POs Post-Graduate Programme

Course: MSc Microbiology (1st semester)

Subject: General Microbiology (Theory)

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to introduce field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition; methods for control of microbes and host- microbe interactions.	
Unit I **Microbial characteristics**	History and scope of microbiology, a brief idea of microbial diversity, Principles of classification of microbes: Morphological, metabolic and molecular criteria for the classification.
Unit II **Microbial diversity**	Structure, classification and life cycle of bacteria, fungi, algae and virus, extremophiles. Growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods (isolation, purification, enrichment techniques and maintenance and enumeration), mode of nutrition.
Unit III **Control of microorganism**	Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms. Antibiotics, antiviral, antifungal, antimicrobial resistance
Unit IV **Microbial Reproduction**	Mode of reproduction in microbes, genetic exchange in microbe, transformation, transduction, conjugation, evolutionary significance
Unit V **Host-microbes interaction**	Host-pathogen interaction, ecological impact of microbes; symbiosis, microbes and nutrient cycles; microbial communication system; bacterial quorum sensing, prebiotics and probiotics, industrial and environmental application of microbes

Recommended Textbooks and References:

1. Pelczar,M.J.,Reid,R.D.,&Chan,E.C.(2001).Microbiology(5th ed.). New York:McGraw-Hill.
2. Willey,J.M.,Sherwood,L.,Woolverton,C.J.,Prescott,L.M.,&Willey,J.M.(2011). Prescott's Microbiology. New York: McGraw-Hill.
3. Matthai,W.,Berg,C.Y.,&Black,J.G.(2005).Microbiology,Principlesand Explorations.Boston,MA:JohnWiley&Sons

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.

PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**(MSc Microbiology- 1st semester) General Microbiology**
CO1	Identify major categories of microorganisms and analyse their classification, diversity, and ubiquity.
CO2	Identify and demonstrate structural, physiological, genetic similarities and differences of major categories of microorganisms; Identify and demonstrate how to control microbial growth.
CO3	Demonstrate and evaluate interactions between microbes, hosts and environment..

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	2	3	1	2	2
CO2	3	2	3	3	1	2		3	3	2	3	1	2
CO3	2	2	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (1st semester)

Subject: Cell and Molecular Biology (Theory)

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules, the understanding of various biological processes becomes deeper and inclusive.	
Unit I **Cellular transport, trafficking and cytoskeleton**	Cell membranes: methods to study organization of membranes, Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; Intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior; Cytoskeleton: Composition, organization and functions of Microfilaments, microtubules, intermediate filaments and associated proteins.
Unit II **Chromatin structure and dynamics**	Chromatin structure, DNA-replication, Gene expression in prokaryotes, Genetic code, Transcription and its regulation; operons, attenuation, anti-termination and anti-sense controls. Prokaryotic translation machinery, Gene expression in eukaryotes: Transcription, general and specific transcription factors, regulatory elements and mechanism of regulation, processing of transcripts. Eukaryotic Translation, Inhibitors of Transcription and Translation in prokaryotes and eukaryotes
Unit III **Cellular Signalling and cell adhesion**	Basic concept of signal transduction, Cell receptors, Second messengers, intracellular signalling cascade, Cell adhesion; cell junctions, cell adhesion molecules.
Unit IV **Cell cycles and its regulation**	Cell cycle, Cell cycle checkpoints, regulation of cell cycle; cell death: different modes of cell death and their regulation.
Unit V **Cancer**	Biology of cancer cells; Carcinogens; Proto-oncogenes, viral and cellular oncogenes; oncogenic transformation; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes.

Recommended Textbooks and References

1. Alberts,B.,Johnson,A.,Lewis,J.,Raff,M.,Roberts,K.,&Walter,P.(2008). *Molecular Biology of the Cell* (5th Ed.). New York: Garland Science.
2. Lodish,H.F.(2016).*MolecularCellBiology*(8thEd.).NewYork:W.H.Freeman.
3. Krebs,J.E.,Lewin,B.,Kilpatrick,S.T.,&Goldstein,E.S.(2014).*Lewin'sGenesXI*. Burlington, MA: Jones &BartlettLearning.
4. Cooper,G.M.,&Hausman,R.E.(2013).*TheCell:aMolecularApproach*(6thEd.). Washington: ASM ;Sunderland.
5. Hardin,J.,Bertoni,G.,Kleinsmith,L.J.,&Becker,W.M.(2012).*Becker'sWorldof theCell*.Boston (8thEd.). BenjaminCummings.
6. Watson,J.D.(2008).*MolecularBiologyoftheGene*(5thed.).MenloPark,CA: Benjamin/ Cummings.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**(MSc Microbiology- 1st semester) Cell and Molecular Biology (Theory)**
CO1	Student should be equipped to understand three fundamental aspects in biological phenomenon like cell structure and cell signalling
CO2	Learn and understand of various biological processes becomes deeper and inclusive. Identify and demonstrate structural and physiological
CO3	Understand the genetic similarities and differences of major categories of microorganisms; Identify and demonstrate how to control microbial growth.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	2	3	2	2	2
CO2	3	2	3	3	1	2		3	3	2	3	1	2
CO3	2	2	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (1st semester)

Subject: Biochemistry (Theory)

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasisondifferentmetabolicpathways. The course shall make the students aware of various disease pathologies within the context of eachtopic.	
Unit I **Bioenergetics &Glycochemistry**	Bioenergetics-basic principles; equilibrium and concept of free energy. basic concepts of metabolism. Coupled reactions, Interconnecting reactions, Electron transport, Oxidative phosphorylation, energetics of chemolithotrophs and autotrophs, Synthesis of ATP and other energy rich compounds.Glycolytic pathways, Citric acid cycle, energy production, Carbohydrate Biosynthesis, Glyoxylate cycle, Gluconeogenesis, Glycogenolysis.
Unit II **Protein Biochemistry**	Nitrogen acquisition andassimilation,Biosynthesis amino acids, Mechanism of transamination reaction, Amino acid oxidation and production of urea, Urea cycle, Pathways of amino acid degradation, Protein structure (primary, secondary, tertiary &quartenary), basic principles of protein purification.
Unit III **Lipid Biochemistry**	Lipid: classification, biosynthesis, *de Novo* biosynthesis, biosynthesis of unsaturated fatty acids, Biosynthesis of membrane lipids and steroids, Degradation of fatty acids, β oxidation, ω oxidation. Principles of lipid metabolic regulations
Unit IV **Nucleic Acid**	Nucleic acids - structure, *de Novo* and salvage pathway of synthesis of purine and pyrimidine bases, regulation of nucleotide biosynthesis. Catabolism of purine and pyrimidine.
Unit V **Enzyme and Enzyme Technology**	Enzyme:nomenclature and classification, catalysis - general principles, quantitation of enzyme activity and efficiency; enzyme kinetics; relevance of enzymes in metabolic regulation, catalytic strategies, regulatory strategies; isozymes, covalent modification, zymogens.

Recommended Textbooks and References

1. Stryer,L.(2002).*Biochemistry*.NewYork:Freeman.
2. Lehninger,A.L.(2004).*PrinciplesofBiochemistry*(4th ed.).NewYork,NY:Worth.
3. Voet,D.,&Voet,J.G.(2004).*Biochemistry*(4th ed.).Hoboken,NJ:J.Wiley&Sons.
4. Dobson,C.M.(2003).*ProteinFoldingandMisfolding*.Nature,426(6968),884-890. doi:10.1038/nature02261.
5. Richards,F.M.(1991).*TheProteinFoldingProblem*.ScientificAmerican, 264(1), 54-63.doi:10.1038/scientificamerican0191-54.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**(MSc Microbiology- 1st semester) Biochemistry (Theory)**
CO1	On completion of this course, students should be able to: Gain fundamental knowledge in biochemistry.
CO2	Understand the enzymes technology
CO3	Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	2	2	1	2	2
CO2	3	2	3	3	1	2		3	3	2	3	1	2
CO3	2	2	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (1st semester)

Subject: Bio-analytical technique (theory)

Credit: 3

Syllabus:

Course Objectives	
The objective of the course is to develop the skills to understand the theory and practice of bioanalytical techniques. In addition to understanding the basic concepts and applications of bioanalytical techniques, this course provides scientific understanding of bioanalytical techniques and detail interpretation of results.	
Unit I **Microscopy**	Microscopy: history and principles of microscopy, Light microscopy: sample preparation, bright field, dark field, phase contrast and fluorescent microscopy; Electron microscopy: fixation and staining techniques in electron Microscopy, transmission and scanning electron microscopy; confocal microscopy, atomic force microscopy.
Unit II **Chromatography**	Chromatography: Basics of Chromatography, Paper chromatography, Thin layer chromatography; Affinity chromatography, Gel Filtration chromatography, Ion Exchange chromatography, Gas chromatography, HPLC.
Unit III **Centrifugation, Biosensors & radio-imaging techniques**	Centrifugation: introduction to laboratory centrifuges, basic principle, RCF and Sedimentation Coefficient, differential centrifugation, density gradient centrifugation. Biosensors: basic techniques, microbial biosensors, radio-imaging techniques (Ultrasonography, CT Scan etc.)
Unit IV **Nucleic acid amplification & Electrophoresis**	Nucleic acid amplification: variation and application of PCR,Electrophoresis: Principle of electrophoresis, agarose gel electrophoresis, Polyacrylamide gel electrophoresis (PAGE) (Native PAGE and SDS PAGE), isoelectric focusing, two-dimensional (2D) gel electrophoresis, pulse field electrophoresis.
Unit V **Spectroscopy**	Spectroscopy: Theory and applications; UV-Visible spectroscopy, Fluorescence spectroscopy, atomic absorption spectroscopy, Infrared spectroscopy (IR), electron spin resonance spectroscopy (ESR), nuclear magnetic resonance spectroscopy (NMR), Mass spectroscopy, X-Ray Diffraction.

Recommended Textbooks and References

1. K. Wilson, J. M. Walker, Eds., Principles and techniques of biochemistry and molecular biology (Cambridge University Press, Cambridge, UK : New York, 7th ed., 2009).
2. R. L. Switzer, Experimental biochemistry (W. H. Freeman and Co, New York, 3rd ed., 1999)
3. R. F. Boyer, Modern experimental biochemistry (Benjamin Cummings, San Francisco, 3rd ed., 2000)
4. R. F. Boyer, Biochemistry laboratory: modern theory and techniques (Prentice Hall, Boston, 2nd ed., 2012).
5. R. Katoch, Analytical techniques in biochemistry and molecular biology (Springer, New York, 2011).
6. D. Harvey, Modern analytical chemistry (McGraw-Hill, Boston, 2000).
7. D. L. Spector, R. D. Goldman, Eds., Basic methods in microscopy: protocols and concepts from cells: a laboratory manual (Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y, 2006).

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop

	capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Biotechnology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	Bio-analytical technique (Theory) (MSc Microbiology- 1 semester)
CO1	On completion of this course, students should be able to understand the basic concepts, applications and limitations of bioanalytical techniques.
CO2	This course provides scientific understanding of bioanalytical technique and detail interpretation of results.
CO3	This will lead to development of practical skills to undertake future analytical/research activities.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	1	3		3	2	3	1	2	2
CO2	3	2	3	3	1	2		3	2	2	3	1	2
CO3	2	1	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (1st semester)

Subject: Genetics (Theory)

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to take students through basics of genetics and classical genetics covering prokaryotic/ phage genetics to yeast and higher eukaryotic domains. On covering all classical concepts of Mendelian genetics across these life-forms, students will be exposed to concepts of population genetics, quantitative genetics encompassing complex traits, clinical genetics and genetics of evolution.	
Unit I **Mendalian Geneticsand Non Mendelian Inheritance**	Mendelian Laws of Genetics, chromosomal theory of inheritance, deviations from Mendel's findings. Non Mendelian Inheritance. Interaction of genes. Allelic and non-allelic interactions, Types of dominance, lethal alleles, multiple alleles, complementary genes, duplicate genes, epistasis.
Unit II **Mutation and DNA repair**	Mutagens, Types of mutations, Effects of Mutations, Mutations in Protein-Coding Genes;auxotrophs and prototroph; Mutations in Regulatory Sequences; Mutations in tRNA and rRNA genes; detection and isolation of mutants. DNA repair: Excision Repair, Direct Repair, Mismatch Repair, Recombinational Repair, The SOS response.
Unit III **Microbial Genetics**	Horizontal Gene Transfer in Prokaryotes, Bacterial Plasmids, Types of Bacterial Conjugation; Bacterial Transformation and DNA Uptake Systems. Generalized Transduction and Specialized Transduction, Genetic Recombination in viruses, yeast and fungal genetics.
Unit IV **Chromosomal and genetic anomalies**	Karyotyping, banding pattern, euchromatin and heterochromatin, structural and numerical alterations in chromosomes, deletions, duplications, translocation, inversion, haploid, aneuploids and polyploids. Gene linked defects. In born errors of metabolism, Pedigree analysis.
Unit V **Genetic markers and Population genetics**	Molecular markers (RFLP, SSLP, AFLP, RAPD, VNTR, SSR, SNP, STR, RAD, STS, QTL). Population genetics, Hardy- Weinberg equilibrium, genetic drift, evolution and neutral evolution, mutation selection, balancing selection, linkage disequilibrium; migrations, adaptive landscape, spatial variation & genetic fitness.

Recommended Textbooks and References

1. Hartl,D.L.,&Jones,E.W.(1998).*Genetics:PrinciplesandAnalysis*.Sudbury, MA: Jones and Bartlett.
2. Pierce,B.A.(2005).*Genetics:aConceptualApproach*.NewYork:W.H.Freeman.
3. Tamarin,R.H.,&Leavitt,R.W.(1991).*PrinciplesofGenetics*.Dubuque, IA: Wm. C.Brown.
4. Smith,J.M.(1998).*EvolutionaryGenetics*.Oxford:OxfordUniversityPress

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**(MSc Microbiology- 1st semester) Genetics (Theory)**
CO1	On successful completion of this course, student will be able : Describe fundamental molecular principles of genetics; Understand relationship between phenotype and genotype in human genetictraits.
CO2	Describe the basics of genetic mapping
CO3	Understand how gene expression is regulated.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	2	2	1	2	2
CO2	3	2	3	3	1	2		3	3	2	3	1	2
CO3	2	2	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (1st semester)

Subject: Microbiology & Cell and Molecular Biology Laboratory

Credit: 3

Syllabus:

Course Objectives	
The objective of this laboratory course is to provide practical skills on basic techniques of microbiology, cell and Moelcular biology.	
Microbiology Laboratory	1. Sterilization, disinfection and safety in microbiologicallaboratory. 2. Preparation of media for cultivationofbacteria. 3. Preparation of media for cultivationof fungi. 4. Isolation and identification of bacteria fromsoil/water samples. 5. Enumeration of bacteria: standard platecount. 6. Isolation and identification of fungi. 7. Studyofcolonyandgrowthcharacteristicsofsomecommonbacteria: Bacillus, E. coli, Staphylococcus, etc. 8. Preparation of bacterial smear andGram'sstaining. 9. Antimicrobial sensitivity test and demonstration of drug resistance. 10. Maintenanceofstockcultures:slants,stabsandglycerolstockcultures 11. Determination of phenol co-efficient ofantimicrobialagents. 12. Determination of Minimum Inhibitory Concentration (MIC)
Cell and Molecular Biology Laboratory	1. Microscopic measurements (micrometry) 2. Observation of Plasmolysis 3. Nucleus staining of blood cells by haematoxylin. 4. Isolation of nucleus, mitochondria, chloroplast and other cell organelles. 5. Karyotyping. 6. To study mitosis in onion root tip and meiosis in flower bud. 7. Isolation of DNA. 8. Isolation of RNA 9. Quantification of Nucleic Acid 10. Agarose Gel Electrophoresis 11. Polymerase Chain Reaction (PCR)
Recommended Textbooks and References K. Wilson, J. M. Walker, Eds., Principles and techniques of biochemistry and molecular biology (Cambridge University Press, Cambridge, UK : New York, 7th ed., 2009). Plummer. An introduction to practical biochemistry (McGraw Hill Education; 3rd edition, 2017)	

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of

	biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**(MSc Microbiology- 1st semester)** **Microbiology & Cell and Molecular Biology Laboratory**
CO1	Isolate, characterize and identify common bacterial organisms;
CO2	Determine bacterial load of different samples; Perform antimicrobial sensitivity tests; Preserve bacterial cultures
CO3	Stain and Measure size of miscroscopic cells

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	2	2	1	2	2
CO2	3	2	3	3	1	2		3	3	1	2	1	2
CO3	2	2	3	2	3	3		2	3	1	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (1st semester)

Subject: Biochemistry & Bio-analytical Techniques Laboratory

Credit: 3

Syllabus:

Course Objectives	
The objective of this laboratory course is to introduce students to experiments in biochemistry. The course is designed to teach students the utility of set of experimental methods in biochemistry in a problem oriented manner.	
Biochemistry Laboratory	1. Qualitative analysis of amino acid 2. Qualitative analysis of carbohydrate 3. Qualitative analysis of lipids 4. Quantitative estimation of protein 5. Quantitative estimation of carbohydrate 6. Quantitative estimation of RNA 7. Quantitative estimation of DNA 8. Enzyme assay 9. Enzyme kinetics
Bio-analytical Techniques Laboratory	1. Demonstration of microscope, centrifugation, colorimeter, spectrophotometer and other instruments. 2. Morphological study of microbes by using microscopy 3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law. 4. Determination of absorption maxima of given sample using spectrophotometer. 5. Separation of amino acids/sugars by paper chromatography. 6. Separation of amino acids/sugars by Thin Layer Chromatography. 7. Agarose Gel electrophoresis 8. Polyacrylamide gel electrophoresis (PAGE)

Recommended Textbooks and References

1. K. Wilson, J. M. Walker, Eds., Principles and techniques of biochemistry and molecular biology (Cambridge University Press, Cambridge, UK : New York, 7th ed., 2009).
2. T. Palmer and P.L. Bonner, ENZYMES: Biochemistry, Biotechnology and Clinical Chemistry (Woodhead Publishing, UK, 2nd ed., 2007)
3. Plummer. An introduction to practical biochemistry (McGraw Hill Education; 3rd edition, 2017)
4. S. Sadasivam and A Manickam, Biochemical Methods (New Age International (P) Limited, New Delhi, 2nd ed., 1996)

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.

PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**(MSc Microbiology- 1st semester) Biochemistry & Bio-analytical Techniques Laboratory**
CO1	On completion of this course, students should be able to: To elaborate concepts of biochemistry with easy to run experiments;
CO2	To familiarize with basic laboratory instruments and understand
CO3	And finally the principle of measurements using those instruments with experiments in biochemistry.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	2	2	1	2	2
CO2	3	2	3	3	1	2		3	3	2	2	1	2
CO3	2	2	3	2	3	3		2	3	1	1	2	3

POs Post-Graduate Programme

Course: MSc Microbiology 1st semester

Subject: (OPEN ELECTIVE) Applied Microbiology (MBPAT01)

Credit: 5

Syllabus:

Course Objectives	
The objectives of this course are to learn students basic and application of Microbiology in various field. This course is designed to introduce the applied part of microbiology in food, dairy, environment, industry and agriculture.	
Unit I **Fundamentals of Microbiology**	Brief history and scope of microbiology, Microbial diversity and general structure and methods for microbial culture, control of microorganisms.
Unit II **Food and dairy microbiology**	Microorganisms important in food and dairy, molds, yeasts and bacteria. Spoilage of food, vegetables, eggs, milk and milk products, meat and meat products, fish and sea foods and canned food, fermented food, pickled cucumber, sauerkraut, bread, cheese, vinegar, mushroom cultivation, basics of food preservation
Unit III **Environmental microbiology**	Treatment of wastewater, septic tanks, lmhoff tank. Role of organic pollutant in water, concept of BOD and COD. Purification of drinking water. Bioremediation of pest control, biosurfactant as a detergent (Dextran, Xanthan).
Unit IV **Industrial Microbiology**	Large scale production of alcohol beverages, wine and vinegar, acetic acid, introduction of fermentation, basic design of fermenters, tannery industry. Use in colorization and decolorization in cosmetics (skin and hair), production of antibiotics, vaccine, therapeutic molecules
Unit V **Microbial products for agriculture**	Biofertilizer, plant and growth promoting fungi, nitrogen fixation. Biopesticides, transgenic crops from Bt and application. Composting, biofuel-ethanol, methanol. Biogas production.
Recommended Textbooks and References 1. Frazier W.C and Westhoff D.C. (2008). Food Microbiology 4th edition. Tata McGraw Hill publication co., New Delhi. 2. Willey, J.M., Sherwood, L. and Woolverton, C.J., 2011. Prescott's microbiology (Vol. 7). New York: McGraw-Hill.	

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics,

	Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Applied Microbiology (Open elective)**
CO1	The objectives of the course are to develop the skills to understand basics and application of Microbiology in various field
CO2	The course designed to introduce the applied part of microbiology in food and environmental sector.
CO3	Student will be able to plan for utilising benefit of microbes

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	2	2	2		2	3	3	3	1	1
CO2	3	3	2	3	3	2		3	3	2	2	1	2
CO3	3	3	2	3	1	2		3	2	3	1	2	1

POs Post-Graduate Programme

Course: MSc Microbiology (2nd semester)

Subject: Immunology

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to learn about structural features of components of immune system as well as their function. The major emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial ,viral or parasitic infection, and prove it by designing new experiments.	
Unit I **Fundamental of immune system**	Introduction and History of Immunology, Molecular and Cellular components of Immune system.Lymphoidorgans.Innate and adaptive immune response.Humoral and cell mediated immune response. Antigens, haptens; Antibody structure and Function; Catalytic Antibodies; Antigen-Antibody reaction and Application
Immune Responses	Inflammatory responses; Major Histocompatibility Complex and Antigen processing and presentation; Complement System; Molecular patterns and their receptors; Cytokines; Activation of innate immune cells. Macrophages-mediated cytotoxicity
Unit III **Lymphocyte Biology**	Immunoglobulin genes; Gene rearrangement of Ig Genes and Antibody diversity; Generation, activation and differentiation of B cells and T cells maturation, Functional subsets of lymphocytes. Cell-mediated cytotoxicity –T cell; NK cell; ADCC; Lymphocyte trafficking, immune tolerance
Unit IV **Immunity against Infection**	Immunity to infection: Immune response against pathogens. immune exhaustion Types of Vaccines and their application; Vaccine designing; Edible vaccine; Cell based vaccines; Monoclonal Antibody; Antibody Engineering
Unit V **Clinical immunology**	Immunosenescence, Immunological Disorders: Hypersensitivity; autoimmunity; immunodeficiency; Transplantation, Tumor immunology.

Recommended Textbooks and References

1. Kindt,T.J.,Goldsby,R.A.,Osborne,B.A.,&Kuby,J.(2006).*KubyImmunology*. New York: W.H.Freeman.
2. Brostoff,J.,Seaddin,J.K.,Male,D.,&Roitt,I.M.(2002).*ClinicalImmunology*. London: Gower Medical Pub.
3. Murphy,K.,Travers,P.,Walport,M.,&Janeway,C.(2012).*Janeway'sImmunobiology*. New York: GarlandScience.
4. Paul,W.E.(2012).*FundamentalImmunology*.NewYork:RavenPress.
5. Goding,J.W.(1996).*MonoclonalAntibodies:PrinciplesandPractice:Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology*. London: AcademicPress.
6. Parham,P.(2005).*TheImmuneSystem*.NewYork:GarlandScience

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Immunology (MSc Microbiology- 2nd semester)**
CO1	On completion of this course, students should be able to: Evaluate usefulness of immunology in different pharmaceutical companies;
CO2	Identify proper research lab working in area of their own interests;
CO3	Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxicT lymphocyte responses and figure out kind of immune responses in the setting of infection(viral or bacterial).

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	2	3	2	2	2
CO2	3	2	3	3	1	2		3	3	2	3	1	2
CO3	2	2	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (2nd semester)

Subject: Recombinant DNA Technology (Theory)

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to teach students with various approaches to conducting genetic engineering and their applications in biological research as well as in biotechnology industries. Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course	
Unit I **Introduction and tools for genetic engineering**	Restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; Cutting and joining of DNA; labeling of DNA: hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization.
Unit II **Different types of vectors**	Cloning and expression vectors: Plasmids; Bacteriophages; Cosmids, Phagemids Artificial chromosome vectors (YACs; BACs); Viral vector for gene delivery; expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors T-vectors
Unit III **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; microarrays; Protein-DNA interactions: electrophoretic mobility shift assay; DNasefootprinting; methyl interference assay, chromatin immunoprecipitation ; protein-protein interactions using yeast two-hybrid system; phage display.
Unit IV **Different types of PCR techniques**	site specific mutagenesis; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; DNA marker: SSCP, DGGE, RFLP, AFLP,
Unit V **Gene silencing and genome editing technologies**	Gene silencing techniques; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; Transgenics-gene replacement; gene targeting; creation of transgenic and knock-out mice; introduction to genome editing by CRISPR-CAS

Recommended Textbooks and References

1. Old,R.W.,Primrose,S.B.,&Twyman,R.M.(2001).*PrinciplesofGeneManipulation:anIntroductiont oGeneticEngineering*.Oxford:Blackwell ScientificPublications.
2. Green,M.R.,&Sambrook,J.(2012).*MolecularCloning:aLaboratoryManual*. Cold Spring Harbor, NY: Cold Spring HarborLaboratoryPress.
3. Brown,T.A.(2006).*Genomes* (3rd ed.).NewYork:GarlandSciencePub.
4. Selectedpapersfromscientificjournals,particularlyNature&Science.
5. TechnicalLiteraturefromStratagene,Promega,Novagen,NewEnglandBiolab*etc.*

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Recombinant DNA Technology (MSc Microbiology- 2nd semester)**
CO1	Given the impact of genetic engineering in modern society, the students should be endowed with strong theoretical knowledge of this technology.

CO2	Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course
CO3	In conjunction with the practical's in molecular biology & genetic engineering, the students should be able to take-up biological research as well as placement in the relevant biotech industry.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	2	3	2	2	2
CO2	3	2	3	2	1	2		3	3	2	1	1	2
CO3	2	2	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (2nd semester)

Subject: Microbial Physiology (Theory)

Credit: 3

Syllabus:

Objectives	
To develop understanding about microbial metabolism, growth and energy generation. Gain knowledge of various fermentation pathways, microbial communication and energetics. Familiarize students with concepts of nitrogen and phosphate assimilation, electron transport chain and transfer of genetic information among microbial communities.	
Unit I **Introduction to Microbial Physiology**	The *E.coli*Paradigm, Metabolic genetic regulation, Energy, oxidation-reduction vs. fermentation, Microbial growth: Growth cycle, continuous culture, factors affecting growth. Concept of aerobic respiration, anaerobic respiration and fermentation.
Unit II **Nutritional Classification**	Classification of bacteria based on nutrients. Membranes of microorganisms, Ion channels Passive and facilitated diffusion, Primary and secondary active transport, concept of uniport, symport and antiport, Group translocation and Iron uptake, Physiology of acidophiles, alkalophiles, osmophiles, Halophiles, Saccharophiles, Thermophiles, Psychrophiles, Luminiscent Bacteria, Bacterial luminescence mechanism,
Unit III **Bioenergetics and Fermentation**	Energetics of chemolithorophs, pH Homeostasis, specific transport systems, cellulose degradation, Metabolism of aromatic compounds, Fermentation pathways in specific group of microorganisms: Lactic acid, propionic acid, butyric acid producing fermentation.

Unit IV **Metabolism**	Characteristics and Metabolism of autotrophs; Endospore formation (differentiation). Bacterial Quorum sensing, chemotaxis, Photosynthesis in microorganisms, nitrogen assimilation and fixation, methanogens and methylotrophs, iron and sulfate reduction, acetogenesis. Hydrocarbon transformation, storage granules,
Unit V **Stress physiology**	Oxidative stress, thermal stress, starvation and stringent response. Transition from aerobic to anaerobic. Introduction to two component system, regulatory systems during aerobic- anaerobic shifts. Osmotic control of gene expression, SOS response and Heat shock response, Electron transport (Respiratory pathway), Phosphate starvation-controlled stimulon, oxidation stress, The Lon system (Proteolytic control).

Recommended Textbooks and References

1. MicrobialPhysiology,Moat,AG,Foster,JWandSpector,MP,Edition4th,JohnWilleyPublication.
2. BiologyofmicroorganismsbyMadigan,MT,Martinko,JM,stahl,DAandclark,DP,Edition13thBenjaminCummings.
3. AdvancesinMicrobialPhysiologybyRabertPoole,RK.,Volume53ElsevierScience&Technology
4. Microbial PhysiologyandMetabolismbyCaldwell,DR,Edition 2nd,StarPubCo.
5. Pollard, T. D., and Earnshaw, W. C., Cell Biology, 2nd Edition, Saunders Elsevier, 2008
6. Lodish, H., Berk A., Kaiser C. A., Krieger M., Scott M.P., Bretscher A., Ploegh H., and Matsudaira P., Molecular Cell Biology, 6th Edition, Freeman, W. H. and Co., 2008.
7. James Darnell, Molecular Cell Biology, 6th Edition, W. H. Freeman & Co, 2007.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for

	use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course	**(MSc Microbiology- 2nd semester)** **Microbial Physiology** **(Cradit-3) Theory**

Outcome	
CO1	Acquaint with basics of metabolism and growth under normal and stressed conditions.
CO2	Understand major fermentation, aerobic and anaerobic pathways for energy generation in microbial cells.
CO3	Knows the concepts of microbial cross-talk.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	2	3	1	2	2
CO2	3	2	3	3	1	2		3	3	2	3	1	2
CO3	2	2	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (2nd semester)

Subject: Environmental Microbiology (Theory)

Credit: 3

Syllabus:

Course Objectives Student Learning Outcomes	
This course aims to introduce and elaborate the fundamental concepts and applications of Environmental Microbiology. The course will introduce major groups of microorganisms and microbial processes to solve environmental problems. This course will also introduce the role of microbes and microbial processes in waste and water treatment, and bioremediation**.**	
Unit I **Introduction to environment**	Components of environment; global environmental problems, pollution: air, water, soil, noise; biogeochemical cycles; Microbial interactions: symbiosis, mutualism, commensalism, amensalism, competition, antibiosis, extremophiles: adaptations and potential applications.
Unit II **Waste management**	Waste: domestic, industrial, and hazardous wastes (storage, transportation, treatment and disposal); solid waste management, wastewater characteristics, BOD, COD, Waste water treatment - physical, chemical and biological treatment processes, eutrophication, algal blooms.

Unit III **Wastewater treatment**	Microbiology of wastewater treatment: Aerobic process - activated sludge, oxidation ditched trickling filter, rotating discs, rotating drums, oxidation ponds. Anaerobic process - anaerobic digestion, anaerobic filters, up flow anaerobic sludge blanket reactors, Treatment schemes for domestic and industrial effluents/wastewater: domestic effluents (sewage), distillery effluents, pulp and paper effluents, textile effluents, tannery effluents, dairy effluents.
Unit IV **Bioremediation**	Bioremediation: Fundamentals, technological aspects and strategies, role of microbes in bioremediation, microbial remediation of lignin, pesticides, heavy metals, oil spill, radionuclides, organic pollutants/xenobiotic, plastic, degradative plasmids, genetically engineered microbes and their role in environment clean-up.
Unit V **Waste recycling**	Microbial waste recycling: organic compost, biogas production, waste to energy, waste to value added products, biofuel, microbial fuel cell, microbiologically enhanced oil recovery (MEOR), bioleaching, biofilm.

Recommended Textbooks and References

1. L. Pepper, C.P. Gerba and T. J. Gentry (2014) Environmental Microbiology.
2. Atlas RM, Bartha R. Microbial ecology, fundamentals and applications. (Pearson Educación SA, 4th ed., 2002)
3. Alexander, M. Biodegradation and Bioremediation. (Academic Press, 2nd ed., 1999)
4. Bitton, G. Encyclopedia of environmental microbiology. (Wiley, John & sons. 2003)
5. Madigan, M. T., and J. M. Martinko. 2010. Brock Biology of Microorganisms, 13th Ed., Pearson Benjamin Cummings, San Francisco, CA.
6. Hurst, C. J., G. R. Knudsen, M. J. McInernney, L. D. Stetzenback, and M. V. Walter (eds.). 1997. Manual of Environmental Microbiology. American Society for Microbiology. Washington, DC.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological

	materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.

PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Environmental Microbiology (MSc Microbiology- 2nd semester)**
CO1	On completion of course, students will be able to understand the:Global environmental problems and their negative impact
CO2	Management of different types of waste
CO3	Role of microbes and microbial processes in wastewater treatment and bioremediation, Role of microbes in recycling of waste

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	3	3	1	2	2
CO2	3	2	3	3	1	2		3	3	2	3	1	2
CO3	2	2	3	2	2	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (2nd semester)

Subject: Biostatistics

Credit: 3

Syllabus:

Course Objectives	
The objective of this course is to give conceptual exposure of statistics, error analysis, hypothesis testing, and design of experiments in biological systems	
Unit I **Data & Sampling methods**	Types of biological data (ordinal scale, nominal scale, continuous and discrete logical systems data), Grouped Data,frequency distribution and graphical representations (bar graph, histogram, box plot and frequency polygon), cumulative frequency distribution, populations, samples, simple random, stratified and systematic sampling.

Unit II **Descriptive statistics,** **Probability** **and distribution**	Measures of Location, Arithmetic Mean, median, mode, range, Variance, Standard Deviation, Coefficient of Variation, Graphic Methods, Obtaining Descriptive Statistics on the Computer, Case study. Introduction to probability and laws of probability, Random Events, Events-exhaustive, Mutually exclusive and equally likely, normal distribution, binomial distribution, Poisson distribution.
Unit III **Correlation and regression analysis, Statistical hypothesis**	Correlation, Covariance, Pearson Correlation coefficient, Rank Correlation Coefficient, scatter and dot diagram, regression analysis, regression coefficient, Standard error of estimate. Making assumption, Null and alternate hypothesis, error in hypothesis testing, confidence interval, one-tailed and two-tailed testing, decision making.
Unit IV **Tests of significance**	Steps in testing statistical significance, selection and computation of test of significance and interpretation of results; Sampling distribution of mean and standard error, Large sample tests, Small sample tests; parametric and Non parametric tests (Mann-Whitney test); paired and unpaired t-test, chi square test.
Unit V **Experimental** **Designs**	Introduction to study designs: Longitudinal, cross-sectional, retrospective and prospective study, Principles of experimental designs, Randomized block, and Simple factorial designs, Analysis of variance (ANOVA), Randomized block Design, introduction to meta-analysis and systematic reviews, ethics in statistics.

Recommended Textbooks and References

1. Jaype Brothers, (2011), Methods in Biostatistics for Medical Students and Research Workers (English), 7thEdition
2. Norman T.J. Bailey, (1995), Statistical Methods in Biology, 3rd Edition, Cambridge UniversityPress.
3. P. N. Arora and P. K. Malhan, (2006), Biostatistics, 2nd Edition, Himalaya PublishingHouse.
4. Jerold Zar, Biostatistical Analysis, 4th Edition. PearsonEducation.
5. Biostatistics: a Foundation for Analysis in the Health Sciences, 7th Edition, Wiley.
6. ML Samuels, JA Witmer (2003) Statistics for the Life Sciences, 3rd edition. PrenticeHall

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.

PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to

	Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Biostatistics (MSc Microbiology- 2nd semester)**
CO1	On completion of this course, students should be able to: Understand how to sum- arise statistical data.
CO2	Apply appropriate statistical tests based on an understanding of study question, type of study and type of data;
CO3	Student learns about how to Interpret results of statistical tests and application in biological systems.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	3	2	1	2	2
CO2	3	2	3	2	1	2		3	3	2	3	1	2
CO3	2	2	3	2	2	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (2nd semester)

Subject: Environmental Microbiology (Theory)

Credit: 3

Syllabus:

Course Objectives Student Learning Outcomes
This course aims to introduce and elaborate the fundamental concepts and applications of Environmental Microbiology. The course will introduce major groups of microorganisms and microbial processes to solve environmental problems. This course will also introduce the role of microbes and microbial processes in waste and water treatment, and bioremediation.

Unit I **Introduction to environment**	Components of environment; global environmental problems, pollution: air, water, soil, noise; biogeochemical cycles; Microbial interactions: symbiosis, mutualism, commensalism, amensalism, competition, antibiosis, extremophiles: adaptations and potential applications.
Unit II **Waste management**	Waste: domestic, industrial, and hazardous wastes (storage, transportation, treatment and disposal); solid waste management, wastewater characteristics, BOD, COD, Waste water treatment - physical, chemical and biological treatment processes, eutrophication, algal blooms.
Unit III **Wastewater treatment**	Microbiology of wastewater treatment: Aerobic process - activated sludge, oxidation ditched trickling filter, rotating discs, rotating drums, oxidation ponds. Anaerobic process - anaerobic digestion, anaerobic filters, up flow anaerobic sludge blanket reactors, Treatment schemes for domestic and industrial effluents/wastewater: domestic effluents (sewage), distillery effluents, pulp and paper effluents, textile effluents, tannery effluents, dairy effluents.
Unit IV **Bioremediation**	Bioremediation: Fundamentals, technological aspects and strategies, role of microbes in bioremediation, microbial remediation of lignin, pesticides, heavy metals, oil spill, radionuclides, organic pollutants/xenobiotic, plastic, degradative plasmids, genetically engineered microbes and their role in environment clean-up.
Unit V **Waste recycling**	Microbial waste recycling: organic compost, biogas production, waste to energy, waste to value added products, biofuel, microbial fuel cell, microbiologically enhanced oil recovery (MEOR), bioleaching, biofilm.

Recommended Textbooks and References

7. L. Pepper, C.P. Gerba and T. J. Gentry (2014) Environmental Microbiology.
8. Atlas RM, Bartha R. Microbial ecology, fundamentals and applications. (Pearson Educación SA, 4th ed., 2002)
9. Alexander, M. Biodegradation and Bioremediation. (Academic Press, 2nd ed., 1999)
10. Bitton, G. Encyclopedia of environmental microbiology. (Wiley, John & sons. 2003)
11. Madigan, M. T., and J. M. Martinko. 2010. Brock Biology of Microorganisms, 13th Ed., Pearson Benjamin Cummings, San Francisco, CA.
12. Hurst, C. J., G. R. Knudsen, M. J. McInernney, L. D. Stetzenback, and M. V. Walter (eds.). 1997. Manual of Environmental Microbiology. American Society for Microbiology. Washington, DC.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements

PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
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PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
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PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
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Course Outcome	**Environmental Microbiology (MSc Microbiology- 2nd semester)**
CO1	On completion of course, students will be able to understand the:Global environmental problems and their negative impact
CO2	Management of different types of waste
CO3	Role of microbes and microbial processes in wastewater treatment and bioremediation, Role of microbes in recycling of waste

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	3	3	1	2	2
CO2	3	2	3	3	1	2		3	3	2	3	1	2
CO3	2	2	3	2	2	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (2nd semester)

Subject: Microbial Systematics (Theory)

Credit: 3

Syllabus:

Course Objectives
Familiarity with general characters of prokaryotic and Eukaryotic microorganisms for conventional and molecular characterization using modern methods. Knowledge of cellular organization, life cycle and economic importance of prokaryotic (Eubacteria, Archaea, Cyanobacteria) and Eukaryotic (Algae, Fungi and protozoans).

Unit I **Origin and evolution of microbial world**	Milestones in Microbiology; Haeckel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese. General characteristics of various groups of prokaryotes: bacteria including, Rickettsiae, Chlamydiae, Spirochaetes and Actinomycetes, Cyanobacteria and Mycoplasmas, Archaea: Significance of Archaea, Evolutionary developments of Archaea.
Unit II **Tools for Systematics**	Classification of bacteria and Archaea according to the Bergey's Manual of Systematic Bacteriology, Numerical taxonomy, Phylogenetic analysis, Polyphasic approach; Modern methods of studying microbial diversity; Microbial culture collections.
Unit III Bacterial Diversity	Eubacteria: Diversity, significance of Gram-positive (Firmicutes, Actinobacteria) and Gram-negative [Proteobacteria: cyanobacteria, Rhizobia, methanotrophs, myxobacteria, magnetotactic bacteria, *Deinococcus-Thermus*, Spirochaetes, Bacteroidetes].
Unit IV **Algal and viral systematics**	Phycology: Algal diversity and distribution; Characteristics; Identification; Classification; Phylogeny; Economic importance and applications; Symbiotic associations of algae with fungi. Virus: characteristics, nomenclature and classification of virus, Viral genomic organization, identification.
Unit V **Mycology**	Mycology: Fungal diversity and distribution; Characteristics; Classification of fungi, Major taxonomic groups of fungi; Identification; Phylogeny; Yeasts: General characteristic, classification; Protozoa: General characteristics, Classification, Structure and significance: *Leishmania*, *Trichomonas*, *Entamoeba*, *Plasmodium*
Recommended Textbooks and References ● Madigan MT, Martinko JM, Dunlap PV, Clark DP (2012). Brock Biology of Microorganisms, Prentice Hall, USA. ● Lansing M Prescott, Donald A Klein, John P Harley, Microbiology, Mc Graw Hill.	

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
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	inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
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M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
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PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Microbial Systematics** **(MSc Microbiology- 2nd semester)**
CO1	Understanding of basic microbial structure and similarities and differences among various groups of microorganisms such as bacteria/ archaea/ cyanobacteria/ fungi/ protozoans.
CO2	Acquaintance on study of microbial diversity using different methods and systematics of bacteria and archaea using polyphasic approach.
CO3	Understand the various methods for identification of isolated and unculturable microorganisms

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	3	2	1	2	2
CO2	3	2	3	2	1	2		3	3	2	3	1	2
CO3	2	2	3	2	2	3		2	3	2	1	3	2

POs Post-Graduate Programme

Course: MSc Microbiology (2nd semester)

Subject: Microbial Technology

Credit: 3

Syllabus:

Course Objectives

The objectives of this course are to introduce students to developments/ advances made in field of microbial technology for use in human welfare and solving problems of the society.

Unit I **Introduction to microbial technology**	Microbial technology in human welfare; Isolation and screening of microbes important for industry; extremophiles: halophiles, thermophiles, psychrophiles as source of industrially important products, advantages of microbial technology
Unit II **Environmental applications of microbial technology**	Environmental application of microbes; bioleaching; Biodegradation; Bioremediation - toxic waste removal and soil remediation; Global Biogeochemical cycles; Environment sensing (sensor organisms/ biological sensors); International and National guidelines regarding use of genetically modified organisms in environment, food and pharmaceuticals.
Unit III **Pharmaceutical applications of microbial technology**	Microbial products in pharmaceutical industry, Recombinant protein and pharmaceuticals production in microbes; Antibiotics and enzymes production, Microbial cell factories; Downstream processing approaches used in industrial production process, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors)
Unit IV **Food applications of microbial technology**	Application of microbes and microbial processes in food, food preservation, Non- recombinant ways of introducing desirable properties in Generally recognized as safe (GRAS); microbes to be used in food (e.g.,Yeast), fermented food products (beverages and dairy products), genetically modified foods.
Unit V **Advances in microbial technology**	Microbial genomics for discovery of novel enzymes, drugs/ antibiotics; Metagenomics and metatranscriptomics, metagenomic library construction and functional screening in suitable hosts, Advanced genome and epigenome editing tools

Recommended Textbooks and References

1. Lee,Y.K.(2013).MicrobialBiotechnology:PrinciplesandApplications. Hackensack, NJ: WorldScientific.
2. Moo-Young,M.(2011).ComprehensiveBiotechnology.Amsterdam:Elsevier.
3. Nelson, K. E. (2015). Encyclopedia of Metagenomics. Genes, Genomes and Metagenomes:Basics,Methods,DatabasesandTools.Boston,MA:SpringerUS.
4. TheNewScienceofMetagenomicsRevealingtheSecretsofOurMicrobialPlanet. (2007). Washington, D.C.: National AcademiesPress.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of

	life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.

PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Microbial Technology (MSc Microbiology- 2nd semester)**
CO1	Students should be able to understand various environmental and pharmaceutical applications of Microbial technology
CO2	This will be imperative for students as it will help them to learn about metagenomics and functional genome and epigenomic editing tool.
CO3	On completion of this course, students would develop deeper understanding of the microbial technology and its applications.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	2	2	3		3	2	3	1	2	2
CO2	3	2	3	2	1	2		3	3	2	2	1	2
CO3	2	2	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (2nd semester)

Subject: Microbial Diagnostics

Credit: 3

Syllabus:

Course Objectives

The objectives of this course are to sensitize students about recent advances in molecular biology and various facets of molecular medicine which has potential to profoundly alter many aspects of modern medicine including pre- or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

Unit I **Genome biology in health and disease**	Central dogma of molecular biology; human identity; chromosomal abbreviations and diseases; gene linked disorders; clinical variability and genetically determined adverse reactions to drugs
Unit II **Genome: resolution, detection & analysis**	PCR based diagnosis; In-situ hybridization; Fluorescence in-situ hybridization (FISH); Nucleic acid sequencing; Microarray; Molecular markers; Diagnostic proteomics
Unit III **Detection of inherited diseases**	Detection of inherited diseases, mutational mechanism of unstable triplet repeats, familial cancer syndromes, Detection of recognized genetic aberrations in clinical samples from cancer patients; Predictive biomarkers for personalized onco-therapy of human diseases, targeted therapies
Unit IV **Molecular detection of infectious diseases**	Direct detection and identification of pathogenic organisms (culturable and unculturable), sampling methods, diagnosis: based on nucleic acids, proteins, immunodiagnostic.
Unit V **Diagnostic metabolomics, Quality assurance and control**	Metabolite profile for biomarker detection in biological samples by using LCMS & NMR technological platforms.Quality oversight; regulations and approved testing.

Recommended Textbooks and References

1. Campbell,A.M.,&Heyer,L.J.(2006).*DiscoveringGenomics,Proteomics, and Bioinformatics*. San Francisco:BenjaminCummings.
2. Brooker,R.J.(2009).*Genetics:Analysis&Principles*.NewYork,NY:McGraw-Hill.
3. Glick,B.R.,Pasternak,J.J.,&Patten,C.L.(2010).*MolecularBiotechnology: PrinciplesandApplicationsofRecombinantDNA*.Washington,DC:ASMPress.
4. Coleman,W.B.,&Tsongalis,G.J.(2010).*MolecularDiagnostics:fortheClinical Laboratorian*. Totowa, NJ: HumanaPress

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and

	methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
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PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
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	Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Molecular diagnostics (MSc Microbiology- 2nd semester)**
CO1	The objectives of this course are to sensitize students about recent advances in molecular biology and various facets of molecular medicine which has potential to profoundly alter many aspects of modern medicine including pre- or postnatal analysis of genetic diseases
CO2	Students should be able to understand various facets of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in early diagnosis and prognosis of human diseases.
CO3	This will be imperative for students as it will help them to learn about molecular basis of diseases

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	2	2	3		3	2	3	1	2	2
CO2	3	2	3	2	1	2		3	3	2	2	1	2
CO3	2	2	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (2nd semester)

Subject: Microbial Bioprospecting

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to inculcate in students knowledge on microbial resources, their identification through various tools. Application of microbial resources for various processes and products	
Unit I **Introduction to Bioprospecting**	Bioprospecting, Major methods of bioprospecting. Screening of microorganisms for value-added products and therapeutic molecules. Bioprospecting of microorganisms from natural environments

Unit II **Microbial resources**	Microbial resources. Bacteria, Fungi and Viruses. Source of microorganism (Soil, Water and Air). Isolation, preservation and maintenance of industrial microorganisms, microbial culture collection, Accessing rare and non-obvious producers of secondary metabolites.
Unit III **Microbial identification**	Defining Microbial Diversity- the Species Concept for Prokaryotic and Eukaryotic Microorganisms. Microbial identification: Morphological methods, Biochemical methods. Chemotaxonomy, Molecular taxonomy. Isoenzymes, ELISA and PCR based identification methods
Unit IV **Tools for microbial bioprospecting**	Microbial bioprospecting assisted by genomics and metagenomics. Mining of microbial genomes for new bioactive natural products. Engineering of microbial natural product biosynthesis pathways. Application of synthetic biology tools for drug discovery in microorganisms.
Unit V **Applications of Bioprospecting**	Biotechnological applications of microorganisms and their derivatives. Production of Industrially important products -organic acids (citric acid), enzymes (cellulasexylanase, amylase, protease) applications of microorganisms in medical and pharmaceutical products. Production of antibiotics, drugs, vitamins and therapeutic peptides.

Recommended Textbooks and References

1. General Microbiology: Sullia SB and Shantharam S
2. Microbial Biotechnology: Glaser AN and Nilaido H
3. Industrial Microbiology : Prescott & Dunn
4. A text of Industrial Microbiology: Crueger W and Crueger A
5. Priciples of Fermentation Technology: Stanbury PF, Ehitaker H, Hall SJ
6. Industrial Biotechnology: SN Jogdan

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and

	inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.

PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Molecular Bio-prospecting (MSc Microbiology- 2nd semester)**
CO1	Students should be able to understand the basics of bioprospecting methods.
CO2	Students should be able to understand the basics of Microbial identification: Morphological methods, Biochemical methods. Chemotaxonomy, Molecular taxonomy. Isoenzymes, ELISA and PCR based identification methods
CO3	They should be well versed in tools and techniques used for selection and screening of microorganisms for value added processes and products.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	2	2	3		3	2	2	1	2	2
CO2	3	2	3	2	1	2		3	3	2	2	1	2
CO3	2	2	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (2nd semester)

Subject: Immunology & Recombinant DNA Technology Laboratory

Credit: 3

Syllabus:

Course Objectives
The objectives of this course are to provide students with experimental knowledge of recombinant DNA technology and to develop an understanding about practical aspects of components of immune system as well as their function. Basic as well as advanced methods will be taught to detect different antigen and antibody interactions, isolation of different lymphocyte cells *etc.* and how they can be used in respective research work

Immunology Laboratory	1. Serum and Plasma separation and storage. 2. Blood Grouping 3. Blood smear identification of leucocytes. 4. Double diffusion, Radial Immunodiffusion. 5. ELISA. 6. Demonstration of Isolation and purification of IgY from chicken egg. 7. SDS-PAGE, Immunoblotting. 8. Dot blot assays. 9. Separation of leucocytes. 10. Demonstration of Phagocytosis. 11. Cryopreservation of WBCs 12. Demonstration of FACS.
Recombinant DNA Technology Laboratory	1. Plasmid DNA isolation and DNA quantitation 2. Restriction Enzyme digestion of plasmid DNA 3. Vector and Insert Ligation 4. Preparation of competent cells 5. Transformation of *E.coli*with standard plasmids, Calculation of transformation efficiency 6. Confirmation of the insert by Colony PCR and Restriction mapping

1. GeneralMicrobiologybyStainerRY, Adelberg,EA,John,LI, Edition,1st,MacmillanPub.
2. Flowthrough(bio) chemicalsensorsbyValearcclM&deCastrol
3. IndustrialMicrobiology:AnintroductionbyMJ,Morgan,NL,Rockey,JS,Higton,G,Edition.1st,Wiley-Blackwell.2001

ManualofIndustrialMicrobial&Biotechnology,byBaltz,RH,Davies,JE,Demain,AL,Demain,Edition 3rd, American Societyof Microbiology.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital

	connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course	**Immunology & Recombinant DNA Technology Laboratory**

Outcome	(MSc Microbiology- 2nd semester)
CO1	Students should be able to gain hands- on experience in gene cloning, protein expression and purification.
CO2	Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in setting of infection (viral or bacterial) by looking at cytokine profile.
CO3	This experience would enable them to begin a career in industry that engages in genetic engineering and immunology as well as in research laboratories conducting fundamental research.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	2	3	2	2	2
CO2	3	2	3	3	1	2		3	3	1	2	1	2
CO3	2	2	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (2nd semester)

Subject: Microbial Physiology & Environmental Microbiology Laboratory

Credit: 3

Syllabus:

Course Objectives

The objectives of this course are to provide students with experimental knowledge of Microbial physiology. And developments of microbial technology for use in human welfare and solving problems of the society.	
Immunology Laboratory	13. Serum and Plasma separation and storage. 14. Blood Grouping 15. Blood smear identification of leucocytes. 16. Double diffusion, Radial Immunodiffusion. 17. ELISA. 18. Demonstration of Isolation and purification of IgY from chicken egg. 19. SDS-PAGE, Immunoblotting. 20. Dot blot assays. 21. Separation of leucocytes. 22. Demonstration of Phagocytosis. 23. Cryopreservation of WBCs 24. Demonstration of FACS.
Recombinant DNA Technology Laboratory	7. Plasmid DNA isolation and DNA quantitation 8. Restriction Enzyme digestion of plasmid DNA 9. Vector and Insert Ligation 10. Preparation of competent cells 11. Transformation of *E.coli*with standard plasmids, Calculation of transformation efficiency 12. Confirmation of the insert by Colony PCR and Restriction mapping
4. GeneralMicrobiologybyStainerRY, Adelberg,EA,John,LI, Edition,1st,MacmillanPub. 5. Flowthrough(bio) chemicalsensorsbyValearcclM&deCastrol 6. IndustrialMicrobiology:AnintroductionbyMJ,Morgan,NL,Rockey,JS,Higton,G,Edition.1st,Wiley-Blackwell.2001 ManualofIndustrialMicrobial&Biotechnology,byBaltz,RH,Davies,JE,Demain,AL,Demain,Edition 3rd, American Societyof Microbiology.	

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological

	materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
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PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.

PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Microbial Physiology & Environmental Microbiology Laboratory (MSc Microbiology- 2nd semester)**
CO1	Students should be able to different biochemical test of microbes for identification
CO2	Understand the pollution parameters for evaluation of wastewater
CO3	This experience would enable them to begin a career in philology and environmental microbiology

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	1	2	3		3	2	3	2	2	2
CO2	3	2	3	3	1	2		3	2	1	2	1	2
CO3	2	2	3	2	3	3		1	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (3rd semester)

Subject: Industrial Microbiology (Theory)

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to provide the information about the fundamental concepts and application of industrial microbiology, thus preparing them to meet the challenges of the related industries.	
Unit I **Introduction to Industrial Microbiology**	Isolation, screening and maintenance (preservation) of industrially important microbes, primary and secondary metabolites, Strain improvement/development through selection, mutation, recombination and other genetic and biochemical methods.
Unit II **Industrial Fermentation**	Principles of industrial fermentation, Substrates for fermentations, various types of fermenters, design and working of a typical bioreactor, introduction to immobilization technology for enzymes and cells, treatment of industrial wastes.
Unit III **Production of alcoholic beverages, organic acid, enzymes etc.**	Production of alcoholic beverages, Organic acid (citric acid, lactic acid), amino acid (lysine, glutamic acid), nucleotides and related compounds. Production of enzymes (protease, amylase, lipase). Production of microbial food, single cell proteins and mushroom.
Unit IV **Production of antibiotics, hormones and commercial products**	Production of antibiotics, Production of hormones, Synthesis of commercial products by recombinant microorganisms: restriction endonucleases, biopolymers, human insulin, growth hormones, interferon and vaccines.
Unit V **Production of vitamins and Steroids**	Prouction of Vitamin B12 (Cyanocobalamin), Riboflavin (vitamin B2); Production of solvents, Production of steroids, alkaloids etc., microorganisms in biotransformation of antibiotics and steroids.

Recommended Textbooks and References

7. Prescott andDunn'sIndustrialMicrobiologybyReed,G,CBSPublishers&Distributors.
8. Biotechnology-AtextbookofIndustrialMicrobiologyWulfCrueger&AnnelieseCrueger
9. MicrobialbiotechnologyFundamentalsofAppliedMicrobiologybyGlazer,AN,andNikaido,H, edition 2nd,Cambridge UniversityPress.
10. GeneralMicrobiologybyStainerRY, Adelberg,EA,John,LI, Edition,1st,MacmillanPub.
11. Flowthrough(bio) chemicalsensorsbyValearcclM&deCastrol
12. IndustrialMicrobiology:AnintroductionbyMJ,Morgan,NL,Rockey,JS,Higton,G,Edition.1st,Wiley-Blackwell.2001
13. ManualofIndustrialMicrobial&Biotechnology,byBaltz,RH,Davies,JE,Demain,AL,Demain,Edition 3rd, American Societyof Microbiology.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.

PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Industrial Microbiology (MSc Microbiology- 3rd semester)**
CO1	On completion of this course students should be able to: Clear about fundamental concepts and application of industrial microbiology, thus preparing them to meet the challenges of the related industries.
CO2	Understand the microbial processes and products in industrial settings
CO3	Understand the management, quality etc. being used in industries to produce the products using microorganisms

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	3	2	2	3		3	3	3	1	2	2

CO2	3	2	3	2	1	2		3	3	2	2	1	2
CO3	2	2	3	2	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (3rd semester)

Subject: Food and Agricultural Microbiology

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to provide the information about the fundamental concepts and application of food microbiology, thus preparing them to meet the challenges of the related industries.	
Unit I **Food, Microbes and Spoilage**	Food as a substrate for microorganisms, their types: food borne microorganisms. Microbial spoilage of food and factors affecting them: Spoilage of various kinds of foods: fish. meat, poultry, sea foods, bread and dairy products). Food poisoning: Botulinism and staphylococcal toxicity. Food adulteration and prevailing food standards in India. Indicator Microorganisms: As an indicator of food quality.
Unit II **Food Preservation and Fermented Food**	Foodpreservation, Food adulteration and prevailing food standards in India. Dehydration and pasteurization of milk. Common fermented foods and food produced by microbes: Curd, yoghurt, sauerkraut, fermented/condensed milk, pickles, sauce, beer, wine, vinegar, cheese, bread and kefir, microbes as food: SCP, mushrooms etc.
Unit III **Plant Microbe Interaction**	Microorganisms in soil: Rhizosphere, phyllosphere, PGPR, Plant microbe relationships: Association and pathogenicity, symptoms of plant diseases caused by fungi, bacteria and viruses, viability and variability in plant pathogens
Unit IV **Plant Pathology**	Principle and methods of control of common fungal diseases (wilt, mildew, rust); bacterial diseases (canker, blight); viral (mosaics and curls). Control of insect pests through biological methods bacteria *(Bacillus thuringiensis*, *Pseudomonas* spp*).* Virus *(nuclear polyhedrosis virus, cytoplasmic polyhedral virus) and* fungi (*Metarrhiniumanisoplial, Beauveriabassiana, Verticellumlecani, Hersutellathompsoni*)
Unit V **Mycorrhiza and Biofertilizers**	Mycorrhizal association: Their types and role in plant nutrition. biocontrol agents, Biofertilizer: Production and method of application, biopesticides, composting.

Recommended Textbooks and References

1. FoodMicrobiologyFundamentalsandFrontiersByDoyle,MP,Beuchat,LR&Montville,TJASMPress
2. FoodMicrobiologybyAdamsAR,&MossMOThirdedition,RoyalSocietyofChemistrypublishing.
3. FoodMicrobiologyByFrazier,WC,andWesthoff,DC.Fourthedition,MacGrawHillspublication
4. PlantPathologybyAgrios GN. Fifth edition, ElsevierAcademicpress.
5. AgricultureMicrobiologybyRangaswami,G,andBagyaraj,DJ,edition2nd,PrenticeHallofIndiaPvt.Ltd., New Delhi.
6. Advances in AgricultureMicrobiologybySubbaRao, NS, Oxford&IBHPub.
7. MolecularplantpathologybyM. Dickinson,BiosScientificPublishers ,New York.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.

PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to

	Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Food and Agricultural Microbiology (MSc Microbiology- 3rd semester)**
CO1	Student should learn about the fundamental concepts and application of food microbiology, thus preparing them to meet the challenges of the related industries.
CO2	Understand the microbial processes and food preservation and products.
CO3	Understand the Principle and methods of control of common fungal diseases (wilt, mildew, rust); bacterial diseases (canker, blight); viral (mosaics and curls). Control of insect pests through biological methods bacteria and Virus.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6

CO1	**3**	**3**	**2**	**2**	**2**	**3**		**3**	**2**	**3**	**1**	**2**	**2**
CO2	**3**	**2**	**3**	**2**	**1**	**2**		**3**	**3**	**2**	**2**	**1**	**2**
CO3	**2**	**2**	**3**	**2**	**3**	**3**		**2**	**3**	**2**	**1**	**3**	**3**

POs Post-Graduate Programme

Course: MSc Microbiology (3rd semester)

Subject: Clinical Microbiology (theory)

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to provide the information about the host pathogen relationship, microbial mechanism of microbial infection such as bacterial and viral infection.	
Unit I **Host-pathogen interaction**	Introduction of medically important microorganisms; normal microflora of human body; Pathogenicity, opportunistic pathogens, virulence, Koch's postulates, bacterial toxins-their types, mycotoxins, lethal dose 50 (LD_{50}) and infectious dose 50 (ID_{50}), Types of hosts. Host defense against microbial invasion; Microbial mechanisms for escaping host defenses.Nosocomial and emerging microbial infectious diseases.
Unit II **Diagnosis and Treatment of Infectious Diseases**	Collection, transportation and examination of pathologic specimens; Detection methods (culture based, biochemical and molecular detection); Chemotherapy, antimicrobial agents; Antibiotic Susceptibility Testing; Antibiotic resistance;Biosafety practices, disposal of biomedical waste.
Unit III **Bacterial Diseases**	Bacterial diseases spread through air (diptheria, tuberculosis, pertusis etc.), food and water (typhoid, cholera, dysentery, etc), soil (anthrax, tetanus, gas gangrene, etc.) and contact (leprosy, conjunctivitis and venereal diseases (gonorrhea and syphilis). Chlamydial and Rickettsial infections, Mycoplasmal infections, Bacterial zoonoses (brucellosis, bubonic plague). Multidrug resistant (MDR) bacteria.
Unit IV **Viral Diseases**	General characteristics of common viral diseases like influenza (pneumotropic): herpes simplex, small pox, measles and rubella (dermotropic); dengue fever, hepatitis and AIDS (viscerotropic): rabies, poliomyelitis (neurotropic), encephalitis and yellow fever (viral zoonoses); Viral hepatitis; Emerging viral diseases such as Severe Acute Respiratory Syndrome coronaviruses
Unit V **Fungal and Protozoan and Helminthic infections**	Fungal diseases: Cutaneous mycoses (Tinea pedis, Tinea corporis, Tinea capitis), Subcutaneous mycoses (Sporotrichosis, Chromomycosis, Mycetoma), Systemic mycoses (Coccidioidomycosis, Histoplasmosis, Blastomycosis), Opportunistic mycoses (Candidiasis, Cryptococcosis, Aspergillosis, Mucormycosis). Protozoan diseases: Amoebic dysentery, Malaria, Trypanosomiasis, Leishmaniasis. Diseases caused by parasitic helminths: Taeniasis, Filariasis (Elephantiasis).

Recommended Textbooks and References

1. Alberts,B.,Johnson,A.,Lewis,J.,Raff,M.,Roberts,K.,&Walter,P.(2008). *Molecular Biology of the Cell* (5th Ed.). New York: Garland Science.
2. Lodish,H.F.(2016).*MolecularCellBiology*(8thEd.).NewYork:W.H.Freeman.
3. Krebs,J.E.,Lewin,B.,Kilpatrick,S.T.,&Goldstein,E.S.(2014).*Lewin'sGenesXI*. Burlington, MA: Jones &BartlettLearning.
4. Cooper,G.M.,&Hausman,R.E.(2013).*TheCell:aMolecularApproach*(6thEd.). Washington: ASM ;Sunderland.
5. Hardin,J.,Bertoni,G.,Kleinsmith,L.J.,&Becker,W.M.(2012).*Becker'sWorldof theCell*.Boston(8thEd.). BenjaminCummings.
6. Watson,J.D.(2008).*MolecularBiologyoftheGene*(5thed.).MenloPark,CA: Benjamin/Cummings.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
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M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Clinical Microbiology (MSc Microbiology- 3rd semester)**
CO1	Student should learn about the host pathogen relationship, microbial mechanism of microbial infection.
CO2	Understand the pathogen specimen, detection methods, antibiotic susceptibility test, biosafety practices
CO3	Understand the bacterial and fungal disease spreading through different sources

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	3		3	2	3	1	2	2
CO2	3	2	3	2	1	2		3	3	2	2	1	2
CO3	2	2	3	3	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (3rd semester)

Subject: Bioinformatics (theory)

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to provide theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.	
Unit I **Bioinformatics basics**	Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; 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.
Unit II **DNA 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
Unit III **Multiple sequence analysis**	Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, updating submitted sequences, methods of phylogenetic analysis
Unit IV **Protein modelling**	Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; assigning secondary structures; sequence alignment- methods, evaluation, scoring
Unit V **Protein structure prediction and virtual library**	Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, sequence based methods of structure prediction, significance analysis, scoring techniques, protein function prediction; elements of in silico drug design; Virtual library

Recommended Textbooks and References

1. Lesk,A.M.(2002).*IntroductiontoBioinformatics*.Oxford:OxfordUniversityPress.
2. Mount,D.W.(2001).*Bioinformatics:SequenceandGenomeAnalysis.*ColdSpring Harbor, NY: Cold Spring HarborLaboratoryPress.
3. Baxevanis,A.D.,&Ouellette,B.F.(2001).*Bioinformatics:aPracticalGuidetothe Analysis of Genes and Proteins*. NewYork:Wiley-Interscience.
4. Pevsner,J.(2015).*BioinformaticsandFunctionalGenomics*. Hoboken, NJ.:Wiley-Blackwell.
5. Bourne,P.E.,&Gu,J.(2009).*StructuralBioinformatics*.Hoboken,NJ:Wiley-Liss.
6. Lesk, A.M.(2004).*IntroductiontoProteinScience:Architecture,Function,and Genomics.* Oxford: Oxford universityPress

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Bioinformatics (MSc Microbiology- 3rd semester)**
CO1	Student should be able to : Develop an understanding of basic theory of these computational tools.
CO2	Gain working knowledge of these computational tools and methods;
CO3	Appreciate their relevance for investigating specific contemporary biological questions; Critically analyse and interpret results of their study.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	3		3	2	2	1	2	2
CO2	3	2	3	2	1	2		3	3	2	2	1	2
CO3	2	2	3	3	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (3rd semester)

Subject: Infection and Immunity (theory)

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to provide Molecular basis of infection and immunity, immune response and knowledge of vaccine	
Unit I **Molecular basis of infection and immunity**	Pathogenesis, Virulence factor, Innate and Acquired Immune responses in infection, Pattern recognition, cellular involvement, role of lymphocytes Macrophages, Neutrophils, NK cells, Defensins, Humoral and Cell mediated Immune responses, Extracellular and Intracellular infections.
Unit II **Infection, Immunity and Immunopathology**	Mechanisms of infectious agents' escape from Immune escape (Innate and adaptive), Antigenic variation, concealment, interference with cellular function, cytokine profile, immunosuppression. Role of immune system in pathology (sepsis, septic shock, toxin, complement, cytokine, cellular components). Infection during pregnancy, transplantation, malignancies, immunodeficiency and old age.
Unit III **Immunodiagnostics**	Diagnostic Immunology - Methods based on precipitation; ODD, CIE, IEP, immunofixation and immunoblotting, Immunonephlometry. Methods based on Agglutination - agglutination of whole cells, agglutination of inert particles coated with Ag/Ab. Haemagglutination – Direct, indirect, passive; CFT, labelled assays – ELISA, RIA, FISH, IFT in vivo reactions- skin tests, immune complex demonstration. Diagnostic evaluation of lymphocytic haemagglutination inhibition, lymphocytic function and CMI, phagocytosis.
Unit IV **Immune response in Specific infections**	Type and magnitude of immune response, immunity in specific bacterial, Fungal disease, Viral, protozoa and parasitic diseases. Epidemiology, Emerging diseases and their control.

Unit V **Vaccinology**	Passive immunization, Correlates of protection and Immunity, Vaccines and Adjuvants, Types of vaccines, established vaccines, Strategies for development, Testing and production of vaccines, Immunostimulation (Specific and Non-specific), Antibodies and Vaccines, Vaccines against AIDS and Tropical Infectious Diseases (Leprosy, malaria and TB etc.). Vaccines against Emerging/re-emerging pathogens. Therapy for immunological diseases. Immuno therapy for Infection and cancer.

1. Primrose,S.B.,Twyman,R.M.,Primrose,S.B.,&Primrose,S.B.(2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
2. Liebler,D.C.(2002).*IntroductiontoProteomics:ToolsfortheNewBiology.* Totowa, NJ: Humana Press.
3. Campbell,A.M.,&Heyer,L.J.(2003).*DiscoveringGenomics,Proteomics,and Bioinformatics*. San Francisco: BenjaminCummings

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific

	temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Infection and Immunity** **(MSc Microbiology- 3rd semester)**

CO1	Student should be learn about Molecular basis of infection and immunity
CO2	Student should be able to Develop an understanding of basic theory of Infection, Immunity and Immunopathology
CO3	Understand the Immune response in Specific infections and vaccinology

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	3		3	3	2	1	2	2
CO2	3	3	3	2	1	2		3	3	2	2	1	2
CO3	2	2	3	3	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (3rd semester)

Subject: Genomics and Proteomics

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course is to provide introductory knowledge concerning genomics, proteomics and their applications.	
Unit I **Basics of genomics**	Brief overview of prokaryotic and eukaryotic genome organization. Extrachromosomal DNA: bacterial plasmids, mitochondria and chloroplast DNA
Unit II **Genome mapping**	Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, *in situ* hybridization, comparative gene mapping
Unit III **Genome sequencing**	Genome sequencing, methods for whole genome sequencing. Contig assembly, chromosome walking and characterization of chromosomes, gene identification, gene annotation, forward and reverse genetics. Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web
Unit IV **Comparative genomics**	Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; Transcriptome analysis, gene ethics; genomics as a tool for evolutionary studies, disease diagnosis and drug designing; Introduction to metabolomics, lipidomics, metagenomics and systems biology

Unit V **Proteomics**	Proteomics: Aims, strategies and challenges; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases, protein chips and functional proteomics; protein-protein and protein-DNA interactions, clinical and biomedical applications of proteomics

Recommended Textbooks and References

4. Primrose,S.B.,Twyman,R.M.,Primrose,S.B.,&Primrose,S.B.(2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
5. Liebler,D.C.(2002).*IntroductiontoProteomics:ToolsfortheNewBiology.* Totowa, NJ: Humana Press.
6. Campbell,A.M.,&Heyer,L.J.(2003).*DiscoveringGenomics,Proteomics,and Bioinformatics*. San Francisco: BenjaminCummings
7. More Books

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Genomics and Proteomics** **(MSc Microbiology- 3rd semester)**

CO1	Students should be able to acquire knowledge and understanding of fundamentals of genomics.
CO2	Students should be able to acquire knowledge and understanding of fundamentals of proteomics,
CO3	Students also learn transcriptomics and metabolomics and their applications in various applied areas of biology.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	3		3	3	3	1	2	2
CO2	3	3	3	2	1	2		3	3	2	2	1	2
CO3	2	2	3	3	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (3rd semester)

Subject: Fermentation Technology (theory)

Credit: 3

Syllabus:

Course Objectives	
The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.	
Unit I **Basic principles of biochemical engineering**	Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics, strain improvement for increased yield and other desirable characteristics. Yield coefficients; unstructured models of microbial growth; structured models of microbial growth
Unit II **Bioreactor design and analysis**	Batch, fed-batch and continuous fermentation, types of bioreactor, immobilized cell systems; upstream processing: media formulation and optimization; sterilization; aeration, agitation, heat and mass transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.
Unit III **Downstream processing and product recovery**	Downstream processing: Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging, effluent treatment and disposal.

Unit IV **Applications of enzyme technology in food processing**	Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes, inter-esterified fat; hydrolyzed protein *etc.* and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.
Unit V **Applications of fermentation technology**	Large scale animal and plant cell cultivation; Fermented foods and beverages; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; biofuels and biorefinery

Recommended Textbooks and References

1. Bioprocess Engineering principles by Pauline M Doran, Elsevier Science and technology Books.
2. Bioprocess Engineering- Basic Concepts by Michael L Shuler and FikretKargi, Pearson Education, Inc.
3. Bioprocess Technology: Volume 1 by P T Kalaiselvan and I Arul Pandi MJP publisher.
4. Bioprocess Engineering: Systems, Equipment and Facilities by Bjorn K. Lydersen, Nancy A. D'Elia, Kim L. Nelson, Wiley India Pvt Ltd.
5. Stanbury PF, Hall SJ, Whitaker A (1999). Principles of Fermentation Technology, Butterworth-Heinemann, 2nd edition.
6. Creuger and Creuger (2001). Biotechnology- A textbook of Industrial Microbiology, Sinauer Associates, Inc.
7. Waites MJ (2001). Industrial Microbiology: An Introduction, Wiley.
8. Industrial Microbiology, Prescott and Dunn

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital

	connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing

	plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Fermentation Technology** **(MSc Microbiology- 3rd semester)**
CO1	Appreciate relevance of microorganisms from industrial context and Carry out stoichiometric calculations and specify models of their growth; Calculate yield and production rates, need for oxygen and oxygen transfer.
CO2	Give an account of design and operations of various fermenters and Present unit operations and principles for basic methods in production technique for bio-based products;
CO3	Critically analyse any bioprocess from market point of view; and industrial importance

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	3		3	3	2	1	2	2
CO2	3	3	3	2	1	2		3	3	3	2	1	2
CO3	2	2	3	3	3	3		2	3	2	1	3	3

POs Post-Graduate Programme

Course: MSc Microbiology (3rd semester)

Subject: Pharmaceutical Microbiology (theory)

Credit: 3

Syllabus:

Course Objectives	
To Understand the basics of pharmaceutical microbiology and important microorganism playing role pharmaceutically To understand different products of microbial origin playing key role in pharmaceutical applications. To understand role of secondary metabolites in pharmaceutical industry. To understand good practices and regulation involved in utilizing microbial product for pharmaceutical application	
Unit I Introduction and application of pharmaceutical microbiology	An introduction and application of pharmaceutical microbiology; Basic aspects of pharmaceutical microbiology; Biology of pharmaceutically important microorganisms: Bacteria and fungi (yeast and molds); Assessment of microbial growth; Isolation, identification, and characterization methods of microorganisms; Handling, cultivation, and preservation methods of microorganisms.
Unit II **Microbial products**	Microbial products in pharmaceutical industry: impacts and opportunities; antibiotics, production of antibiotics antifungal agents, antiviral, antiprotozoal drugs, small molecules, growth factors, hormones, vitamins, therapeutic enzymes, recombinant proteins, immunological products and vaccines etc.
Unit III **Microbial control**	Microbial sources, contamination and spoilage of pharmaceuticals; Factors affecting microbial spoilage of pharmaceutical products; Microbial control in pharmaceutical industries; Antimicrobial resistance, Methodologies for testing of antimicrobial activity (broth-dilution methods and agar diffusion methods); Antimicrobial/preservative efficacy testing.

Unit IV **Microbial production of pharmaceuticals**	Microbial production of pharmaceuticals; Primary metabolic products, Secondary metabolic products; basics of fermentation process; History and discovery of microbial natural products; Screening and development approaches for new microbial natural products; Good laboratory/manufacturing practices for pharmaceuticals production, validation and regulation.
Unit V **Regulatory practices and policies**	Government regulatory practices and policies for pharmaceutical industry: Food and Drug Administration (FDA), The Central Drugs Standard Control Organisation (CDSCO), the Drug Controller General of India (DCGI); patenting of pharmaceutical products

Recommended Textbooks and References

1. Geoff Hanlon & Norman A (2013). HodgesEssential Microbiology for Pharmacy and Pharmaceutical Science, Wiley-Blackwell

2. Madhu Raju Saghee , Tim Sandle , Edward C. Tidswell (2011). Microbiology and Sterility Assurance in Pharmaceuticals and Medical Devices,Business Horizons.

3. Geoff Hanlon, Norman A. Hodges (2013). Essential Microbiology for Pharmacy and Pharmaceutical Science,Wiley-Blackwell.

4. Stephen P. Denyer , Norman A. Hodges, Sean P. Gorman , Brendan F. Gilmore (2011). Hugo and Russell's Pharmaceutical Microbiology,Wiley-Blackwell.

5. Prahlad Singh Mehra (2011). A Textbook of Pharmaceutical Microbiology,I K International Publishing House

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.

PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.

PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Pharmaceutical Microbiology (MSc Microbiology- 3rd semester)**
CO1	Have basic knowledge of pharmaceutical microbiology
CO2	Have well versed with the different microbial products used in pharmaceutical applications
CO3	Better understanding of good laboratory practices and regulations for utilizing microbial product in pharmaceutical applications

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	3		3	3	2	1	2	2
CO2	3	3	3	2	1	2		3	3	3	2	1	2
CO3	2	2	3	3	3	3		2	3	2	1	3	1

POs Post-Graduate Programme

Course: MSc Microbiology (3rd semester)

Subject: Industrial Microbiology & Food, and Agricultural Microbiology Laboratory

Credit: 3

Syllabus:

Course Objectives	
The objective of this course is to provide practical exposure of basic experiments of Industrial Microbiology, and Food and Agriculture Microbiology.	
Industrial Microbiology Laboratory	1. Isolation of protease producing strains and estimation of enzyme. 2. Isolation of amylase producing strains and estimation of enzyme. 3. Isolation of lipase producing strains and estimation of enzyme. 4. Isolation of cellulase producing strain and estimation of enzyme. 5. Production of alcohol. 6. Production of vinegar. 7. Production of citric acid. 8. Production of mushroom. 9. Cell and enzyme immobilization.

Food and Agricultural Microbiology Laboratory	1. Isolation of yeast from food sample. 2. Isolation and enumeration of molds from food sample. 3. Isolation of bacteria from food sample. 4. Microbiological examination of food items 5. Quantitative analysis of milk by standard plate count method. 6. Determination of milk spoilage by methylene blue reduction test. 7. Determination of Thermal Death Point (TDP) of microorganisms. 8. Enumeration of microbial population in soil – bacteria, fungi, actinomycetes. 9. Methods of isolation and purification of microbial culture. 10. Isolation of Rhizobium from legume root nodules. 11. Isolation of Azotobacter from soil. 12. Efficiency assessment of PGPR (Siderophore) 13. Efficiency assessment of PGPR (phosphate solubilisation) 14. Efficiency assessment of PGPR (IAA) 15. Efficiency assessment of PGPR (antifungal activity)

Recommended Textbooks and References

1. Prescott and Dunn's Industrial Microbiology by Reed, G, CBS Publishers & Distributors. 2. Biotechnology - A text book of Industrial Microbiology WulfCrueger&AnnelieseCrueger

3. Microbial biotechnology: Fundamentals of Applied Microbiology by Glazer, AN, and Nikaido, H, edition 2nd , Cambridge University Press.

4. General Microbiology by Stainer RY, Adelberg, EA, John, LI, Edition, 1st, Macmillan Pub.

5. Flow through (bio) chemical sensors by Valearccl M & de Castrol

6. Industrial Microbiology: An introduction by Waites, MJ, Morgan, NL, Rockey, JS,Higton, G, Edition .1st , Wiley-Blackwell. 2001

7. Manual of Industrial Microbial & Biotechnology, by Baltz, RH, Davies, JE, Demain, AL, Demain, Edition 3rd, American Society of Microbiology.

8. Food Microbiology Fundamentals and Frontiers By Doyle, MP, Beuchat, LR & Montville, TJ ASM Press

9. Food Microbiology by Adams AR, & Moss MO Third edition, Royal Society of Chemistry publishing .

10. Food Microbiology by Frazier, WC, and Westhoff, DC. Fourth edition, MacGraw Hills publication

11. Plant Pathology by Agrios GN. Fifth edition, Elsevier Academic press.

12. Agriculture Microbiology by Rangaswami, G, and Bagyaraj, DJ, edition 2nd, Prentice Hall of India Pvt. Ltd., New Delhi.

13. Advances in Agriculture Microbiology by SubbaRao, NS, Oxford & IBH Pub.

14. Molecular plant pathology by M. Dickinson, Bios Scientific Publishers, New York.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics,

	Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Industrial Microbiology & Food, and Agricultural Microbiology Laboratory (MSc Microbiology- 3rd semester)**
CO1	After successful completion of the course student will be able to understand/perform Isolation of microbes from food and soil sample Isolation of microbial strains producing industrially important enzymes
CO2	Microbiological examination of fruits, vegetables, cereal and cereal products (bread) Microbiological examination of canned foods Determination of Thermal Death Point and Thermal Death Time of microorganisms.
CO3	Staining and microscopic examination of microbes Mushroom production Production of alcohol, vinegar and citric acid

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	3		3	3	2	1	2	2
CO2	3	3	3	2	1	2		3	3	3	2	3	2
CO3	2	2	3	3	3	3		2	3	2	2	3	2

POs Post-Graduate Programme

Course: MSc Microbiology (3rd semester)

Subject: Clinical Microbiology & Bioinformatics Laboratory

Credit: 3

Syllabus:

Course Objectives	
The objective of this course is to provide practical exposure of basic experiments of Clinical Microbiology, and Bioinformatics.	
Clinical Microbiology Laboratory	1. Sample collection of normal microbial flora from dermal, nasal and oral sites. 2. To prepare media used for isolation of medically important microorganisms. 3. To perform various biochemical tests for identification of medically important microorganisms. 4. Preparation of transport media for different clinical samples. 5. Antibiotic sensitivity test 6. To determine Minimal Inhibitory Concentration (MIC) of an antibiotic for test microbes.
Bioinformatics Laboratory	1. Applications of computers in biology using MS-office (MS-Word, Excel, Power point) 2. To access scientific data from Literature data bases (PUBMED, LITDB, Medline) 3. To access nucleic acid databases for retrieval of gene sequence. 4. To access protein databases for retrieval of amino acid sequence of target protein. 5. To perform pair wise sequence alignment using Dot matrix. 6. To perform multiple sequence alignment. 7. To find conserved sequences. 8. To prepare Phylogenetic tree and Cladogram 9. 3D protein structure prediction

Recommended Textbooks and References

1. Textbook of Microbiology by Ananthnarayanan and Paniker's, eighth edition, Universities Press.

2. Brock Biology of Microorganisms, M.T, Madigan, J.M. Martinko and J. Parker, Ninth edition, Prentice Hall, Upper Saddle River, NJ.

3. Microbiology: An introduction, G.J. Tortora, B.R. Funke and C.L. Funke.

4. Virology; Renato Dulbecco and Harold S. Ginsberg, Fourth edition, J.B. Lippincott Company, USA

5. An Introduction to viruses, S. B. Biswas and Amita Biswas. Forth edition, Vikas Publishing House PVT LTD New Delhi.

6. Medical Microbiology; Jawetz, Melnick, &Adelberg's, Fifth edition, MacGrow Hills

7. Medical Bacteriology, Medical Mycology and AIDS; N.C.Dey, T.K. Dey and D. Sinha, New Central Book Ajency (P) Ltd.

8. Principles of Therapeutics, Burn J. H., Blackwell Scientific Pub. O. Ltd. Oxford.

9. Principles of Drug Action, The Basis of Pharmacology, Goldstein A., Aronow L., and Kalman S. M., Harper international edition New York.

10. Bioinformatics: Databases, Tools and Algorithms, by OrpitaBosu, Simminder Kaur Thukral, OXFORD University Press.

11. Bioinformatics: Sequence and Genome Analysis by D.W. Mount , second edition, Cold Spring Harbor Laboratory Press

12. Bioinformatics : Methods and Application by S.C. Rastogi, N. Mendira, P. Rastogi, Third edition , PHI Learning Private Limited

13. Introduction to Bioinformatics by Teresa. K. Attwood and David J. Parry- Smith, Low Price edition, Pearson Education

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and

	inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
PSO 3	**Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.

PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Clinical Microbiology & Bioinformatics Laboratory (MSc Microbiology- 3rd semester)**
CO1	After successful completion of the course student will be able to understand/perform, Preparation of basic, selective, enrichment and enriched media used for isolation of medically important bacteria, Biochemical tests used for identification of medically important bacteria.
CO2	To understand the Preparation of transport media for different clinical samples. Applications of computers in biology, Access scientific data from Literature data bases, Access nucleic acid and protein databases
CO3	To understand good practices and regulation Pair wise and multiple sequence alignment. Find conserved sequences, Preparation of Phylogenetic tree and Cladogram, Protein structure prediction

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	3		3	3	2	1	2	2
CO2	3	3	3	2	1	2		3	3	3	2	3	2
CO3	2	2	3	3	3	3		2	3	2	2	3	2

POs Post-Graduate Programme

Course: MSc Microbiology (3rd semester)

Subject: Project Proposal Preparation & Presentation

Credit: 3

Syllabus:

Course Objectives	
The purpose of this course is to help stu- dents organize ideas, material and objectives for their dissertation and to begin de- velopment of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.	
Selection of research lab and research topic:	Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven. Students should engage in systematic and critical review of appropriate and relevant information sources
Writing Research Proposal:	With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, *etc.* Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.
Poster Presentation	Students will have to presentthetopicoftheirprojectproposalafterfewmonthsoftheir selectionofthetopic.Theyshouldbeabletoexplainthenoveltyandimportanceofthe ir researchtopic.
Oral Presentation	At the end , presentation will have to be given by the students to explain work done by them in detail in preparation of proposal. Along with summarizing previously published findings based on review literature, they should also be able to defend the importance of selected research topic.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements

PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
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	Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Project Proposal Preparation & Presentation (MSc Microbiology- 3rd semester)**
CO1	Students should be able to demonstrate the following abilities: Formulate a scientific question; Present scientific approach to solve the problem;
CO2	To understand Interpret, discuss and communicate scientific results in written form; Gain experience in writing a scientific proposal
CO3	Learn how to present and explain their research findings to the audience effectively.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	3		3	3	2	2	2	2
CO2	3	3	3	2	1	2		3	3	3	3	3	2
CO3	2	2	3	3	3	3		2	3	2	2	3	2

POs Post-Graduate Programme

Course: MSc Microbiology (4th semester)

Subject: review of literature for project

Credit: 4

Syllabus

Review of literature:	Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.
PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings,

	field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
PSO 2	**Skilled communicator:** Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
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PSO 4	**Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
PSO 5	**Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**review of literature for project (MSc Microbiology- 4th semester)**
CO1	Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately.
CO2	apply qualitative and/or quantitative evaluation processes to original data.
CO3	keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	3		3	3	2	2	2	2
CO2	3	3	3	2	1	2		3	2	2	2	3	2
CO3	2	2	3	3	3	3		2	1	2	1	1	2

POs Post-Graduate Programme

Course: MSc Microbiology (4th semester)

Subject: Research Project Dissertation

Credit: 16

Syllabus

Course Objectives	
The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.	
Experimental Designing	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 method- technologies and evidence to plan and designed required experiments
performing experiments	Students should 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.

Programme Outcomes (POS)

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M.Sc (Microbiology) Program Specific Outcomes

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Course Outcome	**review of literature for project (MSc Microbiology- 4th semester)**
CO1	Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas: In-depth knowledge of the chosen area ofresearch.
CO2	Capability to critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis.

CO3	Learn how to Competence in research design

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	3		3	3	2	2	2	2
CO2	3	3	3	2	1	2		3	2	2	2	3	2
CO3	2	2	3	3	3	3		2	1	2	1	1	2

POs Post-Graduate Programme

Course: MSc Microbiology (4th semester)

Subject: Research Presentation

Credit: 4

Syllabus

Course Objectives	
The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory and how to present.	
Preparing Presentation	After completion of project work, students should be able to prepare presentation under guidance of their supervisor. Members of research group and senior students should provide training for presentation of project work done.
Presentation of Research Finding	At the end, all students will have to present the research findings of their project. Along with summarizing previously published findings based on review literature, they should also be able to defend the importance of selected research topic. Students will have to explain work done by them in detail about methodology, experimental designing, result and analysis, discussion and conclusion.

Programme Outcomes (POS)

PO1	**Knowledege:** Knowledege will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
PO2	**Critical Thinking:** Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.

PO3	**Skill & Application Development:** Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
PO4	**Inter-disciplinary & Multi-disciplinary Approach:** Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
PO5	**Ethics:** Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
PO6	**Problem Solving & Employability:** Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

M.Sc (Microbiology) Program Specific Outcomes

PSO 1	**Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologicallyimportant molecules and its application in human welfare.
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PSO 6	**Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self- directed learning aimed at personal development and for

Course Outcome	**Research Presentation (MSc Microbiology- 4th semester)**
CO1	Along with summarizing previously published findings based on review literature, they should also be able to defend the importance of selected research topic.
CO2	Students will have to explain work done by them in detail about methodology, experimental designing, result and analysis, discussion and conclusion.
CO3	Learn how to compile and present a research design

Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	3	2	3	2	3		3	3	2	2	2	2
CO2	3	3	3	2	1	2		3	2	2	2	3	2
CO3	2	2	3	3	3	3		2	1	2	1	1	2