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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