniques to analyze and characterize biological samples.*

List of Experiments:

Section A: Immunology

1. Selection of animals, preparation of antigens, immunization and methods of blood collection, serum separation and storage.
2. Antibody titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
4. Complement fixation test.
5. Isolation and purification of IgG from serum or IgY from chicken egg.
6. Immunoblotting, Dot blot assays.
7. Blood smear identification of leucocytes by Giemsa stain.
8. Separation of leucocytes by dextran method.
9. Demonstration of Phagocytosis of latex beads and their cryopreservation.
10. Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation.
11. Demonstration of ELISPOT.
12. Demonstration of FACS.

Section B: INSTRUMENTATION TECHNIQUES:

1. Study of the size of nanobodies using dynamic light scattering.
2. Study of stability of synthesized nanobodies using zeta potential
3. Identification of functional groups using FTIR spectroscopy
4. Synthesis/preparation of nanobodies of metals, metal oxides and their hybrids
5. Synthesis of different morphologies of carbon-based structures
6. Sample preparation for estimation of size and morphological

features using electron microscopy.

7. Study of different morphological and surface features using atomic force microscopy
8. Study of the crystalline information of sample (either solid or thin film) using X- ray diffraction.
9. Quantification of the metal ion concentrations in aqueous samples using atomic adsorption spectroscopy (AAS)/inductively coupled plasma mass spectrometry (ICP-MS).
10. Study of the spectrum of pure and complex samples using mass spectroscopy.
11. Study of the variation of properties of substance with heat using differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA).

Recommended Textbooks and References:

1. *Punt, J., Stranford, S., Jones, P. & Owen, J.A., Kuby Immunology (8th Ed.). Macmillan International Higher Education. 2018.*
2. *Delves, P.J., Martin, S.J., Burton, D.R. & Roitt, I.M., Roitt's Essential Immunology (13th Ed.). Wiley- Blackwell. 2017.*
3. *Kenneth, M. & Weaver, C., Janeway's Immunobiology (9th Ed.). Garland Science. 2016.*
4. *Green, M.R. & Sambrook, J., Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2012.*
5. *Wilson, K. & Walker, L., Principles and Techniques in Practical Biochemistry (5th Ed.). Cambridge University Press. 2000.*
6. *Banwell, C., Fundamentals of Molecular Spectroscopy (4th Ed.) McGraw Hill. 2017.*
7. *Lakowicz, J. & Joseph, R., Principles of Fluorescence Spectroscopy (3rd Ed.) Springer. 2006.*
8. *Valeur, B., Molecular Fluorescence: Principles and Applications (2nd Ed.) Wiley. 2013.*
9. *Serdyuk, I.N., Zaccai, N.R., & Zaccai, G., Methods in Molecular Biophysics: Structure, Dynamics, Function. Cambridge: Cambridge University Press. 2007.*

U25MMI201I : INTERNSHIP

Course Credits	Internal Marks	External Marks	Total Marks	Examination Duration
4	-	-	100	-

Note: Internship of 4 credits of 4 weeks (120 Hrs.) duration after 2nd semester is mandatory for each student either for enhancing the employability or for developing research aptitude.

SEMESTER III

U25MMI301T: RECOMBINANT DNA TECHNOLOGY

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce the fundamental tools and techniques used in genetic engineering.*
- *To impart knowledge on PCR, sequencing methods, and their applications in research and diagnostics.*
- *To develop understanding of gene manipulation strategies and molecular interaction studies.*
- *To explore genome editing technologies and their applications, ethical issues, and regulatory frameworks.*

COURSE OUTCOMES

- *Describe key tools, enzymes, and vectors used in genetic engineering.*
- *Apply PCR and sequencing methods for genetic analysis and diagnostics.*
- *Analyze gene manipulation and molecular interaction techniques.*
- *Evaluate genome editing tools and their biotechnological and ethical implications.*

UNIT I [15 Lecture]

Introduction and Tools of Genetic Engineering: Introduction, General requirements for performing a genetic engineering experiment; Restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase; Cohesive and blunt end ligation; Linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, Hybridization techniques: northern, southern, south-western and far-western and colony hybridization, Fluorescence *in situ* hybridization.

Cloning and Expression Vectors: Vehicles for gene cloning, Plasmids, Bacteriophages, Cosmids and Phagemids as vectors, P1 vectors, F- factor based vectors, Plant and animal viruses as vector, Artificial chromosomes as vectors (YAC, BAC, PAC and MAC vectors), Expression vectors- use of promoters and expression cassettes, Baculovirus, Plant based vectors, Ti and Ri as vectors, yeast vectors, Binary and shuttle vectors.

UNIT II [15 Lecture]

PCR Techniques: Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, Touchdown PCR, Hot start PCR, Colony PCR, Asymmetric PCR, Cloning of PCR products; T-vectors; Proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; Viral and bacterial detection; Mutation detection: SSCP, DGGE, RFLP.

Sequencing Techniques: Sequencing methods; Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; RNA sequencing; Chemical synthesis of oligonucleotides; Next Generation sequencing methods: Illumina and 454 sequencing. Ion torrent sequencing, Third generation sequencing SMRT sequencing, Oxford Nanopore sequencing. Whole genome sequencing and functional genomics (A brief account).

UNIT III [15 Lecture]

Gene Manipulation and Protein-DNA Interaction: Insertion of foreign DNA into host cells; transformation, electroporation, transfection; Construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; Construction of

microarrays – genomic arrays, cDNA arrays and oligo arrays; Study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting assay; Methyl interference assay, Chromatin immunoprecipitation; Principles for maximizing gene expression, Protein purification; His-tag; GST-tag etc.; Protein-DNA interactions. Protein-protein interactions using yeast two-hybrid system; Phage display.

UNIT IV **[15 Lecture]**

Gene Silencing and Genome Editing Technologies: Gene silencing techniques; Introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; Principle and application of gene silencing; Gene knockouts and gene therapy; Creation of transgenic plants; Debate over GM crops; Molecular mechanism of genome editing technologies TALENs, ZFNs and CRISPR, Principles of Synthetic Biology, gene circuits and BioBricks, Application of gene cloning and DNA analysis in Biotechnology; Ethics and regulatory framework of genetic engineering.

Recommended Textbooks and References:

1. *Clark DP and Pazdernik NJ. (2009). Biotechnology-Applying the Genetic Revolution. Elsevier Academic Press, USA.*
2. *Brown T.A., Gene Cloning & DNA Analysis (6th Ed.) Wiley-Blackwell, New York. 2010.*
3. *Watson J.D., A Passion for DNA: Genes, Genomes & Society, Cold Spring Harbor Laboratory press (CSHL). 2009.*
4. *Primrose, S.B. & Twyman, R.M. Principles of Gene Manipulation and Genomics (7th Ed.). Malden, MA: Blackwell Publisher. 2006.*
5. *Green, M.R. & Sambrook, J., Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2012.*
6. *Alcamo, I.E., DNA Technology: The Awesome Skill. Harcourt Academic Press. 2001.*

U25MMI302T: MICROBIAL ENZYME TECHNOLOGY

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h
Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.					

COURSE OBJECTIVES

- *To introduce the fundamentals of enzyme structure, classification, and specificity.*
- *To impart knowledge on enzyme purification methods and catalytic mechanisms.*
- *To develop understanding of enzyme kinetics, inhibition, and regulatory functions.*
- *To explore industrial applications of enzymes and basics of protein engineering.*

COURSE OUTCOMES

- *Describe enzyme properties, classification, specificity, and assay methods.*
- *Explain enzyme purification techniques and catalytic mechanisms using model enzymes.*
- *Analyze enzyme kinetics, inhibition types, and bi-substrate reaction mechanisms.*
- *Evaluate enzyme regulation, industrial applications, and protein engineering strategies.*

UNIT I [15 Lecture]

Introduction to Enzymes: Historical background, Enzymes vs Chemical catalyst, Enzyme nomenclature and classification, Units of activity, Factors affecting rate of chemical reactions, Collision theory, activation energy and transition state theory, Binding Energy, Enzyme assays, Cofactors and coenzymes.

Enzyme Specificity: Substrate and reaction specificity, Lock and key hypothesis, Induced Fit hypothesis, Wrong-way binding hypothesis and Three-point attachment hypothesis.

UNIT II [15 Lecture]

Enzyme Purification: Methods of extraction of enzymes, Enzyme purification techniques- salt fractionation, gel filtration chromatography, ion exchange chromatography, affinity chromatography etc., Testing of enzyme purity.

Enzyme Catalysis: Mechanism of enzyme catalysis, Acid-Base catalysis, Covalent catalysis, Metal ion catalysis, Electrostatic catalysis, Catalysis through proximity and orientation effects, Catalysis by transition state binding. Mechanism of Catalysis in model enzymes – Ribonuclease A, Trypsin, Chymotrypsin, Carbonic anhydrase, Carboxypeptidase A, Lysozyme.

UNIT III [15 Lecture]

Enzyme Kinetics: Factors affecting velocity of enzyme catalysed reactions, Michaelis Menten hypothesis, Transformation of Michaelis- Menten equation and determination of Km and Vmax (Lineweaver-Burk plot, Eadie-Scatchard, Eadie-Hofstee and Hanes plot), Haldane relationship, Enzymes inhibition i.e., reversible and irreversible inhibition, Competitive, Non-competitive and Uncompetitive inhibition. Determination of Km, Vmax and Ki.

Bi-substrate Reactions- Sequential, Ping-Pong reactions.

UNIT IV [15 Lecture]

Regulatory Enzymes: General mechanisms of enzyme regulation, Allosteric enzymes, sigmoidal kinetics and their physiological significance, Symmetric and sequential modes for action of allosteric enzymes. Reversible and irreversible covalent modifications of enzymes

Enzyme Technology: Large scale production of enzymes, Uses of isolated enzymes in food and chemical industries, Therapeutic and medicinal use of enzymes.
Protein Engineering: Concept and Methods, Site directed mutagenesis, Active site mapping, Nature of the active site, Identification of functional groups at the active site, Immobilized enzymes−Methods and Applications.

Recommended Textbooks and References:

1. *Palmer, T. & Bonner, P., Enzymes: Biochemistry, Biotechnology and Clinical Chemistry (2nd Ed.). Howood Publishing Chishester, England. 2008.*
2. *Okotore, R.O. (2015) Essentials of Enzymology Xlibris, USA. 2015.*
3. *Marangoni, A.G., Enzyme Kinetics-A Modern Approach. 2003.*
4. *Engel, P.C., Enzyme Kinetics: The Steady State Approach, Springer Illustrated Edition. 2014.*
5. *Bisswanger, H., Enzyme Kinetics: Principles and Methods (3rd Ed.). Willey-VCH. 2017. 6. Rocha-Martin, J., Immobilization of Enzymes and Cells: Methods and Protocols, Springer US. 2020.*
6. *Price, N.C. & Stevens, L., Fundamentals of Enzymology (3rd Ed.). Oxford University Press, New York. 1999.*
7. *Phillips, J., Fundamentals of Enzymology Ed-Tech Press, United Kingdom. 2019.*
8. *Yon-Kahn, J and Herve, G. (2010) Molecular and Cellular Enzymology, Springer.*
9. *Bailey, J.E. and Ollis, D.F. (2017). Biochemical Engineering Fundamentals. 2nd Edition. McGraw Hill, New York.*
10. *Segel, I. H. (2017). Enzyme kinetics, behavior and analysis of rapid equilibrium and steady-state enzyme systems. First Edition. Wiley.*

U25MMI303T: FOOD MICROBIOLOGY

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h
Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.					

COURSE OBJECTIVES

- *To introduce the roles, sources, and growth factors of microorganisms in food systems.*
- *To explain the mechanisms of food spoilage and principles of traditional and advanced preservation techniques.*
- *To impart knowledge of foodborne pathogens, their toxins, and strategies for infection control.*
- *To develop understanding of modern food safety protocols, microbial testing methods, and quality assurance systems.*

COURSE OUTCOMES

- *Identify and explain the role of various microorganisms in food spoilage, preservation, and fermentation processes.*
- *Apply preservation methods and fermentation techniques for enhancing food safety and shelf-life.*
- *Analyze causes and preventive strategies of foodborne infections, intoxications, and toxin-related disorders.*
- *Evaluate food safety practices and quality assurance systems using modern microbial detection tools and protocols*

UNIT I [15 Lecture]

An Overview of Microbes in Food: Brief historical aspects of microorganism in foods; source, types and role of microorganisms in foods; intrinsic and extrinsic factors affecting microbial growth. Microbiome of food material.

Microbial Spoilage of Foods: Types and causes of spoilage of cereals and cereals products, spoilage of vegetables and fruits, Meat and meat products, Milk and milk products, canned foods.

Food Preservation: General principles of food preservation, various classical, physical, chemical, and biological methods of preservation. New developments in food preservation techniques. Analysis of practical implementation of such techniques. Hurdle technology in food preservation, Bacteriocins and their applications; Probiotic bacteria in foods.

UNIT II [15 Lecture]

Fermented Food Products: Microorganisms involved in food fermentations, Starter Cultures, Fermented meats and sausages; Fermented milk products- Acidophilus and Bulgarian milk, yoghurt, cheese, Kefir, Koumiss; Fermented grains and vegetable products - Sauerkraut, Soy sauce, Tempeh, Miso, Olive, and Kimchi, Nutraceuticals & Nanonutraceuticals.

Protein Engineering: Protein engineering in food technology-objectives, methods, targets, potential applications in food industry and limitations.

UNIT III [15 Lecture]

Food Borne Infections and Intoxications: Types of Food Poisonings, Role of microorganisms and their toxins in food poisoning. Common food borne pathogens: *Bacillus cereus*, *Staphylococcus aureus*, *Vibrio*, *Campylobacter jejuni*, *Clostridium botulinum*, *Clostridium perfringens*, *Escherichia coli*, *Listeria monocytogenes, Salmonellosis, Shigellosis, Yersinia enterocolitica*. Mycotoxins, Enteric viruses and algal toxins. Summary of prevention of microbial food infections. Identification and first aid for specific types of infections.

UNIT IV [15 Lecture]

Food Safety and Quality Assurance in Foods: Microbial testing of foods-traditional methodology and new approaches: Microbiological, Physical, Chemical methods, Immunological methods, Use of gene probes and PCR, bioluminescence, BAX system, Riboprinter and Real Time PCR-based approaches, Microbiological quality standards for food industry. Biosensors in food. Concept of HACCP for quality assurance and food safety in food industry.

Recommended Textbooks and References:

1. *Ray, B. & Bhunia, A., Fundamental Food Microbiology (5th Ed.). CRC Press Inc. 2013.*
2. *Frazier, W.C. & Westhoff, D.C., Food Microbiology (3rd Ed.). Tata McGraw Hill. 1991.*
3. *Banwart, G.J, Basic Food Microbiology. AVI. Pp.462. 1989.*
4. *Jay, J.M., Loessner, M.J. & Golden, D.A., Modern Food Microbiology (7th Ed.) Springer-Verlag New York. 2005.*
5. *Montville, T., Matthews, K. & Kniel, K., Food Microbiology: An Introduction (4th Ed.). ASM press. 2017.*
6. *Doyle, M.P. & Buchanan, R.L., Food Microbiology. ASM Press, Washington. 2012.*
7. *Joshi, V.K. & Pandey, A., Biotechnology: Food Fermentation Vol. 1 & 2, Education Publisher and Distributor, New Delhi. 1999.*
8. *Rayand, B. & Bhunia, A., Fundamental Food Microbiology (5th Ed.). CRC press. 2013.*
9. *Adams, M.R., Moss, M.O. & McClure, P., Food Microbiology (4th Ed.). Royal Society of Chemistry. 2015.*

U25MMI311T: BIOINFORMATICS

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce key bioinformatics databases, tools, and computational platforms.*
- *To provide knowledge of sequence alignment, gene prediction, and phylogenetic analysis.*
- *To develop understanding of protein structure modeling and structure-function analysis.*
- *To explore protein structure prediction techniques and their applications in drug discovery.*

COURSE OUTCOMES

- *Describe biological databases, search tools, and fundamental bioinformatics platforms.*
- *Apply sequence alignment techniques and perform gene and motif prediction.*
- *Analyze protein structures using modeling, alignment, and conformational tools.*
- *Evaluate structure-based prediction methods and explore applications in drug design.*

UNIT I [15 Lecture]

Bioinformatics basics: Bioinformatics basics: Introduction to bioinformatics and omics: role in modern biology and medicine; Introduction to Unix and Linux systems; Database concepts; Protein and nucleic acid databases; Structural databases; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools, AI-ready database mining tools.

UNIT II [15 Lecture]

DNA sequence analysis and Multiple sequence analysis: DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.

Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the BLAST+, MAFFT; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, BioProject, ENA, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

UNIT III [15 Lecture]

Protein modelling: Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein completion: backbone

construction and side chain addition; building peptides; protein displays; substructure manipulations, annealing.

UNIT IV [15 Lecture]

Protein structure prediction and virtual library: Protein folding and model generation; secondary structure prediction and analysis; loop identification and generation; homology modelling—applications, methodology, sequence alignment, and region construction; threading methods; model evaluation and validation; structure prediction for unknown sequences using structural profiles, alignment algorithms, mutation tables, inverse folding, and fold prediction; AlphaFold2 applications, scoring, and validation techniques. Protein function prediction using structure-based and AI-assisted approaches; in silico drug design and target identification.

Virtual Library: Searching PubMed, Science Citation Index, electronic journals, grants and funding information, and current awareness tools.

Recommended Textbooks and References:

1. *Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.*
2. *Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.*
3. *Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.*
4. *Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell.*
5. *Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.*
6. *Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.*
7. *Ramsundar, B. et al. (2019). Deep Learning for the Life Sciences. O'Reilly.*
8. *Gu, J., & Bourne, P. E. (2020). Structural Bioinformatics, 2nd ed. Wiley*

U25MMI304P: RECOMBINANT DNA TECHNOLOGY AND BIOINFORMATICS LAB

Couse Credits	Internal Marks	External Marks	Total Marks	Examination hours
3	25	50	75	4h

COURSE OBJECTIVES

- *Learn key molecular techniques including gene cloning, vector construction, transformation, and recombinant protein analysis.*
- *Understand regulatory mechanisms of gene expression through lac operon experiments and phage-based assays.*
- *Develop hands-on skills in RNA isolation, cDNA synthesis, PCR, and gel-based molecular diagnostics.*
- *Explore and apply bioinformatics tools for sequence analysis, gene prediction, structural modeling, and miRNA targeting.*

COURSE OUTCOMES

- *Perform gene cloning techniques including plasmid isolation, restriction digestion, ligation, transformation, and insert verification.*
- *Analyze gene expression and recombinant protein production using SDS-PAGE and purification techniques.*
- *Apply computational tools for sequence alignment, gene prediction, structural modeling, and database navigation.*
- *Interpret experimental data from lac-operon studies, phage assays, PCR, and Southern hybridization.*

List of Experiments (Recombinant DNA Technology):

1. Concept of lac-operon:
   a) Lactose induction of β-galactosidase.
   b) Glucose Repression.
   c) Diauxic growth curve of *E.coli*
2. Phage titre with epsilon phage/M13
3. Genetic Transfer-Conjugation, gene mapping
4. Plasmid DNA isolation and quantification
5. Restriction Enzyme digestion of plasmid DNA
6. Agarose gel electrophoresis
7. Isolation of RNA from plant tissue
8. Synthesis of cDNA using RNA
9. Polymerase Chain Reaction and analysis by agarose gel electrophoresis
10. Vector and Insert Ligation.
11. Preparation of competent cells.
12. Transformation of *E. coli* with standard plasmids, Calculation of transformation efficiency.
13. Confirmation of the insert by Colony PCR and Restriction mapping
14. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E. coli,* SDS-PAGE analysis
15. Purification of His-Tagged protein on Ni-NTA columns

a) Random Primer labeling
b) Southern hybridization.

List of Experiments (Bioinformatics):

1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
11. Construction and study of protein structures using Deepview/PyMol.
12. Homology modeling of proteins.
13. Use of tools for mutation and analysis of the energy minimization of protein structures.
14. Use of miRNA prediction, designing and target prediction tools.

Recommended Textbooks and References:

1. *Green, M.R. & Sambrook, J., Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2012.*
2. *Mount, D.W., Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2001.*
3. *Baxevanis, A.D., & Ouellette, B.F., Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience. 2001.*
4. *Pevsner, J., Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell. 2015.*
5. *Bourne, P. E., & Gu, J., Structural Bioinformatics. Hoboken, NJ: Wiley-Liss. 2009.*

U25MMI305P: FOOD MICROBIOLOGY AND ENZYME TECHNOLOGY LAB

Couse Credits	Internal Marks	External Marks	Total Marks	Examination hours
3	25	50	75	4h

COURSE OBJECTIVES

- *Train in microbial analysis of food, milk, and water.*
- *Understand food safety standards and detection methods.*
- *Develop skills in enzyme extraction, assay, and kinetics.*
- *Apply enzyme immobilization and purification techniques.*

COURSE OUTCOMES

- *Conduct microbial testing of food and water as per standards.*
- *Use rapid methods for microbial detection.*
- *Analyze enzyme activity, kinetics, and inhibition.*
- *Perform enzyme immobilization, reuse, and purification.*

List of Experiments:

Section A) Food Microbiology:

1. Microbial analysis of food products: The Bacterial Count
2. Microbiological standards in foods-Statutory, recommended and supplementary tests for microbiological analysis of various foods: Baby foods, meat, vegetables, fruits, cereals, surfaces, containers and water.
3. Microbial analysis of milk: The Reductase Test
4. Direct microscopic count of microscopic in Milk
5. Standard Plate Count of Milk
6. Microbiological analysis of water- Most probable number, SPC of water, coliform count of water
7. New methods, One step method for detection of microorganisms in foods/water.

Section B) Enzyme Technology

1. Enzyme extraction from plant or microbial source
2. Assay of enzyme activity (e.g., amylase or protease)
3. Effect of pH on enzyme activity
4. Effect of temperature on enzyme activity
5. Substrate concentration and enzyme kinetics (Km & Vmax)
6. Enzyme inhibition study (competitive/non-competitive)
7. Enzyme immobilization using alginate beads
8. Reusability of immobilized enzyme
9. Zymography for enzyme activity detection
10. Enzyme purification by ammonium sulfate precipitation

Recommended Textbooks and References:

1. *Matthews, K.R., Kniel K.E. & Montville, T.J., Food Microbiology: An Introduction (4^{th} Ed.). ASM Press, Washington, DC. 2019.*
2. *Goldberg I. & Williams R., Biotechnology and Food Ingredients, Van Nostrant., Reinhold, New York. 1991.*
3. *Ricke, S., Donaldson, J.R. & Phillips, C.A., Food Safety: Emerging Issues, Technologies and Systems. Academic Press. 2015.*

SEMESTER IV

U25MMI401T: SOIL AND ENVIRONMENTAL MICROBIOLOGY

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h
Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.					

COURSE OBJECTIVES

- *To understand the occurrence, composition, and ecological functions of microbial communities in soil and environmental systems.*
- *To analyze the roles of microbes in regulating key biogeochemical cycles and sustaining ecosystem balance.*
- *To evaluate the potential applications of microbial diversity in agriculture, industry, waste valorization, bioremediation, and pollution abatement.*
- *To integrate and apply knowledge from case studies to propose innovative, microbe-based solutions for current and emerging environmental challenges.*

COURSE OUTCOMES

- *Explain the significant components of soil and environmental microbiology, with emphasis on the distribution and roles of microbial communities in soil, water, and air.*
- *Analyse microbial diversity and formulate microbial consortia for nutrient transformation, plant-microbe interactions, and biocontrol applications.*
- *Evaluate the roles of microbes in sustainable agriculture and waste management.*
- *Develop roadmaps or assertions for addressing environmental challenges and pollution abatement, based on bioremediation case studies.*

UNIT I [15 Lectures]

Significance, History and Challenges of Environmental Microbiology: A brief history of environmental microbiology; Scope and challenges of modern environmental microbiology, soil, water and air microbiology; Significance of microbes in addressing environmental problems and pollution abatement.

Microbial Transformations: Role of microbes in balancing key biogeochemical cycles including carbon, nitrogen, sulfur, phosphorous and silicon cycle; Biodegradation of soil organic constituents-degradation of cellulose, hemicelluloses and lignin; Humic substances in soil-genesis, structure, composition and role in agriculture and environment; Microbial biodeterioration of materials and its control.

UNIT II [15 Lectures]

Microbial diversity and extreme environment: Distribution of microbial communities such as bacteria, fungi, micro-algae, protozoa and viruses in soil, water and air; Microbes of extreme environment- oligotrophs, thermophiles, psychrophiles, acidophiles, alkaliphiles and halophiles; Microbial ecology and resource utilization; Environmental sample collection and processing.

Analytical techniques for revealing microbial diversity in the environment: Cultural methods, physiological methods, metagenomics and related methods; Next-generation sequencing; Analysis by FAME, measuring metabolic capabilities using BIOLOG, G+C analysis, slot-blot hybridization of community DNA, and fluorescent in situ hybridization of intact cells.

UNIT III [15 Lectures]

Biocontrol and microbial inoculants: Microorganisms involved in biological control of plant diseases; Biocontrol agents and mechanisms of disease suppression; Biological control of insects and nematodes; Production and use of microbial inoculants.
Climate change and Agroecosystem- Climate change and soil health; Effect on microbes and soil microbial diversity; Role of microbes in climate resilient sustainable agriculture; CRISPR/cas system-based genome editing of crops and microbiome.

UNIT IV [15 Lectures]

Bioremediation of environmental pollutants: Microbial enzymes as versatile tools for pollution abatement; e-waste remediation; Biodegradation of pesticides & xenobiotic compounds, heavy metals, etc.; Case studies on oil spills and other environmental tragedies; Role of microorganisms in sustainable agriculture and organic farming; Use of biosensors for their detection; Biofilms and quorum sensing.
Biomass waste management of plant's residues: Lignocellulolytic microorganisms, enzymes and their biotechnological applications in: (i) biopulping, (ii) biobleaching, (iii) textiles (iv) biofuels, (v) animal feed production; Challenges in waste management.

Recommended Textbooks and References:

1. Alexander, M. (1977). Introduction to Soil Microbiology. John Wiley, New York
2. Paul, E.A. (2007). Soil Microbiology, Ecology and Biochemistry. 3rd Ed. Academic Press, New York
3. Tate, R.L. (2012) Soil Microbiology, Wiley-Blackwell., NY
4. Dixon; G.R. and Tilston, E.L. (2010) Production. Springer, Heidelberg.
5. Pankaj, U., Babele, P. and Singh, A.K., 2025. Plant-microbiome Interactions for Climate-resilient Agriculture. Springer
6. Bloem; J., Hopkins; D.W. and Benedetti, A. (2008) Microbiological Methods for Assessing Soil Quality, CABI, Wallingfard.
7. Maier, R.M., Pepper, I.L. & Gerba, C.P. (2009.) Environmental Microbiology. 2nd Ed. Academic Press.
8. Wicket, L. P. and Hershberger,C. D. (2000) Biocatalysis and Biodegradation: Microbial transformation of organic compounds. ASM Publications.
9. Forster,C. F. and Wase, D.A.J. (Eds.) (2001). Environmental Biotechnology. Ellis Harwood Ltd. Publication.
10. Madsen, L. Eugene (Ed.) (2008). Environmental Microbiology: From genomes to biogeochemistry. Blackwell Publishing.
11. Olguin, J. E., Sanchez, G., Hernandez, E. (Eds.) (2000). Environmental Biotechnology and Cleaner Bioprocesses. Taylor & Francis Ltd.
12. Kumar, V., Bilal, M., Shahi, S.K., Garg, V.K. (Eds.) (2023) Metagenomics to Bioremediation; Applications, Cutting Edge Tools, and Future Outlook. Elsevier, Global Book Production, Academic Press.
13. Borém, A., Santos, F. R., Bowen, D.E. (Eds.) (2003) Understanding Biotechnology. Pearson Education, Inc.

U25MMI402T: PLANT-MICROBE INTERACTIONS

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES.

- *To understand the principles of plant-microbe interactions in various plant habitats.*
- *To explore the molecular and genetic basis of mutualistic and pathogenic associations.*
- *To examine the role of microbes in sustainable agriculture and plant health.*
- *To understand and apply microbiological tools for plant disease diagnosis and management.*

COURSE OUTCOMES

- *Explain key plant-microbe interactions and microbial roles in the phyllosphere and rhizosphere.*
- *Analyze molecular and genetic mechanisms in beneficial plant-microbe relationships.*
- *Evaluate microbial applications in sustainable agriculture and crop productivity.*
- *Design integrated strategies for plant disease management using microbiological and molecular tools.*

UNIT I [15 Lectures]

Plant-microbial Interactions- Introduction to Plant-microbe Interactions; Microbiological processes of phyllosphere and rhizosphere; Positive and negative interactions; Plant-microbe symbiosis; Symbiotic associations- legume-rhizobial symbiosis, actinorhizal symbiosis, and associative symbiosis, mycorrhizal associations and phosphate nutrition; Biological nitrogen fixation; Plant growth promoting rhizobacteria; Microbial antagonism.
Mechanisms and Molecular Basis-Omics techniques for understanding of plant-microbe interactions; Metabolomics tools and studies for plant-microbe interactions; Signal exchange in mutualistic and pathogenic interactions; Induced systemic resistance and microbial elicitors

UNIT II [15 Lectures]

Microbes and sustainable agriculture- Microbial consortia in sustainable agriculture; Microbial inoculants and biofertilizers; Classification of microbial inoculants- *Azotobacter* inoculants, *Azospirillum* inoculants Cyanobacterial inoculants, etc.; Algalization; Phosphate solubilizing microbes, Silicate solubilizing microbes; Influence of Soil Microbiota on Crop Productivity; Microbial control of plant pathogens- concepts and practices; Microbial pesticides; Bacterial, Viral and fungal pesticides; Mycoherbicides; Applications and Case Studies- Biofertilizers and biopesticides
Plant-microbiome Interactions for Climate-resilient Agriculture- Climate change and its effect on Plant-microbe interactions; Emerging role of beneficial microbes in plant stress management; Rhizosphere engineering for sustainable agriculture

UNIT III [15 Lectures]

Plant-Pathogen Interactions- Physiology & Biochemical basis of plant diseases; Causes of disease; Pathogenesis, pathogenesis in relation to environment; Effect of microbial

infections on plant physiology, photosynthesis, respiration, transpiration, translocation; Enzymes and toxins in plant diseases; Phytoalexins.

Some important plant diseases and their etiological studies: Crown gall; Symptoms of viral diseases and their control; Diseases of some important cereals and crops.

UNIT IV [15 Lectures]

Genetic basis of plant diseases and disease control: Genetics of host-pathogen interactions; resistance genes; Resistance mechanisms in plants; Principles of plant disease control; Physical and chemical methods of disease control; Application of microbiology in plant disease management; Integrated plant disease management (IDM) – Concept, advantages and importance.

Molecular approach: Molecular diagnosis; Transgenic approach for plant protection; Disease forecasting: Important milestones in disease control; Relevance of forecasting in Indian farming.

Recommended Textbooks and References:

1. Plant Pathology by G. N. Agrios. 5th edition. Academic Press. 2005

2. Plant Pathology by R.S. Mehrotra, and A. Aggarwal, 3rd edition. Tata McGraw Hill. 2017

3. Bacterial plant pathology: cell and molecular aspects by D. C. Sigee. Cambridge University Press.1993.

4. Molecular plant pathology by M. Dickinson. BIOS Scientific Publishers, London. 2003.

5. The essentials of Viruses, Vectors and Plant diseases by A.N. Basu& B.K. Giri. Wiley Eastern Limited.1993.

6. Madsen, L. Eugene (Ed.) (2008). Environmental Microbiology: From genomes to biogeochemistry. Blackwell Publishing.

7. Kumar, V., Bilal, M., Shahi, S.K., Garg, V.K. (Eds.) (2023) Metagenomics to Bioremediation; Applications, Cutting Edge Tools, and Future Outlook. Elsevier, Global Book Production, Academic Press.

8. Sahu, J., Vaishnav, A., & Singh, H. B. (Eds.). (2022). Plant-Microbe Interactions: Harnessing Next-Generation Molecular Technologies for Sustainable Agriculture. CRC Press.

9. Pankaj, U., Babele, P. and Singh, A.K., 2025. Plant-microbiome Interactions for Climate-resilient Agriculture. Springer

10. Pirzadah, T. B., Malik, B., & Hakeem, K. R. (Eds.). (2021). Plant-Microbe Dynamics: Recent Advances for Sustainable Agriculture. CRC Press.

11. Mathur, P., & Roy, S. (Eds.). (2025). Plant Microbiome and Biological Control: Emerging Trends and Applications. Springer.

12. Bhar, A. (Ed.). (2025). Plant-Microbe Interactions: A Comprehensive Review. *Bentham Science.*

U25MMI403T: NANO PARTICLES IN MICROORGANISMS AND BIOSYSTEMS

Couse Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce the fundamentals, history, and interdisciplinary applications of nanotechnology in various sectors.*
- *To explore biological systems for the synthesis of nanoparticles and assess related safety and ethical issues.*
- *To understand the development and functional properties of nano-composite biomaterials for biomedical use.*
- *To examine advancements in tissue engineering, regenerative medicine, and nanomedicine for clinical applications.*

COURSE OUTCOMES

- *Summarize the scope, types, and applications of nanomaterials across diverse sectors.*
- *Demonstrate biological methods of nanoparticle synthesis using microbes and plants.*
- *Analyze the structure, synthesis, and biomedical applications of nano-composites and biomimetic materials.*
- *Evaluate nanotechnology applications in tissue engineering, regenerative medicine, and cancer therapy.*

UNIT I [15 Lectures]

Nanotechnology: An Overview, Insights and intervention into the Nano world, Historical Developments, Applications of Nanotechnology in different areas of Food, Agriculture, Cosmetics & Consumer products, Textile and Medical Sciences. Nanomaterials: Various classes, properties & applications, Concept of Bionanotechnology & Nanobiotechnology, Biomimicking.

UNIT II [15 Lectures]

Biological Methods of Synthesis: Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis.

Microorganisms for Toxicity Detection: Safety & Toxicological aspects related to nanomaterials and Ethical issues. Nanotoxicity assessment.

UNIT III [15 Lectures]

Nano-composite Biomaterials, Teeth and Bone Substitution: Natural Nano-composite systems such as spider silk, bones, shells; organic-inorganic Nano-composite formation through self-assembly. Biomimetic synthesis of Nano-composite material; Use of synthetic nano-composites for bone, teeth replacement, Nano-phase Materials Coatings, Advantages of nanomaterial used as implants, Nano phase materials in tissue engineering applications.

UNIT IV [15 Lectures]

Engineering: The status of tissue engineering of specific organs, including bone marrow, skeletal muscle, and cartilage. Cell biological fundamentals of tissue engineering. Nano-

regenerative medicine towards clinical outcome of stem cell and tissue engineering in humans, carbon nanotubes in healthcare, nanomedicine & Cancer therapy.

Recommended Textbooks and References:

1. *Goodsell, D.S., Bionanotechnology: Lessons from Nature, Wiley-Liss Inc. 2004.*
2. *Mahendra, R. & Nelson, D., Metal Nanoparticles in Microbiology. Springer. 2011.*
3. *Nicola, C. & Mahendra, R., Nano-Antimicrobials. Springer. 2012.*
4. *Freitas, R.A., Nanomedicine, Vol. IIA: Biocompatibility, Landes Bioscience. 2003.*
5. *Nalwa, H.S., Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology, American Scientific Publishers. 2005.*
6. *Mirkin, C.A. & Niemeyer, C.M. Nanobiotechnology II. Wiley-VCH Verlag GmbH & Co. KGaA. 2007.*
7. *Ventra, M.D., Introduction to Nanoscale Science and Technology (Nanostructure Science and Technology). 2009.*
8. *Ramakrishna, S., Murugan, R. & Kumar, T.S.S., Biomaterials: A nano approach, CRC Press/Taylor & Francis. 2010.*

U25MMI411T: MEDICAL MICROBIOLOGY

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	**4**	**30**	**70**	**100**	**3h**
Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.					

COURSE OBJECTIVES

- *To explain the infection process and mechanisms by which pathogens invade and damage host tissues.*
- *To provide detailed knowledge of bacterial pathogens, their morphological traits, pathogenicity, and diagnostic approaches.*
- *To introduce major fungal and protozoal pathogens, focusing on their clinical relevance and identification.*
- *To explore the structure, pathogenesis, and control of significant viral diseases, including emerging infections.*

COURSE OUTCOMES

- *Describe infection processes and mechanisms of microbial entry, colonization, and tissue damage.*
- *Identify key pathogenic bacteria along with their morphology, pathogenesis, and diagnostic methods.*
- *Distinguish major fungal and protozoal pathogens based on characteristics, disease manifestations, and lab diagnosis.*
- *Analyze viral pathogens of clinical significance with reference to their structure, diagnosis, and prevention strategies.*

UNIT I [15 Lectures]

Infection Process: Process of infection-Types, stages of infection, Establishment of pathogenic microorganisms: Entry, spread and tissue damage. Mechanism of bacterial adhesion, colonization and invasion of mucous membranes of respiratory, enteric and urogenital tracts. Aggresssins and toxins.

UNIT II [15 Lectures]

Pathogenic Bacteria: Morphological characteristics, pathogenesis and laboratory diagnosis including rapid methods of following pathogenic bacteria; *Staphylococcus, Streptococcus, Neisseria, Klebsiella, Proteus, Salmonella, Shigella, Virbrio, Campylobacter, Pseudomonas, Acinetobacter, Yersinia, Francisella, Pasteurella, Haemophilus, Bordetella, Bacillus, Clostridium, Mycobacterium, Actinomyces, Nocardia, Bacteroides, Fusobacterium, Listeria, Legionella. Mycoplasma, Rickettsiae, Chlamydiae,* Spirochetes.

UNIT III [15 Lectures]

Pathogenic Fungi: Morphological characteristics, pathogenesis and laboratory diagnosis of following pathogenic fungi; - Microsporum*; Trichophyton; Histoplasmacapsulatum; Blastomycesdermatitidis; Candida albicans; Cryptococcus neoformans; Pneumocystis carinii.*

Protozoal Pathogens: General description, biological properties and diseases caused by Protozoa- *Plasmodium* spp, *Giardia intestinalis, Entamoebahistolytica, Pneumocystis jiroveci, Leishmaniatropica.*

UNIT IV **[15 Lectures]**

Viral diseases: Structure, cultivation, pathogenicity, lab diagnostics, prevention and control of viral diseases-Hepatitis, Herpes, Measles, Rabies, Polio, Rubella, Rotaviruses, Japanese Encephalitis, HIV, SARS, Ebola, Avian Flu, Swine Flu, Covid-19 and future pandemics.

Recommended Textbooks and References:

1. *Atlas, R.M., Principles of Microbiology, McMillan, New York. 2006.*
2. *Tortora, G.J., Funke, B.R., Case, C.L., Microbiology -An Introduction, 8th Edition, Pearson education Pvt. Ltd. Singapore. 2004.*
3. *Walsh, G., Biopharmaceuticals: Biochemistry and Biotechnology, John Wiley & Sons, New York. 1998.*
4. *Benjamin, E., Immunology-A short course (6th Ed.). John Wiley, New York. 2009.*
5. *Punt, J., Stranford, S., Jones, P. & Owen, J.A., Kuby Immunology (8th Ed.). Macmillan International Higher Education. 2018.*
6. *Ryan, K.J., Sherris Medical Microbiology (5th Ed.). McGraw-Hill. 2010.*

U25MMI404P: SOIL AND ENVIRONMENTAL MICROBIOLOGY LAB

Couse Credits	Internal Marks	External Marks	Total Marks	Examination hours
3	25	50	75	4h

COURSE OBJECTIVES

- *Introduce structural and functional components of the immune system, focusing on innate and adaptive mechanisms.*
- *Explain lymphocyte development, antigen recognition, and molecular basis of immune responses.*
- *Familiarize students with immunological techniques used in diagnostics, vaccine development, and research.*
- *Explore the immune basis of diseases like hypersensitivity, autoimmunity, immunodeficiency, and tumor immunity, along with therapies.*

COURSE OUTCOMES

- *Explain the roles of innate and adaptive immune components in host defense.*
- *Describe B and T cell responses and the molecular basis of antigen recognition and presentation.*
- *Apply immunological techniques to detect and analyze antigen-antibody interactions.*
- *Evaluate immune disorders and propose strategies for immunotherapy and disease management.*

List of Experiments

1. Introduction to various instruments and their working principles used in environment biotechnology laboratory.
2. Testing of tap and pond water for its purity to potable by MPN/any other method.
3. Testing of total dissolved solids of water.
4. Testing of dissolved oxygen concentration of water sample.
5. Testing of biological oxygen demand (BOD) of sewage sample.
6. Testing of chemical oxygen demand (COD) of sewage sample.
7. Isolation of xenobiont degrading bacteria by selective enrichment technique.
8. Test for the degradation of aromatic hydrocarbon by bacteria.
9. Effect of sulphur dioxide on crop plants.
10. Estimation of nitrate in drinking water.
11. Estimation of Phosphate in Water Samples
12. Assessment of Soil Microbial Activity using dehydrogenase or respiration assays.

Recommended Textbooks and References:

1. *Environmental Microbiology – A laboratory manual, L.L. Gerba, C.P. and Brendeeke. J.W. (1995) Academic Press, New York.*
2. *Experiments in Microbiology, Plant Pathology and Biotechnology 5th edition Aneja K.R. (2018) New Age International Publisher – New Delhi.*
3. *Microbiology – A laboratory manual 10th edition. Cappuceino J. and Sheeman N. (2016) Addison Wesley, California.*
4. *Environmental Microbiology – A laboratory manual. Pepper, I.L.; Gerba, C.P. and Brendecke, J.W. (2015) Academic Press, New York.*

U25MMI405P: NANO PARTICLES IN MICROORGANISMS AND MEDICAL MICROBIOLOGY LAB

Couse Credits	Internal Marks	External Marks	Total Marks	Examination hours
3	25	50	75	4h

List of Experiments

COURSE OBJECTIVES

- *Learn green and chemical methods for nanoparticle synthesis.*
- *Understand key nanoparticle characterization techniques.*
- *Explore biomedical and environmental applications of nanomaterials.*
- *Build and test nano-based systems using simple models and assays.*

COURSE OUTCOMES

- *Synthesize and characterize various nanoparticles.*
- *Analyze nanoparticle size and stability using UV-Vis and DLS.*
- *Assess nanoparticle bioactivity and toxicity.*
- *Design basic nano-enabled devices and delivery systems.*

1. Green synthesis of silver nanoparticles using plant extract.
2. Chemical synthesis of gold nanoparticles via citrate reduction.
3. UV-Visible spectroscopy for nanoparticle size estimation.
4. Microscopic observation of natural nanostructures, e.g., diatoms, lotus leaf.
5. Synthesis of iron oxide nanoparticles using co-precipitation method.
6. Preparation of chitosan nanoparticles for drug delivery applications.
7. Demonstration of carbon nanotube structure using models/simulations.
8. Zeta potential and DLS analysis (demo/simulated) for nanoparticle stability.
9. Design of polymeric nanocapsules using alginate and calcium chloride.
10. Paper-based microfluidic device fabrication (basic Lab-on-a-chip model).
11. Colorimetric detection of glucose using gold nanoparticle assay.
12. Assessment of nanoparticle toxicity using seed germination inhibition test.
13. Antibacterial assay of biosynthesized nanoparticles (e.g., against *E. coli*).
14. Simulated nanoparticle penetration test using agar-based diffusion.
15. Study of nanoparticle degradation in different pH and temperature conditions.

Recommended Textbooks and References:

1. *Anil Kumar, S., Karthik, L., Bhaskara Rao, K.V. A Practical Manual on Synthesis of Nanoparticles and Its Applications in Biology. ResearchGate Publication, 2017.*
2. *Kharissova, O.V., Dias, H.R., Kharisov, B.I. Handbook of Green and Sustainable Nanotechnology. 1st Edition, Springer, Switzerland, 2023.*
3. *Liu, Y., Mazumder, A., Ghosh, S., Bhowmik, R.N. Synthesis and Characterization of Superparamagnetic Iron Oxide Nanoparticles: A Series of Laboratory Experiments, Journal of Chemical Education, 2024, Vol. 101, No. 2, pp. 345–352.*

U25MMI401D: DISSERTATION WORK/ PROJECT WORK

Couse Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
12	**0**	**0**	**100**	**-**	**-**
Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.					

Planning & Performing Experiments:

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

Thesis writing:

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

Recommended Textbooks and References:

1. *Gosling, J.P., Planning, Conducting and Analysing Experiments in Science: A Complete Step-by-Step Guide. Chichester, UK: Wiley. 2022.*
2. *Kirk, R.E., Experimental Design: Procedures for the Behavioral Sciences (4th ed.). Thousand Oaks, CA: Sage Publications. 2012.*
3. *Hofmann, A.H., Scientific Writing and Communication: Papers, Proposals, and Presentations (4th ed.). New York, NY: Oxford University Press. 2022.*
4. *Turabian, K.L., A Manual for Writers of Research Papers, Theses, and Dissertations (9th ed.). Chicago, IL: University of Chicago Press. 2018.*

U25VAC130T: ENVIRONMENTAL MICROBIOLOGY

Couse Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
2	2	15	35	50	2h
The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt three questions in all selecting one question from each unit consisting of 10 marks each including compulsory Question No. 1.					

COURSE OBJECTIVES

- *Understand various types of environmental pollution and their control methods.*
- *Learn biological approaches for waste management and sustainable agriculture.*
- *Explore biotechnological applications in biodegradation, bioremediation, and biofuel production.*
- *Familiarize with environmental regulations, ethics, and responsible biotechnology use.*

COURSE OUTCOMES

- *Identify pollution types and apply appropriate control strategies.*
- *Apply agrobiotechnology tools like biofertilizers and biopesticides for environmental management.*
- *Demonstrate understanding of microbial roles in bioremediation and waste treatment.*
- *Evaluate biotechnological solutions for sustainable development and environmental ethics.*

UNIT I [15 Lectures]

Role of Agrobiotechnology for Environmental Management: Types and impacts of environmental pollution (air, water, soil, noise); pollution control methods including physical, chemical, and biological approaches; wastewater treatment processes like activated sludge and trickling filters; solid waste management through recycling, composting, and landfilling; use of bioinsecticides (*Bacillus thuringiensis*, baculoviruses) and biofungicides (*Trichoderma*, *Pseudomonas fluorescens*) in sustainable agriculture; application of biofertilizers and plant–microbe symbiosis (nitrogen fixation, mycorrhiza); and the role of PGPR in crop improvement and soil health.

UNIT II [15 Lectures]

Environmental Applications of Biotechnology: Biodegradation of xenobiotics and recalcitrant compounds; bioremediation techniques including bioventing, bioaugmentation, and phytoremediation; microbial degradation of pesticides, heavy metals, and hydrocarbons; composting and vermicomposting technologies; production of biofuels such as biogas, bioethanol, and biodiesel; industrial effluent treatment and waste management; biotechnological applications in mining including bioleaching and bioremediation; production and use of biofertilizers and biopesticides; environmental regulations and policies; corporate social responsibility and environmental ethics.

Recommended Textbooks and References:

1. *G. M. Evans and J. C. Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers.*
2. *B. Ritmann and P. L. McCarty, (2000), Environmental Biotechnology: Principle & Applications, 2nd Ed., McGraw Hill Science.*
3. *Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.*
4. *Thakur I.S. (2016) Environmental Biotechnology, Ik International Publishing house*
5. *Sharma P.D.(2007) Ecology and Environment, Rastogi publications.*
6. *Bartha A.(2009) Microbial Ecology, Dorling Kindersley Gupta M. (2018) Fundamentals of Environmental Biology, Ik International Publishing house*
7. *H. J. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc.*

U25OEC330T: PRINCIPLES OF NANO SCIENCE AND TECHNOLOGY

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
2	2	15	35	50	2h
The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt three questions in all selecting one question from each unit consisting of 10 marks each including compulsory Question No. 1.					

COURSE OBJECTIVES

- *To introduce fundamentals of nanobiotechnology, nanomaterials, and their synthesis.*
- *To explore applications of nanotechnology in agriculture, environment, and industry.*
- *To provide insights into biomedical applications including drug delivery and diagnostics.*
- *To discuss safety, ethical, and societal concerns related to nanotechnology.*

COURSE OUTCOMES

- *Describe nanobiotechnology concepts, materials, synthesis methods, and safety aspects.*
- *Identify applications of nanotechnology in agriculture, environment, and industry.*
- *Analyze biomedical uses of nanomaterials in drug delivery, diagnostics, and therapy.*
- *Evaluate ethical, societal, and environmental implications of nanoscience.*

Syllabus Outline

UNIT I [15 Lecture]

Introduction to Nanotechnology and Nanomaterials: Introduction to Nano-biotechnology, Insights and intervention into the Nanoworld, Historical Background, recent advances and future aspects, Safety, Health and environmental issues, Societal implications and ethical issues in Nanoscience and Nanotechnology. **Nanomaterials**- Types, Properties and applications; Synthesis methods- Physical, Chemical and Biological methods of synthesis; Carbon Nanotubes; Nanowires; Smart materials.

UNIT II [15 Lecture]

Applications of Nanotechnology in different fields: Agriculture and food processing- Nanopesticides, nanofertilizers, nanonutraceuticals, nanomaterials in food packaging, Smart nanoparticles in Agriculture; Environmental applications- removal of contaminants, Remediation of pollutants using nanomaterials; applications in Space, Defence, Consumer durables, Textiles, Cosmetics etc. Biomedical nanotechnology/ Nanomedicine, Lab-on-a-chip, Nanosensors, Nanotechnology in Cancer Therapy and Detection, Imaging, Drug Delivery, tissue repair etc.

Recommended Textbooks and References:

1. *Kulkarni, S, K. 2014. Nanotechnology- Principles and Practices. 3rd Edition, Capital Publishing Company.*
2. *Vajtai, R 2013. Handbook of Nanomaterials, Springer.*
3. *Hari Singh Nalwa 2011. Encyclopaedia of Nano Science and Nanotechnology. American Scientific Publishers.*
4. *Balzani, V., Credi, A. and Verturi, M. 2003. Molecular Devices and Machines- A Journey into Nanoworld. Wiley-VCH Verlag.*
5. *Albert Folch (2013) "Introduction to BioMEMS", CRC Press.*
6. *Wolfson, J.R.: 2003, 'Social and Ethical Issues in Nanotechnology: Lessons from Biotechnology and Other High Technologies', Biotechnology Law Report, 22, no 4, 376-96.*
7. *Bhushan, Bharat. 2004. Handbook of Nanotechnology. Springer.*

U25SEC430T/ U25SEC404T: BIO-ENTREPRENEURSHIP, INTELLECTUAL PROPERTY RIGHTS & BIOSAFETY

Couse Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
2	2	15	35	50	2h
The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt three questions in all selecting one question from each unit consisting of 10 marks each including compulsory Question No. 1.					

COURSE OBJECTIVES

- *Explain the concept, scope, and significance of bio-entrepreneurship and identify key entrepreneurial traits.*
- *Describe the biotech start-up ecosystem, funding opportunities, and support mechanisms.*
- *Develop foundational knowledge in business planning, financial modelling, and commercialization strategies.*
- *Understand the basics of IPR, biosafety, and relevant national/international legal frameworks for biotechnology.*

COURSE OUTCOMES

- *Identify the characteristics of successful bio-entrepreneurs and summarize the role of biotechnology in entrepreneurship.*
- *Analyze components of a business plan and evaluate funding models and commercialization pathways.*
- *Explain the types of intellectual property and outline the patent filing process and biotech-specific IP laws.*
- *Apply biosafety principles and assess regulatory guidelines related to GMOs, risk levels, and international protocols.*

UNIT I [15 Lecture]

Bio-entrepreneurship: Introduction to Bio-entrepreneurship (Definition, scope, and importance, Entrepreneurial traits and types, Role of biotechnology in entrepreneurship development). Start-up Ecosystem in Biotechnology (Incubators, accelerators, and biotech parks, Public-private partnerships, National and international funding agencies (e.g., BIRAC, DBT, DST, Venture Capital). Business Plan and Financial Management (Market analysis and business strategy, Writing a business plan, financial projections, costing, funding models). Regulatory Environment and Commercialization (Drug development and clinical trial regulations, Regulatory bodies: CDSCO, DBT, WHO, FDA, Product lifecycle and go-to-market strategy)

UNIT II [15 Lecture]

Intellectual Property Rights and Biosafety: Introduction to IPR (Patents, copyrights, trademarks, trade secrets, Patent filing process in India and internationally, Criteria for patentability (novelty, inventive step, industrial application). Patent Laws and Biotechnology (Biotechnology-specific IP laws (genes, GMOs, biological materials, WTO and TRIPS agreement and Indian Patent Act, Compulsory licensing, patent infringement and litigation. IP Management and Technology Transfer (Licensing, MTA, NDA, commercialization of IP, Role of TTOs and IP management cells). Biosafety Principles and Risk Management (Biosafety levels (BSL-1 to BSL-4), Genetically Modified Organisms (GMOs) and LMOs, Cartagena Protocol and Indian biosafety guidelines

Recommended Textbooks and References:

1. *"Bio Entrepreneurship" by Dr. G. Chelladurai, Dr. Sr. S. Iruthaya Kalai Selvam, and Dr. Priya Sundarrajan*

2. *"Biotechnology Entrepreneurship: Leading, Managing, and Commercializing Innovative Technologies" by M.D. Shimasaki.*
3. *Bioentrepreneurship and Transferring Technology Into Product Development" by Swati Agarwal*
4. *"Innovation and Entrepreneurship" by Peter F. Drucker*
4. *"Law Relating to Intellectual Property Rights" by V.K. Ahuja.*
5. *"Fundamentals of Intellectual Property Rights" by Ramakrishna B & Anil Kumar H.S*
6. *"Patent Law for Scientists and Engineers" by Howard B. Rockman*
7. *"Biosafety in Microbiological and Biomedical Laboratories (BMBL)" – CDC & NIH Guidelines*
8. *"Environmental Biotechnology and Biosafety" by Suresh Chandra*
9. *"Biosafety and Bioethics" by R. C. Sobti and P. K. Gaur*
10. *Adams, D.J. & Sparrow, J.C., Enterprise for Life Scientists: Developing Innovation sand Entrepreneurship in the Biosciences. Bloxham: Scion. 2008.*
11. *Karhad, P., How to Patent an Idea in India: From Idea to Granted Patent in Quickest Time, Saving Costs and Making Money with Your Patented Invention; A Step by step guideline on Intellectual Property in India. 2018.*
12. *Chopra, R.K., Indian Patent System. Himalaya Publishing House. 2010.*
13. *Patzelt, H. & Brenner, T., Handbook of Bioentrepreneurship: 4 (International Handbook Series on Entrepreneurship). Springer. 2010.*
14. *Shimasaki, C.D. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier. 2014.*
15. *Jordan, J.F., Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press. 2014.*

U25EEC430T: RESEARCH METHODOLOGY

Couse Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
2	**2**	**15**	**35**	**50**	**2h**
The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt three questions in all selecting one question from each unit consisting of 10 marks each including compulsory Question No. 1.					

COURSE OBJECTIVES

- *To introduce scientific methods and reasoning in biology.*
- *To develop skills in scientific writing and ethics.*
- *To explain statistical tools for data analysis.*
- *To train in research software and referencing tools.*

COURSE OUTCOMES

- *Explain scientific methods, reasoning, and research approaches in biological sciences.*
- *Develop and assess technical and scientific writing for publications and reports.*
- *Apply statistical tools and tests for data analysis and experimental design.*
- *Use research software and reference tools for effective scientific communication.*

UNIT I [15 lectures]

History of Science and Science Methodologies: Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology.

Scientific Communication: Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, their types, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and nonblind review, scientific misconduct.

UNIT II [15 lectures]

Biostatistics: Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, factorial experiment design. Introduction and. Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/Mendeley, applications of SPSS and R softwares.

Recommended Textbooks and References:

1. *Valiela, I., Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press. 2001.*
2. *On Being a Scientist: A Guide to Responsible Conduct in Research, Washington, D.C.: National Academies Press. 2009.*
3. *Gopen, G.D. and Smith, J.A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558. 1990.*
4. *Rosner, B., Fundamentals of Biostatistics. Boston, MA: Duxbury Press. 2000.*
5. *Daniel, W.W., Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley. 1987.*