SARDAR PATEL UNIVERSITY
Vallabh Vidyanagar, Gujarat
(Reaccredited with 'A' Grade by NAAC (CGPA 3.25)
Syllabus with effect from the Academic Year 2022-2023

PROGRAMME STRUCTURE

M.Sc. Microbiology Semester: III

Programme Outcome (PO) - For M.Sc. Microbiology Programme	Programme specific outcome for M.Sc. Microbiology Students completing the MSc degree programme in Microbiology which is a two year full time program will be able to understand and explain various areas related to microbiology subjects like molecular biology, recombinant DNA technology and immunology. The student will be well versed with the concepts of aseptic handling techniques, maintenance and preservation of industrially as well as clinically important microbial cultures and correlate the molecular basis microbial physiology and ecology. The student will also be enlightened about application in different fields related to Microbial Technology Students will be able to design and establish a microbiology laboratory, they will be able to design the experiments related to basic microbiology, and perform biological assays using whole cells as well as enzymes and be able to identify microorganisms using biochemical as well as molecular identification techniques. Students will be able to execute a short project involving the knowledge and techniques of basic and advanced microbiology, biochemistry, cell biology and bioprocess engineering. The student will be skilled enough to be employed as microbiologist in fermentation industry, clinical laboratory, research and development organization, food and drugs administration, etcor purse doctoral studies in any field of Biological sciences
Programme Specific Outcome (PSO) - For MSc Microbiology Semester - III	1. The student on successful completion of this Semester will gain indepth insight into molecular mechanisms of all processes taking place in Microbial cell. 2. The students will also be able to correlate all biochemical events with cellular processes as well as how cells respond to several environmental stimuli.

To Pass	(1) At least 40% marks in each paper at the University Examination and 40% aggregate marks in Internal and External Assessment. (2) At least 33% Marks in each paper in Internal Assessment.

Course Type	Course Code	Name Of Course	Theory/ Practical	Credit	Exam Duration in hrs	Component of Marks		
						Internal Total	External Total	Total
Core Course	PS03CMIC51	Microbial Technology	T	4	3	30	70	100
	PS03CMIC52	Environmental Microbiology	T	4	3	30	70	100
	PS03CMIC53	Enzymology	T	4	3	30	70	100
	PS03CMIC54	Practical	P	4	3	30	70	100
	PS03CMIC55	Practical	P	4	3	30	70	100
Elective Course (Any One)	PS03EMIC51	Biomanufacturing Principles and Practices	T	4	3	30	70	100
	PS03EMIC52	Toxicology	T	4	3	30	70	100
	PS03EMIC53	Bioinformatics	T	4	3	30	70	100

Master of Science (Microbiology)
M. Sc (Microbiology) Semester III

Course Code	PS03CMIC51	Title of the Course	**Microbial biotechnology**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	This course focuses on industrial applications of bioprocesses (Industrial Biotechnology) for the commercial manufacture of value-added biotechnological products like organic acids, vitamins, aminoacids, antibiotics, enzymes, biopharmaceuticals, fermented foods, microbial biomass etc. Major objectives are….. 1. To understand and critically evaluate the role of micro-organisms in specific biotechnological processes. 2. To understand biochemistry for overproduction of various industrially important microbial metabolites. 3. To learn about industrial fermentation processes (upstream and downstream) for various primary metabolites, secondary metabolites, microbial biomass, biotransformations, and fermented foods.

Course Content		
Unit	Description	Weightage* (%)
1.	• Scope of Microbial biotechnology . • Microbial production and applications of primary metabolites: Citric acid, Ethanol, L Glutamic acid, L Lysine ,Vitamins B_{12} and vitamin B_2 • Industrially important microbial enzymes: Types, mode of action and applications of microbial amylases and proteases	25
2.	• Microbial production of therapeutically important products:. o Antibiotics: Penicillin, Streptomycin o Ergot alkaloids : Production by Saprophytic cultivation • Biotransformations of steroids: Hydroxylations and dehydrogenations, Sterol biotransformations. • Probiotics and prebiotics: Fundamental aspects and health benefits	25
3.	• Production of single cell protein from bacteria, fungi and algae: Characteristics, Nutritional value and safety. Substrates used, process examples, applications. • Cultivation of edible and medicinal mushrooms: Nutritional and	25

	medicinal properties. • Production and applications of microbial exopolysaccharides: Classification, biological functions, Structure and Biosynthesis of Xanthan and Alginate, Factors affecting fermentative production of exopolysaccharides and recovery. • Production of bioplastics	
4.	• Physiological characteristics, functions and production of lactic starter cultures. • Microbiology and technology of Fermented foods and dairy products: o Cheese making: Cheese varieties, manufacture of cheddar cheese, Sources and properties of rennets. o Yoghurt making: • Technology of Beer brewing:	25

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will …….	
1.	Get acquainted with the industrial aspect of the field of Microbiology and also learn about growth pattern of microbes in different industrial systems.

2.	Develop understanding of the variety of fermentations and subsequent processing approaches available for the manufacture of biological products.
3.	Acquire experimental knowhow of some of the industrial products produced by microorganisms such as enzymes, fermented foods etc.
4.	Be able to demonstrate a clear understanding of how biochemical pathways relate to biotechnological applications.

Suggested References:

- Comprehensive Biotechnology Vol-4, Murray Moo Young.
- Biotechnology-Rehm and Reid.
- Microbial Technology: Pepler
- Microbiology and technology of fermented foods: R. W. Hutkins. Blackwell publishing.
- Topic related review papers

On-line resources to be used if available as reference material
On-line Resources

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Master of Science (Microbiology)
M. Sc (Microbiology) Semester III

Course Code	PS03CMIC52	Title of the Course	Environmental Microbiology
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To understand major environmental pollution issues and possible solutions through knowledge of microbiolology. 2. To understand biogeochemical cycling of essential elements and its implications. 3. To understand physiological and molecular adaptations in extremophiles and their possible biotechnological applications, 4. To understand various beneficial plant- microbes interactions and their importance in agriculture. 5. To learn various experimental approaches for detection and quantification of microbes in environment. 6. To understand fundamental aspects of microbial ecology.

Course Content		
Unit	Description	Weightage* (%)
1.	Global environmental problems: Global warming, Ozone depletion, Acid rain Water pollution: Sources and types, Physical, chemical and biological pollution of water. Eutrophication and its control. Microbial Indicators of water pollution Biodeterioration of wood and metals: Role of micro-organisms, mechanisms and control.	25
2.	Biogeochemical cycles: Cabron, Nitrogen , Sulphur , Iron and Phosphorous cycles. Detrimental effects of diverted biogeochemical cycles: acid mine drainage, nitrous oxide emission, nitrate pollution of ground water Biological Nitrogen Fixation in detail: Asymbiotic, symbiotic and associative nitrogen fixation. Structure, function and genetic regulation of nitrogenases.	25
3.	Microorganisms in extreme environments: Characteristics of extreme environments ,Microbial diversity, habitat and adaptive strategies of thermophiles and hyperthermophiles, psychrophiles and psychrotrophs, halophiles, acidophiles and alkalophiles. Biotechnological applications of extremophiles Methods to study microorganisms in environment: Detection of microbial populations: Phenotypic detection, Lipid profile analysis, molecular detection	25

	Determination of microbial biomass: Biochemical assays, physiological approaches. Physiological methods to study microbial activity	
4.	Microbial communities and ecosystems: Microbial community dynamics, Structure of microbial communities, Ecosystems,Structure and function of some microbial communities in nature. Beneficial Interactions between microorganisms and plant: Mycorrhyzae, Symbiotic nitrogen fixing associations between rhizobia and legumes , Anabaena and Azolla, Plant growth promoting rhizobacteria: Transport / Mobility of microorganisms in soil and subsurface: Factors affecting transport, Novel approaches to facilitate microbial transport	25
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Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Gain awareness about different Types of Environmental Pollution and Related Issues
2	Understand and appreciate crucial role of microbes in various biogeochemical cycles .

3.	Appreciate the diversity of microorganism and microbial communities inhabiting a multitude of extreme habitats and will be able to understand unique features of extremophiles which can be exploited for various industrially important activities/products and environmental conservation.
4.	Learn different methods for detection of microbes from various environments and their characterization.
5.	Understand fundamental aspects of microbial ecology and become familiar with current research in environmental microbiology.
6	Understand various plant microbes interactions especially rhizosphere, phyllosphere and mycorrhizae and their applications especially the biofertilizers

Suggested References:

- . Environmental Microbiology. R. M. Maier, I. L. Pepper & G. P. Gerba.
- Comprehensive Biotechnology Vol-4, Murray Moo Young.
- Biotechnology- Rehm and Reid.
- Microbial Ecology: Fundamentals and Applications- Atlas & Bartha, fourth edition, Pearson Education.
- Environmental science, B. J. Nebel and R. T. Wright.
- The prokaryotes- 3 rd edition, volume 2
- Brock Biology of micro organisms by Madigan,Martinko, Dunlap, and Clark

On-line resources to be used if available as reference material
On-line Resources

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Master of Science (Microbiology)
M Sc Microbiology Semester III

Course Code	PS03CMIC53	Title of the Course	ENZYMOLOGY
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. Understanding of basics properties of enzymes 2. Understand reaction kinetics of enzyme reactions, their mechanisms and experimental methods to study them 3. Understand the applications of enzymes and their engineering

Course Content		
Unit	Description	Weightage* (%)
1.	**Introduction to Enzymology & Practical Enzymology** Introduction and historical developments in enzymology Protein Structure: Primary, secondary, tertiary and quaternary structure, techniques used in enzyme characterization Enzyme nomenclature and classification, Characteristics, chemical nature and properties of enzymes, enzyme specificity and rate enhancement. Enzyme Activity, assay methods, factors affecting enzyme activity, progress curve, enzyme activators, coenzyme and cofactors. Enzyme purification: Objectives and strategy, separation techniques, test of purity, case study	25
2.	**Enzyme Kinetics (Single substrate and Multi-substrate)** Chemical reaction kinetics and catalysis Single substrate kinetics: Equilibrium and Steady state kinetics, significance of Km, Vmax & Kcat, enzyme efficiency. Multisubstrate kinetics: General rate equation, compulsory order, random order and ping-pong mechanisms and their primary and secondary plots. Enzyme inhibition and its kinetics: Reversible and irreversible inhibition, competitive, non-competitive and uncompetitive, mixed, partial, substrate inhibition. Thermal kinetics: Effect of temperature on reaction rate, enzyme stability, Arrhenius equation and activation energy.	25
3.	**Enzyme catalytic mechanisms and control of enzyme activity** Enzyme catalytic mechanisms: Factors affecting catalytic efficiency, Mechanism of Lysozyme, Chymotrypsin, Carboxypeptidase,. Aspartate transcarbomylase	25

	Oligomeric enzymes: Sigmoidal kinetics and regulation, Protein ligand binding, Co-operativity, MWC & KNF models Experimental approaches to understand enzyme mechanisms Control of single enzyme activities by changes in covalent structure, ligand induced conformational changes and feedback inhibition.	
4.	**Enzymes Technology and Applications** Enzyme engineering: Structure function relationship, Methods of enzyme alterations, examples of engineered proteins Enzyme Immoblization, enzyme sensors, analytical and industrial applications of enzymes Enzymes in non conventional media, Isoenzymes and its physiological significance, Ribozymes and Abzymes	25

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Appreciate the versatility of enzymes in the living systems, their properties and working
2.	Handle and work with enzymes to understand in depth their kinetics, mechanisms and their regulatory roles.
3.	Understand and work with the applications of enzymes in industries, therapeutics and other sectors and also the role of engineered enzymes
4	Appreciate the significance of isoenzymes, abzymes and ribozymes

Suggested References:

Sr. No.	References
1.	The chemical kinetics of enzyme action: K. J. Laider and P. S. Bunting, Oxford University Press, London.
2.	Enzyme Structure and mechanism: Alan Fersht, Reading, USA.
	Understanding Enzymes: Trevor Palmer
	Fundamentals of Enzymology: Nicholes C. Price and Lewis Stevens, Oxford Univ. Press.
	Enzymes: M. Dixon, E. C. Webb, CJR Thorne and K. F. Tipton, Longmans, London
	Enzyme Technology: Anusha Bhaskar and V.G. Vidhya, MJP Publishers, Chennai, India.
	Enzymes:, Catalysis, Kinetics and Mechanisms, By N.S. Punekar. Springer nature publications, Singapore
	ENZYME KINETICS A Modern Approach by Alejandro G. Marangoni. John Wiley & Sons, Inc., Hoboken, New Jersey.
	Proteins: Thomas Creighton
	Biochemistry: Lubert Stryer.
	Biochemistry: D Voet and J Voet, Fourth edition, John Wiley Publishers

	Enzymology, T Devsena, Oxford Publication

On-line resources to be used if available as reference material
On-line Resources:
https://www.expasy.org/
https://www.ncbi.nlm.nih.gov/
https://onlinecourses.nptel.ac.in
https://www.swayamprabha.gov.in/index.php/home

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Course Code	PS03CMIC54	Title of the Course	LAB-I
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To learn to isolate bacterial cells and carry out fermentation experiments. 2. To learn various experimental techniques of environmental microbiology

PS03CMIC54

List of Practical Exercises:

1. Cellulase production by Solid State Fermentation (SSF) (Endoglucanase assay, Filter paper activity, Protein estimation by Folin's and Lowry's method).
2. Saccharification of agro-waste by cellulase
3. Yoghurt making
4. Isolation of lactic acid bacteria
5. Antimicrobial activity of Lactobacillus strains
6. Screening and isolation of proteolytic bacteria
7. Screening and isolation of Amylase producing bacteria
8. Microbiological analysis of drinking water (Detection and enumeration of coliforms, Fecal coliform MPN test, Detection of *E. coli,* Differentiation of coliforms)
9. Detection and enumeration of fecal Streptococcus and Enterococcus groups from recreational water
10. Oxidation of sulphur in soil
11. Demonstration of Nitrification in soil and its inhibition
12. Isolation of sulphur oxidizing bacteria from soil
13. Isolation of phosphate solubilizing microorganisms from soil

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

1.	Work in industrial microbiology laboratory.
2.	Perform soil and water analysis
3	Investigate microbial diversity and quantitate microorganisms in natural ecosystems.

References:

1	Thimmaiah S. K. (2012). Standad Methods of Biochemical Analysis. Kalyani Publishes, New Delhi, India.

Course Code	PS03CMIC55	Title of the Course	LAB-II
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To learn to perform enzyme assay 2. To learn to experimentally determine kinetics of an enzyme 3. To learn methods of enzyme immobilization

PS03CMIC55 (Lab II)

List of Practical Exercises:

Part A: Practicals corresponding to PS03CMIC53

1. Invertase Assay
2. Progress curve
3. Enzyme curve
4. Substrate saturation curve
5. Optimization of pH for invertase activity
6. Analysis of Substrate saturation data by various plots
7. Inhibition kinetics
8. Optimization of Temperature for invertase activity
9. Effect of temperature on Rate of reaction and determination of activation energy
10. Effect of temperature on enzyme stability
11. Enzymology workshop: kinetics, plots and numericals

Part B: Practicals related to corresponding elective paper

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

1.	determine activity of enzyme in a given sample.
2.	experimentally determine kinetic parameters of an enzyme.
3	to design experiments for biochemical characterization of any enzyme.

References:

1	Thimmaiah S. K. (2012). Standad Methods of Biochemical Analysis. Kalyani Publishes, New Delhi, India.

(Master of Science) (Microbiology)
(M. Sc.) (Microbiology) Semester (III)

Course Code	PS03EMIC51	Title of the Course	Biomanufacturing Principles and Practices
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1.To make the students understand the concept, development and use of SOPs in Biomanufacturing 2.To impart knowledge on essential quality parameters and their measurement in Biomanufacturing. 3. Familiarize the students to the basic needs of a Biotechnology industry

Course Content		
Unit	Description	Weightage* (%)
1.	Overview and design of biomanufacturing, quality by design approach, technical considerations, phases and scale up: life cycle of manufacturing, raw material considerations, compliance and quality in biomanufacturing, lean biomanufacturing; Standard manufacturing operating procedures of biotechnology, quality control of protein production, and final fill and finish of product; Case studies to be included at least: therapeutic proteins, monoclonal antibodies, human vaccines.	25%
2.	Introduction to quality system, main elements of a quality system; Essential of quality system; Practical implementation of a quality system; Structure of quality manual, correlation between GMP requirements (WHO) and ISO 9001:2000.	20%
3.	Personnel: Principles of human resource management, duties of senior management, organizational structures, qualification and profiles requirement. Premises: Official requirements, material & personnel flow and layout, air cleanliness classes and grades, construction elements, barrier systems, isolators and safety cabinets, building services, heating ventilation air conditioning (HVAC), process gases, qualification of premises and HVAC systems, pharma monitoring of HVAC systems, particle monitoring.; Process Validation: Official requirements, Validation - a key element of quality management, validation planning and procedure, validation documentation, process validation and product lifecycle ; Cleaning	30%

	Validation: Official requirements, how to validate cleaning procedures.	
4.	Production: Sanitation, GMP in production process, sterilisation processes, aseptic processing, freeze-drying, testing for sterility, testing for endotoxins, testing for leakage and for particles, microbiological monitoring, packaging materials, packaging process. Information: National bodies and pharmaceutical associations; Pharmacopeia; EU directives and guidelines, USA: CFR and FDA guidelines, ICH-guidelines, PIC/S guidelines, GMP of other regions, WHO guidelines.	25%

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand fundamental operations, procedures and rules of Industrial manufacturing with special reference to Biological products.
2.	Learn the basic components of an industry, GMP and SOP along with industry standards of testing, sterilization and packing

3.	Become familiar with industry certification process, it's significance and relevance
4.	Learn various guidelines and regulations for biomanufacturing in detail

Suggested References:	
Sr. No.	References
1.	Introduction to Biomanufacturing, by Northeast Biomanufacturing Center and collaboration, 2012.
2.	Introduction to Biomanufacturing, by Mark Witcher. In Encyclopedia of Industrial Biotechnology.
3.	Good Manufacturing Practices for Pharmaceuticals (e-resource): A Plan for Total Quality Control. Sidney Willig and James Stoker
4.	Biotechnology Operations: Principles and Practices, by John M. Centanni, Michael J. Roy; CRC press
5.	GMP Manual; Publisher Maas & Peither America, Inc. GMP Publishing.

On-line resources to be used if available as reference material
On-line Resources

Master of Science (Microbiology)
(M.Sc.) (Microbiology) Semester (III)

Course Code	PS03EMIC52	Title of the Course	Toxicology
Total Credits of the Course	04	Hours per Week	03

Course Objectives:	i. To learn about the dose-response relationships and understand the tocixity of various substances ii. To comprehend the knowledge of absorption, distribution, metabolism and elimination of xenobiotics iii. To provide an overview on legislative measures in the field of food, drugs and environmental toxciants

Course Content		
Unit	Description	Weightage* (%)
1.	Definition and scope of toxicology: Eco-toxicology and its environmental significance, Biochemical Aspects of Toxicology Toxic effects: Basic for general classification & nature. Measurement of Dose-Response Relationships, Synergism and Antagonism Acute and Chronic exposures, Factors influencing Toxicity. Pharmacodynamics & Chemodynamics, dose conversion between animals and human Diagnosis of toxic changes in liver and kidneys: Metabolism of drugs: paracetamol and aspirin with their toxic effects on tissues.	25
2.	Xenobiotics Metabolism: Absorption & distribution. Phase I reactions. Oxidation, Reduction, Hydrolysis and Hydration. Phase II reaction/Conjugation: Methylation, Glutathione and amino acid conjugation. Detoxification. Biochemical basis of toxicity: Metabolism of Toxicity: Disturbances of Excitable membrane function. Altered calcium Homeostasis. Covalent binding of cellular macromolecules & Genotoxicity. Tissue specificity of Toxicity. Toxicity testing: Models for toxicity testing; Acute and Chronic toxicology testing, Experimental design; Genetic toxicity testing & Mutagenesis assays In vitro Test systems – Bacterial Mutation Test, Ames test, *In vivo* Mammalian Mutation tests –DNA repair assays, Chromosome damage test, Evaluation of Apoptosis and necrosis	25
3.	Pesticides: Insecticides: Organochlorines, Anti cholinesterases-Organophosphates and Carbamates, Fungicides: Captan, Di-thio carbamates, Herbicides:2,4 D, Atrazine; Food additives: Preservatives,	25

	Processing aids, Flavor and taste modifiers, Nutritional additives; Role of diet in cardio-vascular disease and cancer. Toxicology of food additives; Metal Toxicity: Toxicology of Arsenic, mercury, lead and cadmium.	
4.	Regulatory Toxicology: Rules and regulations of Nuclear Regulatory Commission (NRC); Environmental Protection Agency (EPA); Food and Drug Administration (FDA); Drug Enforcement Administration (DEA); Occupational Safety and Health Assessment (OSHA); Committee for Purpose of Control and supervision of experimental on animals (CPCSEA)	25

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Learn the toxicity testing methods and designing of animal experimentations in pharmaceutical and drug industries or research organizations
2.	Correlate concentrations of doses, duration of exposure and animal responses

Suggested References:

Sr. No.	References
1.	Klaassen, C., D., (Ed) (2013). Casarett and Doull's toxicology : the basic science of poisons. McGraw-Hill Education, New York.
2.	Timbrell, J. A., (2008). Principles of biochemical toxicology. Taylor and Francis Ltd., London.
3.	Smart, R. C., Hodgson, E., (Ed.) (2013). Molecular and biochemical toxicology. John Wiley and Sons, Inc.

On-line resources to be used if available as reference material
On-line Resources

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Master of Science (Microbiology)
M.Sc. (Microbiology) Semester III

Course Code	PS03EMIC53	Title of the Course	Bioinformatics
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. To get knowledge and awareness of the basic principles and concepts of biology, computer science and mathematics 2. To explore existing software effectively to extract information from large databases and to use this information in computer modelling 3. To get problem-solving skills, including the ability to develop new algorithms and analysis methods. 4. To train student for understanding of the intersection of life and information sciences, the core of shared concepts, language and skills the ability to speak the language of structure-function relationships, information theory, gene expression, and database queries.

Course Content		
Unit	Description	Weightage* (%)
1.	❖ **Introduction to Bioinformatics:** ▪ Introduction and Bioinformatics Resources: ▪ Knowledge of various databases and bioinformatics tools available at these resources, the major content of the databases, Literature databases: ▪ Describe about various approaches in genome sequencing and NGS ▪ Overview of Sequence trace files (or chomatograms) raw data output from sequencer machines, Assembling and storing of the sequencer data files. ▪ Nucleic acid sequence databases: GenBank, EMBL, DDBJ ▪ Protein sequence databases: SWISS-PROT, TrEMBL, PIR, PDB, SCOP, CATH ▪ Genome Databases at NCBI, EBI, TIGR, SANGER ▪ Other Databases of Patterns/Motifs/System Biology (Gene and protein network database and resources) ❖ **Sequence analysis:** ▪ Various file formats for bio-molecular sequences: GENBANK, FASTA, GCG, MSF, NBRF-PIR etc. ▪ Basic concepts of sequence similarity, identity and homology, Definitions of homologues, orthologues, paralogues, xenologus. ▪ Scoring matrices: basic concept of a scoring matrix, PAM and BLOSUM series.	25%

	▪ Database Searches: what are sequence-based database searches, BLAST and FASTA algorithms, various versions of basic BLAST and FASTA. ▪ Pairwise and Multiple sequence alignments: basic concepts of sequence alignment, Needleman & Wuncsh, Smith & Waterman algorithms for pairwise alignments, Progressive and hierarchical algorithms for MSA. ▪ Use of pairwise alignments and Multiple sequence alignment for analysis of Nucleic acid and protein sequences and interpretation of results.	
2.	❖ **Gene prediction:** ▪ Gene structure in Prokaryotes and Eukaryotes, Gene prediction methods: Neural Networks, Pattern Discrimination methods, Signal sites Predictions, Evaluation of Gene Prediction methods. ❖ **Computational RNA Structure analysis:** ▪ Secondary and tertiary structure of RNA. Various algorithms of RNA folding and their analysis. Energy minimization in RNA folding. RNA sequence alignment based on secondary structure and its applications in functional genomics and phylogeny. ❖ **Transcriptomics:** ▪ Complete transcript cataloguing and gene discovery sequencing ▪ Microarray based technologies and computation based technologies	25%
3.	❖ **Genomics:** ▪ Concepts and tools for genomics and comparative Genomics ▪ Ancient conserved regions ▪ Horizontal gene transfer ▪ Functional classification of genes ▪ Gene order (synteny) is conserved on chromosomes of related organisms. ▪ Prediction of gene function based on a composite analysis. ▪ Functional genomics. ▪ Putting together all of the information into a genome database. ❖ **Phylogenetic analysis:** ▪ Definition and description of phylogenetic trees and various types of trees, Molecular basis of evolution, Method of construction of Phylogenetic trees: Distance based method (UPGMA, NJ), Character Based Method (Maximum Parsimony and Maximum Likelihood method).	25%
4.	❖ **Proteomics and Protein Computational Biology:** ▪ Tools for proteomics: Acquisition of protein structure	25%

	information, databases and applications. ▪ Structural classification of proteins, Protein structure analysis structure alignment and comparison, ▪ Secondary structure and evaluation: algorithms of Chou Fasman, GOR methods. ▪ Tertiary Structure: Basic principles and protocols, Methods to study 3D structure; Prediction of specialized structures. Protein folding, Protein modelling, Method of protein structure evaluation; Active site prediction. ▪ Protein-protein and protein-ligand interaction/Docking; Drug Designing, QSAR studies. ❖ **Protein structure comparison and classification:** ▪ Classes, Folds, Motif, Domain; ▪ Purpose of structure comparison ▪ Algorithms such as FSSP, VAST and DALI. ▪ Principles of protein folding and methods to study protein folding.	

Teaching-Learning Methodology	Online / Offline / Presentation / Videos	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	To get introduced to the basic concepts of Bioinformatics and its significance in Biological data analysis.
2.	To get introduced to the basics and advance of sequence alignment and analysis.
3.	To get overview about biological macromolecular structures and structure prediction methods.
4.	To understand the structural organisation, structural properties and various techniques employed in the structure determination of Biological macromolecules – DNA &

	Protein.
5.	To get exposed to computational methods, tools and algorithms employed for Biological Data Interpretation.
6.	To have hands on training on various computational tools and techniques employed in Biological sequence analysis.
7.	To get exposed to various tools and methodologies used in multiple sequence alignment, phylogenetic analysis and genetic diversity analysis observed in biological sequences.
8.	To impart knowledge on chemical databases, various advanced techniques and tools like docking, QSAR studies etc employed in computational drug discovery.
9.	To get knowledge about various approaches in genome sequencing and NGS.

Suggested References:

Sr. No.	References
1.	Bioinformatics: A Beginners Guide, Clavarie and Notredame
2.	Bioinformatics: David Mount
3.	Bioinformatics: Rastogi
4.	Introduction to Bioinformatics: Arthur M. Lesk
5.	Bioinformatics: Principles and applications, Ghosh and Mallick
6.	Bioinformatics: Genes, Proteins and Computer, C A Orengo
7.	Protein Structure Prediction: Methods and Protocols, Webster, David (Southern Cross Molecular Ltd., Bath, UK)

On-line resources to be used if available as reference material

On-line Resources

Nucleotide Sequence Databases (the principal ones)

- NCBI - National Center for Biotechnology Information
- EBI - European Bioinformatics Institute
- DDBJ - DNA Data Bank of Japan

Protein Sequence Databases

- SWISS-PROT & TrEMBL - Protein sequence database and computer annotated supplement
- **UniProt** - UniProt (Universal Protein Resource) is the world's most comprehensive catalog of information on proteins. It is a central repository of protein sequence and function created by joining the information contained in Swiss-Prot, TrEMBL, and PIR.
- PIR - Protein Information Resource
- MIPS - Munich Information centre for Protein Sequences
- HUPO - HUman Proteome Organization

Database Searching by Sequence Similarity

- BLAST @ NCBI
- PSI-BLAST @ NCBI
- FASTA @ EBI
- BLAT Jim Kent's Blat is just superb in terms of speed and the integrated view you get for viewing the results

Sequence Alignment

- USC Sequence Alignment Server - align 2 sequences with all possible varieties of dynamic programming
- T-COFFEE - multiple sequence alignment
- ClustalW @ EBI - multiple sequence alignment
- MSA 2.1 - optimal multiple sequence alignment using the Carrillo-Lipman method
- BOXSHADE - pretty printing and shading of multiple alignments
- Splign - Splign is a utility for computing cDNA-to-Genomic, or spliced sequence alignments. At the heart of the program is a global alignment algorithm that specifically accounts for introns and splice signals.
- Spidey - an mRNA-to-genomic alignment program

Protein Domains: Databases and Search Tools

- InterPro - integration of Pfam, PRINTS, PROSITE, SWISS-PROT + TrEMBL
- PROSITE - database of protein families and domains
- Pfam - alignments and hidden Markov models covering many common protein domains
- SMART - analysis of domains in proteins
- ProDom - protein domain database
- PRINTS Database - groups of conserved motifs used to characterise protein families
- Blocks - multiply aligned ungapped segments corresponding to the most highly conserved regions of proteins

Protein 3D Structure

- PDB - protein 3D structure database
- RasMol / Protein Explorer - molecule 3D structure viewers
- SCOP - Structural Classification Of Proteins
- UCL BSM CATH classification
- The DALI Domain Database
- FSSP - fold classification based on structure-structure alignment of proteins
- SWISS-MODEL - homology modeling server
- Structure Prediction Meta-server

- K2 - protein structure alignment
- DALI - 3D structure alignment server
- DSSP - defines secondary structure and solvent exposure from 3D coordinates
- HSSP Database - Homology-derived Secondary Structure of Proteins
- PredictProtein & PHD - predict secondary structure, solvent accessibility, transmembrane helices, and other stuff
- Jpred2 - protein secondary structure prediction
- PSIpred (& MEMSAT & GenTHREADER) - protein secondary structure prediction (& transmembrane helix prediction & tertiary structure prediction by threading)

Phylogeny & Taxonomy

- The Tree of Life
- Species 2000 - index of the world's known species
- TreeBASE - a database of phylogenetic knowledge
- PHYLIP - package of programs for inferring phylogenies
- TreeView - user friendly tree displaying for Macs & Windows

Gene Prediction

- Genscan - eukaryotes
- GeneMark
- Genie - eukaryotes
- GLIMMER - prokaryotes
- tRNAscan - SE 1.1 - search for tRNA genes in genomic sequence
- GFF (General Feature Format) Specification - a standard format for genomic sequence annotation

Metabolic, Gene Regulatory & Signal Transduction Network Databases

- KEGG - Kyoto Encyclopedia of Genes and Genomes
- BioCarta
- **DAVID** - **D**atabase for **A**nnotation, **V**isualization and **I**ntegrated **D**iscovery - A useful server to for annotating microarray and other genetic data.
- stke - Signal Transduction Knowledge Environment
- BIND - Biomolecular Interaction Network Database
- EcoCyc
- WIT
- **PathGuide** A very useful collection of resources dealing primarily with pathways
- SPAD - Signaling Pathway Database
- CSNDB - Cell Signalling Networks Database
- PathDB
- Transpath
- DIP - Database of Interacting Proteins
- PFBP - Protein Function and Biochemical Networks

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SARDAR PATEL UNIVERSITY
Vallabh Vidyanagar, Gujarat
(Reaccredited with 'A' Grade by NAAC (CGPA 3.25)
Syllabus with effect from the Academic Year 2022-2023

PROGRAMME STRUCTURE

M.Sc. Microbiology Semester: IV

Programme Outcome (PO) - For M.Sc. Microbiology Programme	Programme specific outcome for M.Sc. Microbiology Students completing the MSc degree programme in Microbiology which is a two year full time program will be able to understand and explain various areas related to microbiology subjects like molecular biology, recombinant DNA technology and immunology. The student will be well versed with the concepts of aseptic handling techniques, maintenance and preservation of industrially as well as clinically important microbial cultures and correlate the molecular basis microbial physiology and ecology. The student will also be enlightened about application in different fields related to Microbial Technology Students will be able to design and establish a microbiology laboratory, they will be able to design the experiments related to basic microbiology, and perform biological assays using whole cells as well as enzymes and be able to identify microorganisms using biochemical as well as molecular identification techniques. Students will be able to execute a short project involving the knowledge and techniques of basic and advanced microbiology, biochemistry, cell biology and bioprocess engineering. The student will be skilled enough to be employed as microbiologist in fermentation industry, clinical laboratory, research and development organization, food and drugs administration, etcor purse doctoral studies in any field of Biological sciences
Programme Specific Outcome (PSO) - For MSc Microbiology Semester - IV	1. On successful completion of this semester student will have sufficient understanding of bioreactors, control of process parameters and various aspects of microbial fermentation, to enable him/her to work as Fermentation plant as microbiologist. 2. Student should be able to correlate genes and their functions as well as inheritance in bacteria. 3. Student will gain sufficient fundamental knowledge of immunology and should be able to perform various immunoassays independently. …

To Pass	(1) At least 40% marks in each paper at the University Examination and 40% aggregate marks in Internal and External Assessment. (2) At least 33% Marks in each paper in Internal Assessment.

Course Type	Course Code	Name Of Course	Theory/ Practical	Credit	Exam Duration in hrs	Component of Marks		
						Internal Total	External Total	Total Total
Core Course	PS04CMIC51	R DNA Technology	T	4	3	30	70	100
	PS04CMIC52	Environmental Biotechnology	T	4	3	30	70	100
	PS04CMIC53	Practical	P	4	3	30	70	100
	PS04CMIC54	Viva-Voce	=	1	=	=	50	50
Elective Course (Any Two)	PS04EMIC51	IPR and Biosafety	T	4	3	30	70	100
	PS04EMIC52	Research Ethics and Scientific Writing	T	4	3	30	70	100
	PS04EMIC53	Systems Biology	T	4	3	30	70	100
	PS04EMIC54	Biomaterials and Tissue Engineering	T	4	3	30	70	100
	PS04EMIC55	Biodiversity and Conservation	T	4	3	30	70	100
	PS04EMIC56	Food and Dairy Microbiology	T	4	3	30	70	100
	PS04EMIC57	Mycology and Plant Pathology	T	4	3	30	70	100
		OR						
Core Course	PS04CMIC51	R DNA Technology	T	4	3	30	70	100
	PS04CMIC52	Environmental Biotechnology	T	4	3	30	70	100
	PS04CMIC53	Practical	P	4	3	30	70	100
	PS04CMIC54	Viva-Voce	=	1	=	=	50	50
Elective Course	PS04EMIC58	Dissertation	=	12	=	=	300	300

(Master of Science) (Microbiology)
(M. Sc.) (Microbiology) Semester (IV)

Course Code	PS04CMIC51	Title of the Course	R-DNA Technology
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1 To understand the basic tools and techniques used for manipulation of DNA 2. To become familiar with the strategies for production of transgenic organisms 2. To learn applications of genetic engineering in agriculture, industry and medicine

Course Content		
Unit	Description	Weightage* (%)
1.	Concept and importance of Genetic Engineering; General strategies and Steps involved in gene cloning: Extraction and purification of DNA and RNA from bacteria, virus, plant and animal cells; physical and enzymatic methods for cutting DNA; Salient features of different enzymes used in R-DNA technology, Introduction of DNA into host cells; screening and selection methods for recombinant clones.	25%
2.	Basic properties and cloning strategies for vectors derived from Plasmids, bacteriophages and their chimeric vectors, YAC, BAC, HAC/MAC and viral vectors for Plant and animal cells. Salient features of expression vectors for heterologous expression in *E. coli*, Yeast, insect and mammalian system. Shuttle vectors and gene trapping vectors. Vector design and modification strategies; chemical synthesis of oligonucleotides.	25%
3.	DNA sequencing and sequence assembly: Maxam-Gilbert's and Sanger's methods, Shot gun sequencing, Next generation sequencing strategies for large genomes. DNA mapping and DNA fingerprinting: Physical and molecular mapping, Hybridization and PCR based methods of fingerprinting. Site directed mutagenesis: Methods and applications. Polymerase Chain Reaction: Principle and basic types of PCR; Reverse Transcription and Real Time PCRs. Construction genomic and cDNA libraries;	25%
4.	Applications of Genetic engineering in improvement of plants, animals and microbes; Gene editing and its applications; Metagenomics and	25%

	Metabolic engineering; Gene therapy; Restriction and regulations for the release of GMOs; Biosafety and levels of Physical and Biological containment; The Indian Guidelines for release and use of GM organisms.	

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	explain different steps involved in gene cloning, different enzymes available and how to choose an enzyme for a particular application in genetic engineering.
2.	describe salient features of different vectors available, their design and strategies to be applied for cloning and selection of recombinants.
3.	explain details of preparation of genomic and cDNA libraries as well as discuss various strategies for screening of recombinant clones.
4	explain the PCR and its variants in detail along with their applications. Students will be able to design PCR primers and reaction parameters.
5	describe different types of molecular markers and their applications in detail.
6	explain various DNA sequencing techniques and their applications in detail.

7.	describe genetic engineering guidelines and regulatory procedures to be followed while conducting genetic engineering experiments

Suggested References:	
Sr. No.	References
1.	Principles of Gene Manipulation and Genomics" by Sandy B Primrose and Richard Twyman
2.	Genetic Engineering by Smita Rastogi and Neelam Pathak
3.	Gene cloning : An introduction. T. A. Brown

On-line resources to be used if available as reference material
On-line Resources

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Master of Science (Microbiology)
M. Sc (Microbiology) Semester IV

Course Code	PS04EMIC56	Title of the Course	Food and Dairy Microbiology
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To understand about types of food spoilage and factors influencing food spoilage as well as microorganisms associated with spoilage of food. 2. To learn about food borne pathogens and types of infections or poisoning caused upon consumption of pathogen contaminated food products.. 3. To gain insights into methods of food preservation and production of fermented foods. 4. To gain information about detection of pathogens in food as well as analysis of food quality. 5. To learn about regulations governing and certifications for food quality and recommended sanitation practices for food processing plants.

Course Content		
Unit	Description	Weightage* (%)
1.	Scope of food microbiology Food as a substrate a) Microorganisms important in food microbiology – Bacteria, yeasts and moulds. b) Factors influencing microbial growth in food. Food Spoilage a) General principles underlying food spoilage and contamination. b) Spoilage of canned food, sugar products, vegetables, fruits, meat and meat products, milk and milk products fish, seafood and poultry	25
2.	Food poisoning a) Indicator food borne pathogens b) Bacterial food borne infections and intoxications-*Brucella, Campylobacter, Clostridium, Escherichia* (ETEC/EHEC/EPEC/EAEC), *Salmonella, Shigella, Listeria, Vibrio, and Yersinia.* c) Non- bacterial food borne infections and intoxications- Nematodes, protozoa, algae, fungi, and viruses. d) Culture and non-culture based detection of food pathogens and viruses e) General methods for diagnosis of infections, intoxications and preventive measures.	25
3.	Food preservation Principles of food preservation – Physical and chemical preservation	25

	methods, Bio preservatives Food fermentations Starter cultures for fermented foods: Biochemical activities in fermentation of foods. Oriental fermented foods: Shoyu, Temph, Kimchi etc Fermented milk products: Yogurt, Kefir, Koumiss etc. Fermented vegetables – Sauerkraut Application of microbial enzymes in food industry	
4.	Genetically modified foods. Biosensors in food Food research organizations/institutes in India Recent foodborne outbreaks Food sanitation – Microbiology of food plant sanitation, water and milk testing Food laws and quality control – HACCP, Codex alimentarius, PFA, FPO, MFPO, BIS, FSSAI AGMARK.	25
...		

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

1.	describe the types of food spoilage and factors influencing food spoilage.
2	associate a type of food spoilage with the causative microorganisms
3.	describe different types of food poisoning or infection and design a study to determine the cause of food poisoning or food borne infection.
4.	recommend a method of preservation for a particular type of food and expected extension in the shelf life of foods preserved thereby.
5.	understand science and technology in production of a fermented food of high quality.
6	decide a method of sanitation for a food processing plant
7	describe the applicable laws for food processing and/packaging as well as associated quality certifications.

Suggested References:

- Food Microbiology, Frazier and Westhoff
- Food microbiology, Adam and Moss
- Dairy Microbiology by Robinson. Volume II and I.
- Fundamental Food Microbiology, Bibek Ray and ArunBhuniya

On-line resources to be used if available as reference material
On-line Resources

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Master of Science (Microbiology)
M.Sc. (Microbiology) Semester (IV)

Course Code	PS04EMIC57	Title of the Course	Mycology and Plant Pathology
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	To understand the fungal classification. 2. To study the structure and reproduction fungi. 3. To understand modern techniques in mushroom cultivation 4. To understand structure and reproduction of lichens. 5. To understand various diseases caused by bacteria fungi and virus.

Course Content		
Unit	Description	Weightage* (%)
1.	Introduction to Fungi: History and classification of Fungi (Alexopoulas, 1962, Ainsworth 1973, Kirk et.al. 2008). Fungi: General characteristics. Economic importance of fungi. Life cycle, morphology, structure and reproduction in Kingdom: Fungi, Kingdom: Chromista and kingdom:Protozoa.	25%
2.	Lichens: Morphology, reproduction and economic importance. Techniques of mushroom cultivation: Schedule and systems of cultivation; composting; peak heating; spawn preparation and mushroom stains spawning and mycelia growth; supplementation; cultivation technique from casing to ruffling and recovery growth to harvesting; pests and diseases and its protection.	25%
3.	The disease triangle: Role of environment, host and pathogen in disease formation. Symptoms, life cycle and control of fungal diseases: Rusts, smuts, blast, red-rot, powdery mildew and tikka diseases. Symptoms, life cycle and control of bacterial and viral diseases: Leaf blight, canker, leaf spot, Mosaic, panama and leaf curl diseases.	25%
4.	Control measures for plant diseases. Chemical control, biological control and integrated disease and pest management. Host- pathogen interactions, plant defense mechanisms. HR and SAR in plant defense. Molecular mechanisms and signaling pathways in plant defenses.	25%
...		

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Students will have clear understanding of fundamentals of various classifications. Students will have clear understanding of various diseases and their control.
2.	Students will have clear understanding reproduction of various classes of fungi.
3.	Students will have understanding techniques involved in cultivation of various mushrooms and their economic importance
4	Students will have clear understanding of biology and economic importance of lichens.
5	Students will have clear understanding of various diseases and their control.

Suggested References:	
Sr. No.	References
1.	Dube, H. C. (2013). *An introduction to fungi*. Scientific Publishers.
2.	Alexopoulos, C. J., Mims, C. W., & Blackwell, M. (1996). *Introductory mycology* (No. Ed. 4). John Wiley and Sons.
3	Singh, R. S. (1980). Principles of Plant pathology.
4.	Singh, R. S. (2018). *Plant diseases*. Oxford and IBH Publishing

On-line resources to be used if available as reference material
On-line Resources

Master of Science (Microbiology)
M. Sc Microbiology Semester IV

Course Code	PS04CMIC52	Title of the Course	**Environmental Biotechnology**
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To understand and address environment issues using knowledge of microbiology 2. To understand fundamentals of waste water treatment processes and biochemistry for removal of pollutants from water and technologies developed for that.. 3. To understand basic concepts of biodegradation and bioremediation strategies for conservation of environment. 4. To understand some of the major pollution problems caused by organic and inorganic pollutants and bioremediation technologies. 5. To learn about eco-friendly biotechnological processes for recovery of various resources. 6. To learn about need and applications of various biofertilizers and biocontrol agents.

Course Content		
Unit	Description	Weightage* (%)
1.	Waste water treatment- Waste water characterization and its significance: COD, BOD, TOC, TOD, Inorganic constituents, solids, biological components. Principles and aims of biological wastewater treatment processes: Primary, secondary and tertiary treatment of waste water. Biochemistry and microbiology of inorganic phosphorus and nitrogen removal from waste water. Suspended growth processes: Activated sludge process: Biology of activated sludge, flocculation, sludge settling, oxidation ditches, waste stabilization ponds. Fixed film processes: Biofilm formation and slaughing, Trickling filters, rotating biological contactors, fluidized bed and submerged aerated filters.	25
2.	Anaerobic digestion: microbiological and biochemical fundamentals, factors influencing anaerobic digestion. Anaerobic waste water treatment systems: Upflow anaerobic sludge blanket , rotating biological contactors, anaerobic filters. Merits and demerits of anaerobic treatment of waste. Composting: Objectives, fundamentals, microbiology, factors influencing composting and composting systems. Compost quality and uses. Vermicomposting.	25

	Toxicity testing in waste water treatment plants using microorganisms: Monitoring environmental processes with biosensors: BOD biosensor, Pesticide biosensor	
3.	Biodegradation of organic pollutants: Xenobiotic and recalcitrant organic compounds, mechanisms of biodegradation, factors affecting biodegradation, Acclimation phase in biodegradation. Biodegradation of simple aliphatic, aromatic, polycyclic aromatic hydrocarbons, halogenated hydrocarbons, azo dyes and lignin. Bioremediation approaches: Intrinsic bioremediation, Biostimulation, Bioaugmentation: Use of genetically modified organisms.. In situ and ex situ bioremediation technologies with examples. Bioremediation of heavy metal pollution, Phytoremediation. Biological treatment of waste gas (polluted air): biofilters, bioscrubbers, membrane bioreactors, biotrickling filters.	25
4.	Bioleaching of metals: Characteristics of commercially important microbes, mechanisms of bioleaching, factors affecting bioleaching and current biomining processes. Biobeneficiation of gold ores. Biodesulfurization of coal: Removal of organic and inorganic sulfur from coal. Microbially enhanced oil recovery. Microbial Insecticides: Bacterial, fungal and viral insecticides in pest management. Biofertilizers: applications of nitrogen fixing and phosphate solubilising/ mobilizing biofertilizers.	25
...		

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%

3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Get trained with analysis of waste waters to judge pollution potential and biological waste water treatment.
2.	Develop ability to understand various bioremediation strategies to overcome pollution problems caused by various pollutants in air, water and soil.
3.	Understand and apply solid waste management technologies and significance of generating valuable products from waste.
4.	Gain technical knowledge about environment friendly biotechnological processes for recovery of valuable resources .
5.	Understand the need and production of biofertilizers and biopesticides for enhanced crop production in agriculture.

Suggested References:

- Comprehensive Biotechnology Vol-4, Murray Moo Young.
- Biotechnology-Rehm and Reid.
- Waste water microbiology by G. Bitton
- Biodegradation and bioremediation by M.Alexander
- Waste water treatment for pollution control, 2nd edition. Arceivala
- Environmental Biotechnology by H. Jordening and Josef Winter
- Handbook of water and waste water Microbiology by Horan
- Topic related review articles

On-line resources to be used if available as reference material
On-line Resources

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Course Code	PS04CMIC53	Title of the Course	LAB-I
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To learn to handle enzymes used in R-DNA technology and perform various experiments in genetic engineering 2. To learn to do water analysis. 3. To learn analysis of environmental samples.

PS04CMIC53 (Lab 1)

List of Practical Exercises:

1. Restriction Digestion
2. Restriction Mapping
3. Ligation
4. Cloning of a gene in plasmid vector
5. Amplification of a desired fragment by PCR
6. RFLP
7. RAPD
8. Expression of a Recombinant Protein
9. Waste water characterization.
    a. BOD
    b. COD
    c. Nitrate estimation
    d. Sulfate estimation
10. Study of phosphate solubilizing activity
11. Isolation of 2,4 dichlorophenoxyacetic acid degrading bacteria
12. Isolation of naphthalene degrading bacteria
13. Dehydrogenase activity of soil
14. Bioremoval of chromium from polluted water
15. Decolourization of Azo dyes by microorganisms.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	perform experiments and contribute in the field of environmental biology.
2	perform experiments related to recombinant DNA technology.

References:

1	Thimmaiah S. K. (2012). Standad Methods of Biochemical Analysis. Kalyani Publishes, New Delhi, India.
2	Short Protocols in Molecular Biology, Frederick M. Ausubel, Roger Brent , Robert E. Kingston , David D. Moore , J. G. Seidman, John A. Smith , Kevin Struhl (Editor)
3	Molecular Cloning: A Laboratory Manual by Joseph. Sambrook, David W. Russell. ISBN 978-1-936113-41-5

Master of Science (Microbiology))
M.Sc. (Microbiology) Semester IV

Course Code	PS04EMIC51	Title of the Course	IPR and Biosafety
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. To introduce basic concepts of ethics and safety that are essential for different disciplines of science and procedures involved and protection of intellectual property and related rights. 2. To understand balanced integration of scientific and social knowledge in sustainable development.

Course Content		
Unit	Description	Weightage* (%)
1.	**Biotechnology and society:** Biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs private funding. **Bioethics:** Social and ethical issues in biotechnology. Principles of bioethics. Ethical conflicts in biotechnology- interference with nature, unequal distribution of risk and benefits of biotechnology, bioethics vs business ethics. Introduction and need of bioethics, its relation with other branches, types of risk associated with genetically modified microorganisms, Ethical Issues involving GMOs; ethics related to human cloning, human genome project, prenatal diagnosis, agriculture and animal rights, data privacy of citizens health**;** ethical issues in India and abroad through case studies; Socio-economic impact of biotechnology.	25%
2.	**Bio- safety:** Definition of bio-safety; History, evolution and concept of biosafety; need and application of biosafety in laboratories and industries; biosafety guidelines and regulations, international and national norms of biosafety; Implementation of biosafety guidelines; Classification and Description of Biosafety levels; Design of clean rooms and biosafety cabinets; Risk assessment and containment levels; biohazard, bio-medical and hazardous wastes, handling and disposal; transportation of biological materials; bio-terrorism; biosafety protocol (Cartagena biosafety protocol) regulations to protect nature, growers and consumers interest and nation interest; Good laboratory practice (GLP) and Good manufacturing practice (GMP), Use of GMO's and their release, GM products, issues in use of GMO's, risk for animal/human/agriculture and environment owing to GMOs., Biotechnology and bio-safety concerns at the level of individuals,	25%

	institutions, society, region, country and world. Bio safety regulation: handling of recombinant DNA products and process in industry and in institutions.	
3.	**IPR I:** The Concept/History of Intellectual Property; Intellectual Property System in India; Kinds of Intellectual Property Rights; Advantages and Disadvantages of IPR. International Instruments concerning Intellectual Property Rights: the Berne Convention, Universal Copyright Convention, The Paris Convention, Patent Co-operation Treaty, Trade Related Intellectual Property Rights (TRIPS), The World Intellectual Property Organization (WIPO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Intellectual Property Organisation (WIPO); World Trade Organization (WTO) European Patent Office (EPO). Patents Act, 1970 ; Trade Mark Act, 1999; The Designs Act, 2000; The Geographical Indications of Goods (Registration and Protection) Act, 1999; Copyright Act, 1957 ; The Protection of Plant Varieties and Farmers' Rights Act, 2001; The Semi Conductor Integrated Circuits Layout Design Act, 2000; Trade Secrets; Utility Models; IPR & Biodiversity; The Convention on Biological Diversity (CBD) 1992; Application forms of IPR and Intellectual property protection. Concept of property with respect to intellectual creativity, Tangible and Intangible property.	25%
4.	**IPR II:** Classification of patents in India, Classification of patents by WIPO, Categories of Patent, Special Patents, Patenting Biological products, Patent document, Granting of patent, Rights of a patent, Patent Searching, Patent Drafting, filing of a patent, different layers of the International patent system, Utility models, Concept related to patents novelty, non-obviousness, utility, anticipation, prior art etc. Type of patents. Indian patent act and foreign patents. Patentability, Patent application, Revocation of patent, Infringement and Litigation with case studies on patent, Commercialization and Licensing. Patent Cooperation Treaty (PCT); Copyright Overview of Copyright, Importance of Copyrights, Process for copyright, case studies. Overview of Trademarks & Trade Secret, Importance of Trademarks & Trade secret, Rights of Trademark & Trade Secret, Types of Trademarks, Registration process for Trademark & Trade Secret, Duration of Trademark and trade secret, Case Studies Geographical Indications Overview of Geographical Indications, Importance of Geographical Indication Protection, Case studies	25%

	Infringement: Direct, Contributory, and Induced Infringement; How Infringement is Determined; Who Is an Infringer; Official Machinery, Controller, Powers and Functions Defences to Infringement; Case studies	

Teaching-Learning Methodology	Online / Offline / Presentation / Videos

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Interpret basics of biosafety and bioethics and its impact on all the biological sciences and the quality of human life.
2.	Recognize importance of biosafety practices and guidelines in research.
3.	Comprehend benefits of GM technology and related issues.
4.	Recognize importance of protection of new knowledge and innovations and its role in business.

Suggested References:	
Sr. No.	References
1.	Fleming, D.A., Hunt, D.L., (2000). Biotechnology and Safety Assessment (3rd Ed) Academic press.ISBN-1555811804,9781555811808.
2.	Thomas, J.A., Fuch, R.L. (1999). Biotechnology and safety assessment (3rd Ed). CRC press, Washington. ISBN: 1560327219, 9781560327219

3.	Law and Strategy of biotechnological patents by Sibley. Butterworth publication.(2007) ISBN: 075069440, 9780750694445.
4.	Intellectual property rights- Ganguli-Tat McGrawhill. (2001) ISBN-10: 0074638602,
5.	Intellectual Property Right- Wattal- Oxford Publicatiopn House.(1997) ISBN:0195905024.
6.	Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. (2nd ed) ISBN-10 3527304320.
7.	Encyclopedia of Bioethics 5 vol set, (2003) ISBN-10: 0028657748.
8.	Thomas, J.A., Fuch, R.L. (2002). Biotechnology and safety Assessment (3rd Ed) Academic press.
9.	B.D. Singh. Biotechnology expanding horizons.
10.	H.K.Das. Text book of biotechnology 3rd edition.
11.	*Sateesh, M.K., Bioethics and Biosafety, IK International Publishers (2008)*
12.	*Singh I. and Kaur, B., Patent law and Entrepreneurship, Kalyani Publishers (2006).*
13.	*Srinivasan, K. and Awasthi, H.K., Law of Patents, Jain Book Agency (1997)*
14.	Deepa Goel, ShominiParashar, (2013), IPR, Biosafety and Bioethics, Pearson.

On-line resources to be used if available as reference material
On-line Resources

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Master of Science (Microbiology)
M. Sc. Microbiology Semester (IV)

Course Code	PS04EMIC52	Title of the Course	RESEARCH ETHICS AND SCIENTIFIC WRITING
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To inculcate professional ethics in students of Science, especially in Biology 2.To familiarize types of plagiarism and tools for their detection 3. To teach various modes of data collection and its processing 4. To impart professional, scientific writing skills …

Course Content		
Unit	Description	Weightage* (%)
1.	Definition and significance of ethics; Professional ethics in Scientific research and development: Common ethical breaches; data fabrication; data falsification. Plagiarism: redundant publication; duplicate publication.	25%
2.	Types of plagiarism; tools and techniques for detection of plagiarism. Conflict of interest; salami slicing and authorship issues. Good Laboratory Practices (GLP): Instrument validation, reagents and materials certification, documentation and its record, Quality assurance and certification of laboratory facilities.	25%
3.	Data collection methods: Primary data and secondary data. Internet, online data collection, journals and books. References: Basic types of referencing; Quoting, paraphrasing and citing. APA, MLA and the Chicago/ Turabian styles of listing references.	25%
4.	Scientific writing: Basic differences between popular and scientific writing; fundamental rules of scientific writing; structure and content of research papers, thesis and dissertations. Do's and don't for scientific writing. Tools and techniques for correction and editing of manuscripts. Selection and publication in journals.	25%

Teaching-Learning	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power

Methodology	point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the significance of professional ethics in Scientific research
2.	Appreciate the types and pitfalls of plagiarism
3.	Learn how to collect data from primary and secondary sources
4.	Understand the differences between, common, popular and scientific writing and learn the basics of scientific writing

Suggested References:	
Sr. No.	References
1.	Professional ethics and human values: M. Govindarajan, S. Natarajan and V.S. Senthilkumar
2.	The craft of Scientific writing: Michael Alley
3.	Science and Technology ethics: Raymond Spier
4.	Scientific writing and research quality: Prasanna Kumar and Pawan Kumar Bharti

On-line resources to be used if available as reference material
On-line Resources

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Master of Science (Microbiology)
M.Sc. (Microbiology) Semester (IV)

Course Code	PS04EMIC53	Title of the Course	Systems Biology
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To introduce the concept of systems and synthetic Biology to the students 2. To provide insight into quantitative modelling of biological systems at the molecular and cellular level, as well as how they are used, analysed and developed

Course Content		
Unit	Description	Weightage* (%)
1.	Concepts and working principles of System Biology - Practical applications of System Biology in Life Sciences - Introduction to System Biology platforms, Proprietary system Biology platform. Microarray data analysis - Microarray analysis platforms - Introduction to Concepts and principles of Microarray technology	25%
2.	Models and Modeling: purpose, adequateness, advantage of computational modeling, basic notion for computational models, model scope, statements, system state, variables parameters constants, behavior, classification, steady states.	25%
3.	Analysis of complex biological systems: Sequencing (DNA & amino acid), Protein structure analysis. Metabolic networks and flux balance analysis: Mathematical modeling of metabolic networks; formulation and optimization of Flux Balance Analysis; computational tools for FBA.	25%
4.	Introduction to synthetic biology. Modeling synthetic Biology; Applications of synthetic Biology. Human and Pathogens--Cancer genomics (Tumor complexity)--Gene regulatory network Codon optimization Algorithmic Drug designs. Current and emerging areas in the field of computational and systems biology.	25%
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Teaching-	

Learning Methodology	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Model macromolecular complexes on different time and length scales model macromolecular structures with the help of experimental information
2.	Explain cellular processes by describing the interactions between macromolecules in a kinetic network
3.	Appreciate the significance of synthetic Biology and its potential in future
…	

Suggested References:	
Sr. No.	References
1.	System Biology: Computational Systems Biology (Hardcover) by Andres Kriete (Editor), Roland Eils (Editor)
2.	Microarray Data Analysis: Gene Expression Data Analysis. A Beginner's Guide By: Helen Causton (Imperial College), J Quackenbush and AlvisBrazma (The European Bioinformatics Institute)

3	Klipp E (2009) Systems biology: a textbook. Wiley-VCH, 1/e.

On-line resources to be used if available as reference material
On-line Resources

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(Master of Science) (Microbiology)
(M. Sc.) (Microbiology) Semester (IV)

Course Code	PS04EMIC54	Title of the Course	BIOMATERIALS AND TISSUE ENGINEERING
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To impart knowledge on the types and properties Biomaterials used in medicine. 2.Understand the composition of implants and their pros and cons. 3. Learn tissue engineering and its applications 4. Gain an understanding of stem cells and their emerging role in treatment of genetic and somatic disorders.

Course Content		
Unit	Description	Weightage* (%)
1.	Biomaterials: Introduction-definition of biomaterials, applications of biomaterials, classification of biomaterials, Comparison of properties of some common biomaterials. Effects of physiological fluid on the properties of biomaterials. Biological responses (extra and intra-vascular system). Surface properties, physical properties and mechanical properties of materials.Types of implant materials: Metallic, polymeric, ceramic and composite materials.	25%
2.	Properties of commonly used implant materials: Stainless steel and alloy importance of stress- corrosion cracking; role of passive films in tissue adhesion.Polymeric implant materials: general classification; Polyolefins polyamides, acrylic polymers, fluorocarbon polymers, silicon rubbers, acetals. Biodegradable polymers and synthetic polymers and their applications.Ceramic implant materials: Bioceramics; Common types of bioceramics. Bio -reabsorbable and bioactive ceramicsHost tissue reactions: importance of interfacial tissue reaction (e.g. ceramic/bone tissue reaction).Composite implant materials: different reinforcement materials, Composite theory of fiber reinforcement.	25%
3.	Tissue engineering: Introduction, stem cells, morphogenesis, generatic of tissue in the embryo, Tissue homeostasis, Cellular signalin Extracellular matrix as a biologic scaffold for tissue engineerin Scaffold fabrication, bioactive scaffold, Natural polymers in tissu engineering applications, Degradable polymers for tissue engineering.	25%
4.	Basic Biology Of Stem Cells: Stem Cells : Introduction, hematopoiet differentiation pathway; Potency and plasticity of stem cells, source	25%

	embryonic stem cells, hematopoietic and mesenchymal stem cells, Ste Cell markers, FACS analysis and differentiation. Stem cell system Liver, neuronal stem cells, Types and sources of stem cell wi characteristics: embryonic, adult, haematopoetic, fetal, cord bloo placenta, bone marrow, primordial germ cells, cancer stem cells induce pleuripotent stem cells.	
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Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand about various types of biomaterials for a wide range of biomedical applications.
2.	Basic functions and performance of implant materials as well as corrosion and degradation mechanisms of biomaterials.
3.	Choice of biomaterials based on function, biological environments, toxicity. bioadhesion and implant surface interaction with tissues. Scaffolds for tissue-engineering, growth factor, stem cell signaling.
…	

Suggested References:	
Sr. No.	References
1.	Tissue Engineering: Bernhard O Palsson, Sangeeta N. Bhatia.
2.	Fundamentals of Tissue Engineering and Regenerative Medicine: Meyer, U,: Meyer, Th.; Handschel, J.; Wiesmann,H.P .
3	Biomaterials: Science and Engineering: J B Park
4	Biomaterials: Sujata V. Bhat

On-line resources to be used if available as reference material
On-line Resources

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(Master of Science) (Microbiology)
(M.Sc.) (Microbiology) Semester (IV)

Course Code	PS04EMIC55	Title of the Course	Biodiversity and Conservation
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To impart knowledge of fundamental concepts of biodiversity, the range of its extant and the need for conservation. 2. To provide information of the main threats to biological diversity and the ability to evaluate the effects of human influences on biodiversity. 3. To demonstrate the differences between the different categories of red listed species. 4. To understand different modes of biodiversity conservation, their merits and limitations. 5. To integrate the information generated from scientific investigations and use findings to address conservation and biodiversity issues.

Course Content		
Unit	Description	Weightage* (%)
1.	Biodiversity: Concepts, levels and types, changes in tune and space, evolution, species concept; significance of biodiversity for life security. Biogeography. Terristrial, Marine, Aquatic and Agricultural biodiversity: Changing patterns and practices. Influence of modern lifestyle on biodiversity. Pros and cons of genetically modified species	25
2.	Global conservation measures, institutions and conventions; IUCN concept of threatened and endangered species. The Red Data Books of Indian plants and animals. Causes and consequences of loss of biodiversity. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): aims, major ratifications and amendments. Exotic and invasive species: A few case studies of intentional and non-intentional introduction of exotic species and their influence on local biodiversity.	25
3.	Principles and strategies of biological diversity conservation: *in-situ* conservation and *ex-situ* conservation. Biosphere reserves, major protected areas (sanctuaries, national parks, biosphere reserves) of India and Gujarat. Wetlands, mangroves and coral reefs for conservation of wild biodiversity. Concept of Sacred groves and their role in biodiversity conservation.	25

	Role of botanical gardens, field gene banks, seed banks, in vitro repositories, cryobanks in conservation of plants and animal sperms. Role of Zoos, breeding centers in conservation of animals.	
4.	Biodiversity hot spots in India and world; Indian Biodiversity Act 2002; Major objectives of biodiversity authority board; Biodiversity and economics with special reference to India; People's Biodiversity register: Objectives, importance and modality of preparation. General account of the activities of Botanical Survey of India (BSI) and Zoological Survey of India (ZSI), National Bureau of Plant Genetic Resources (NBPGR), Indian Council of Agricultural Research (ICAR), Council of Scientific & Industrial Research (CSIR), Department of Biotechnology (DBT) and Department of Environment and Forest, Wild life Protection Society of India, Wildlife Instititute of India (WII), Animal Welfare Board of India and Bombay Natural History Society (BNHS) in the context of Indian biodiversity conservation.	25

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

1.	Understand the concept of biodiversity, its role for our survival, different direct and indirect threats on biodiversity.

2.	Appreciate the global and national initiatives and local traditions for biodiversity conservation.
3.	Become familiar with different modes of conservation, institutes involved in biodiversity conservation.
4.	Learn various guidelines and regulations for utilizing the biodiversity judiciously.

Suggested References:	
Sr. No.	References
1.	Wilson, E., O., (1988). Biodiversity. The National Academies Press. Harvard. Washington, DC.
2.	Hunter, M., L., Gibbs, J. P., (2007). Fundamentals of Conservation Biology. 3rd Edn. Blackwell Publishing, Malden.
3.	Myers, N., Mittermeier, R., A., Mittermeier, C. G., Fonseca, G., A., da, Kent, J., (2000). Biodiversity Hotspots for Conservation Priorities. Nature, 403, 853-858.
4.	Rodgers, N. A., Panwar, H. S. Planning a Wildlife Protected Area Network in India. Vol. 1. The Report Wildlife Institute of India, Dehradun.

On-line resources to be used if available as reference material
On-line Resources
Biodiversity: **Author:** John Spicer
Brian W. van Wilgen: Biological Invasions in South Africa
Recent review articles and research papers

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