Course Name: Master of Science
Discipline : Microbiology
CHOICE BASED CREDIT SYSTEM
(For those who joined in June 2023 and after)

II M.Sc. MICROBIOLOGY

SEMESTER I

Course	Course Code	Course Title	Hours	Credit	Marks			Focus on Employability/ Entrepreneurship/ Skill Development
					I	E	Total	
Core I	P23MBC11	General Microbiology and Microbial Diversity	6	4	25	75	100	Employability
Core II	P23MBC12	Immunology, Immunomics and Microbial Genetics	6	4	25	75	100	Employability
Core III	P23MBCP11	Practical-I	6	4	40	60	100	Skill Development
Elective I	P23MBE13	Forensic Science/ Health Hygiene/ Microalgal Technology (Among the three choices anyone can be choosen by the student)	4	3	25	75	100	Employability
Elective II	P23MBE14	Bioinstrumentation/ Herbal Technology and Cosmetic Microbiology / Essentials of Laboratory Management and Biosafety (Among the three choices anyone can be choosen by the student)	4	3	25	75	100	Employability
Professional Competency Course	P23MBS11	Entrepreneurship in Biobusiness	2	2	25	75	100	Entrepreneurship
Ability Enhancement Compulsory Course Soft Skill – I	P23MBAE11	Tissue culture technology	2	2	25	75	100	Skill Development
Total			30	22				

SEMESTER II

Part	Course code	CourseTitle	Hours	Credit	Marks			Focus on Employability/ Entrepreneurship/ Skill Development
					I	E	Total	
Core IV	P23MBC21	Medical Bacteriology & Mycology	5	4	25	75	100	Employability
Core V	P23MBC22	Medical Virology and Parasitology	5	4	25	75	100	Employability
Core VI	P23MBC23	Microbial Biochemistry	4	3	25	75	100	Employability
Core VII	P23MBCP21	Lab: Medical Bacteriology, Mycology, Virology and Parasitology	6	5	40	60	100	Skill Development
Core VIII	P23MBCP22	Lab: Microbial Biochemistry	6	4	40	60	100	Skill Development
NME 2	P23MBN21	Public Health in Microbiology	4	4	25	75	100	Skill Development
		Total	30	24				

Semester	Part	Subject Name	Hours	Credit	Int + Ext =Total	Local	Regional	National	Global	Professional Ethics	Gender	Human Values	Environment & Sustainability	Employability	Entrepreneurship	Skill Development	Subject Code	Revised / New / No Change / Interchanged & Percentage of Revision
III	Core 11	**Molecular Biology & Recombinant DNA technology**	5	4	25+75=100		✔									✔	**P24MBC31**	**New**
	Core 12	Environmental & Agricultural Microbiology	5	4	25+75=100		✔									✔	**P24MBC32**	**Mark Change**
	Core 13	**Food & Industrial Microbiology**	4	4	25+75=100	✔										✔	**P24MBC33**	**Revised 10%**
	Core 14 Lab	**LAB: Environmental & Agricultural Microbiology**	6	5	40+60=100	✔								✔			**P24MBCP31**	**Revised 10%**
	Core 15 Lab	**LAB: Molecular Biology, Recombinant DNA technology, Food & Industrial Microbiology**	6	5	40+60=100		✔							✔			**P24MBCP32**	**New**
	Elective 2	**Bioinformatics**	4	4	25+75=100				✔					✔			**P24MBE31**	**New**
	Total		**30**	**26**														
IV	Core 16	**Research Methodology and Biostatistics**	5	4	25+75=100		✔									✔	**P24MBC41**	**New**
	Elective 3	**Fermentation Technology**	5	4	25+75=100		✔									✔	**P24MBE41**	**New**
	Core	Project/Internship	20	10	40+60=100		✔							✔			**P24MB4PV**	**Credit Change**
	Total		**30**	**18**														

SEMESTER III

Course Title : Molecular Biology & Recombinant DNA Technology	**Total Hours : 75**
Course Code : P24MBC31	**Total Credits : 4**

Course Outcomes:

Cos	CO Statement
CO1	Describes the Nucleic acids (DNA & RNA) in detail, with respect to both their structure and types.
CO2	Understand the mechanisms of central Dogma (replication, transcription and translation)
CO3	Emphases on gene regulation in prokaryotes and presents the operon concept.
CO4	Provide the molecular features of Genetic recombination.
CO5	Learn the techniques & applications of rDNA technology

Unit I **(15 hours)**

Nucleic acids: Structure of DNA (Watson and Crick's model of DNA) – Different forms of DNA – B DNA, A DNA and Z DNA - Nucleic acids as hereditary material: DNA as genetic material (Griffith and Hershey – Chase experiment). Types of RNA – rRNA, mRNA and tRNA (Clover leaf model). Central Dogma – DNA Replication – Semi conservative Replication of DNA & Rolling circle, Enzymes involved in DNA Replication.

Unit II **(15 hours)**

Transcription: organization of transcriptional units, mechanism of transcription in prokaryotes, Post transcriptional modification of mRNA: capping, polyadenylation and splicing. Translation – Genetic code, Wobble hypothesis and the mechanism of translation.

Unit III **(15 hours)**

Mutation - Spontaneous mutation, Point mutation, Transition and Transversion. Induced mutation: Chemical mutagens and Physical mutagens. DNA Repair Mechanisms – Photoreactivation, Excision Repair, Recombination Repair. Regulation in Prokaryotes – *lac* operon, *ara* operon, *trp* operon.

Unit IV **(15 hours)**

Introduction to rDNA technology – Mode of action and application of Enzymes: Restriction endonucleases (Types I, II and III), DNA polymerase, DNA ligase, Alkaline phosphatase, Methyl transferases, Topoisomerase. Uses of Linkers and adapters. Structural properties and applications of Vectors (Plasmid vectors):- Artificial Vectors: pBR322 and pUC19 – Phage Based vectors: lambda Vector – Cosmids – Phagemids – Bacterial Artificial Chromosome

(BAC) and Yeast Artificial Chromosome (YAC).

Unit V **(15 hours)**

Construction of Genomic library and cDNA library – Principle and applications in analysis of recombinants: Selection and screening of recombinants (Colony hybridization, Insertional inactivation and Blue and white colony selection). Applications of r-DNA technology: Gene therapy;- *Ex vivo*: Serve Combined Immuno Deficiency (SCID) and *In vivo*: Cystic Fibrosis Transmembrane Regulator (CFTR) – Transgenic animals (sheep and mice) – Transgenic plants – Bt cotton and Golden rice.

Text Books:

1. David Freifelder, "Molecular Biology", Jones and Bartlett Publisher, 2/2004.

Reference Books:

1. Verma, P.S., Agarwal, V. K., "Genetics", S Chand and Company limited, 9/2019
2. Maloy, S.R., Freifelder, D. and Cronan, J.E., "Microbial Genetics", Jones and Barlett Publishers, US, 2001.
3. Darnell, J., Lodish, H., and Baltimore, D., "Molecular Cell Biology", Scientific American Books, New York, 1990.
4. Freifelder, D. and Malacinski, G.M. "Essentials of Molecular Biology", John and Bartlett Publishers, London, 1987.
5. Desmound S.T. Nicholl, "An introduction to Genetic Engineering (Second Edition) by (Studies in Biology Series)", Cambridge University Press, Cambridge, 2002.
6. Brown, T.A., "Gene Cloning", Bios Scientific publishers, Oxford University Press, United Kingdom. 1999.

e- Resources:

1. https://www.biochemistry.org/wp-content/uploads/2019/04/BASC02_full.pdf
2. https://www.vanderbilt.edu/AnS/Chemistry/Rizzo/Chem220b/Ch28.pdf
3. http://gdcganderbal.edu.in/Files/a8029a93-30ad-4933-a19a-59136f648471/Link/Transcription_Prokaryotes_2012-c_c610b1f3-17b2-48e8-b488-30de80f05ee7.pdf
4. http://www.bx.psu.edu/~ross/workmg/Struc_Nucleic_Acids_Chpt2.pdf
5. https://chem.ucr.edu/sites/g/files/rcwecm2681/files/2019-10/Chapter23.pdf
6. https://sites.engineering.ucsb.edu/~shell/che170/DNA-notes.pdf
7. https://www.pearson.com/content/dam/one-dot-com/one-dot-com/us/en/higher-ed/en/products-services/sanders-2e-info/pdf/ch8.pdf
8. https://www.cs.cmu.edu/~wcohen/GuideToBiology-pictures-color-release1.5.pdf
9. https://facultystaff.richmond.edu/~lrunyenj/bio554/lectnotes/chapter13.pdf
10. https://docs.ufpr.br/~microgeral/arquivos/pdf/pdf/Transposons.pdf
11. https://www.shcollege.ac.in/wp-content/uploads/NAAC_Documents_IV_Cycle/Criterion-II/2.3.2/ppt/Dr_Gibykuriakose_Transposibleelements.pdf
12. http://www.mantorlab.unimi.it/mantorlab/sito/Teaching_files/Lezione%2012%20-The%20Operon%20model.pdf

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Course title: Core -11 - Environmental & Agricultural Microbiology	**Total hours : 75**
Subject Code: P22MBC32	**Total Credits: 4**

Course Outcomes:

COs	CO Statement
CO1	Impart knowledge about soil fertility.
CO2	Understand the role of biogeochemical cycles in sustainable environment.
CO3	Gain knowledge about major air and water pollutants.
CO4	Know the usage of microorganisms in sustainable agriculture.
CO5	Study about various plant pathogens.

Unit I **15 Hours**

Soil micro flora – Factors influencing the soil microflora – Role of microorganisms in soil fertility. Microbial interactions – Mutualism, commensalism, competition, amensalism, parasitism and predation. Interaction between microbes and plants, Mycorrhizae. Rhizosphere and phyllosphere.

Unit II **15 Hours**

Biogeochemical cycles: Carbon, nitrogen, sulfur and phosphorous cycle. Bioleaching – Principle and Applications. Nitrogen fixation types – Symbiotic, asymbiotic and associative symbiotic – Components and mechanisms – Phosphate solubilization – Microbes in waste treatment: Solid – Saccharification and composting; Liquid – aerobic and anaerobic method.

Unit III **15 Hours**

Air pollution – Sources, major pollutants – Acid rain, Greenhouse effect, Global warming and Ozone layer depletion. Assessment of air quality. Water pollution – Sources and nature of pollutants in water. Microbial assessment of water quality – Most Probable Number technique, membrane filtration, Biological Oxygen Demand & Chemical Oxygen Demand.

Unit IV **15 Hours**

Microbes for sustainable agriculture – *Azospirillum*, *Rhizobium*, *Azotobacter*, *Azolla*, and Blue green algae – Mass production, field application and significance of biofertilizers. Biopesticides: Types – Bacterial - *Bacillus thuringiensis*, Viral – Nuclear Polyhedrosis Virus, Fungal – *Trichoderma*. Biopesticides - Mode of action.

Unit V **15 Hours**

Study of microbes as plant pathogens – Bacteria: *Agrobacterium*, *Xanthomonas*, Mycoplasma: Sandal spike, grassy shoot. Viruses: TMV, Tomato leaf curl. Fungi: *Puccinia*, *Pyricularia*, tikka disease of ground nut, cotton wilt (*Fusarium*) and late blight of potato.

Text books:

1. Subbarao, 1995, Soil microorganisms and plant growth, 4/e, Oxford and IBH, New York.
2. Ronald M. Atlas and Richard Bartha, 1997, Microbial Ecology, 4/e, Benjamin-Cummings Publishing Company.
3. Mehrotra and Ashok Agarwal, 2005, Plant pathology, 2/e, Tata McGraw-Hill publishing company Ltd., Delhi.

References books:

1. Michael T. Madigan *et.al*., 1997, Brocks's Biology of Microorganisms, 8/e, Prentice Hall International Inc.
2. Dubey and Maheshwari, 1999, A text book of Microbiology, 1/e, Chand publications, New Delhi.

Course title: FOOD & INDUSTRIAL MICROBIOLOGY	**Total hours :60**
Subject Code: P24MBC33	**Total Credits:4**

Course Outcomes:

COs	CO Statement
CO1	To obtain information on the basic principles of the food borne microbes
CO2	To understand the role of varied microbes in food preservation.
CO3	To understand various kinds of preservation and spoilage of food products
CO4	To know about the different types and microorganisms that causes food borne illness
CO5	To acquire fundamental knowledge about industrial microbes

Unit I **12 Hours**

Food as a substrate for microorganisms – pH, Moisture requirement, Oxidation-Reduction Potential and Nutrient content; Contamination of foods – From Green plants & fruits, Animals and Air; Factors affecting the growth of microorganisms in foods – Associative growth and Effect of Environmental conditions; Chemical changes caused by food microorganisms.

Unit II **12 Hours**

Principles of food preservation and Methods of food preservation – Asepsis, Removal of Microorganisms, use of high temperature, use of low temperature, Drying, Food additives – added preservatives, developed preservatives and Radiation – UV, Ionizing, Gamma and Cathode rays. Applications to food preservation.

Unit III **12 Hours**

Contamination, Spoilage and Preservation of Cereals and Cereal Products, Sugar and sugar products, Vegetables and Fruit, Meat and Meat products, Milk and Milk Products, Eggs, Poultry.

Unit IV **12 Hours**

Food-borne illness: Bacterial – Botulism, Staphylococcus food intoxication,

Salmonellosis; Mycotoxin – Alfatoxin and Patulin. Microbiology in Food Sanitation – Bacteriology of water supplies, Sewage & waste treatment and Disposal.

Unit V **12 Hours**

Industrial Microbiology – Introduction: The Era of the discovery of microbes, The Era of the Discovery of Antibiotics, A century of growth of industrial fermentations, Industrial sterilization, Production of Baker's yeast, Use of yeast and yeast by products. Immobilization techniques by yeast.

Text Books:

1. Frazier, W. C. and Westhoff, D.C., 2014, Food Microbiology, Tata Publishing Company Limited, New Delhi.
2. Patel. A.H. 2012. Industrial Microbiology. 2nd Edition, Published by Pan Macmillan India, limited
3. Adams, M.R. and Moss, M.O., 2000, Food Microbiology, New Age International (P) Ltd., New Dehli.
4. Moshrafuddin Ahamed and Basumatary, S.K., 2008, Applied Microbiology, MJP Publishers, Chennai.

Reference Books:

1. Joshi, V.K. 2009. Biotechnology: Food Fermentation Microbiology, Biochemistry, and Technology. Volume 2.
2. Prajapati, J. B. and Behare, P. V., 2018. Fundamentals of Dairy Microbiology.
3. Garbutt, J. 1997. Essentials of Food Microbiology. Arnold International Students Edition.
4. Wood, B. J. 1997. Microbiology of Fermented Foods. Volume I and II. Elsevier Applied SciencePublication.
5. Ayers, J.C. Mundt, J.O. Sandinee, W.E. 1980. Microbiology of Foods by W.H. Freemanand Co

e-Resource link:

1. https://www.fda.gov/food/laboratory-methods-food/bam-chapter-18-yeasts-molds-and-mycotoxins#:~:text=Both%20yeasts%20and%20molds%20cause,processed%20foods%20and%20food%20mixtures.
2. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=111435
3. https://nofima.com/worth-knowing/foodpreservation/#:~:text=Temperature%20preservation,-Canned%20food%3A%20The&text=Sterilized%20food%20is%20heated%20to,pathogenic%20bacteria%20in%20the%20food.
4. https://www.pdfdrive.com/food-microbiology-e1079759.html
5. https://www.foodstandards.gov.au/consumer/safety/foodborne-illness/Pages/Toxins-in-seafood.aspx

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Course title: LAB: ENVIRONMENTAL & AGRICULTURAL MICROBIOLOGY	**Total hours :90**
Subject Code: P24MBCP31	**Total Credits: 5**

Course Outcomes:

COs	CO Statement
CO1	Understand the pure culture techniques
CO2	Enumerate the microorganisms in the environmental samples
CO3	Apply the skills in isolation of Plant growth promoting organisms
CO4	To determine the Biological and chemical oxygen demand of water samples
CO5	To gain the technical skills in isolation of secondary metabolite producing organisms

1. Enumeration of bacterial and fungal from soil and water.
2. Enumeration of bacteria from air (Open plate method).
3. Isolation of *Rhizobium* from rhizospheric soil
4. Isolation of plant growth promoting bacteria- *Azotobacter*, *Azospirillum* and *P. fluorescens*
5. Determination of Biological Oxygen Demand of the polluted water sample in the surrounding area.
6. Determination of Chemical Oxygen Demand of the polluted water sample in the surrounding area.
7. Staining and observation of *Mycorrhizae* from infected roots.
8. Antibiosis in soil – Crowded plate technique
9. MPN techniques.
10. Industrial visit to nearby Agriculture research station and reporting.

Course title: LAB: Molecular Biology, Recombinant DNA technology, Food & Industrial Microbiology	**Total hours :90**
Subject Code: P24MBCP32	**Total Credits:5**

Course Outcomes:

COs	CO Statement
CO1	To understand the isolation of genomic and plasmid DNA from bacteria
CO2	Applying the skills gained through the molecular and recombinant technology through various techniques.
CO3	To understand the method of gene transfer in bacteria through transformation process.
CO4	Gain the knowledge on isolation of microorganisms from fermented foods
CO5	Applying the skills gained through the production of beverages and ethanol by using microorganisms

1. Transformation in bacterial cell.
2. Restriction Digestion of Plasmid DNA – Single and Double digestion
3. DNA Ligation
4. SDS – PAGE – Demonstration
5. PCR technique - Demonstration
6. Isolation of microorganisms from Spoiled fruits and vegetables, Spoiled meat and meat products and Spoiled Milk and milk products
7. Determination of quality of milk sample by methylene blue reductase test and resorcinol test.
8. Isolation of microorganisms from fermented foods – Curd, Yoghurt & Cheese.
9. Wine production and ethanol by using yeast.
10. Immobilization of Yeast by sodium alginate.
11. Industrial visit and Submission of Report – Nearby Dairy or sugar industries.

References Books:

1. Frederick M. Ausubel 1987. Current protocols in Molecular biology John Wiley and Sons publications, USA.
2. Jeffrey H. Miller, 1999. A short course in bacteria genetics: A laboratory manual and handbook for E. coli and related bacteria.
3. Cappuccino, J.G. and Sherman, N. 2002. Microbiology: A laboratory manual (7th Edition), Addison Wesley, New York.
4. Patel. A.H. 2012. Industrial Microbiology. 2nd Edition, Published by Pan Macmillan India, limited.
5. Harley and Prescott 1996, Laboratory Exercises in Microbiology, McGraw Hill Higher Education, 5thEdition

e-Resources link:

- https://nishat2013.files.wordpress.com/2013/11/laboratory-exercises-in-microbiology-book.pdf

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Course Title: Elective 2 -Bioinformatics	**Total hours : 60**
Subject Code: P24MBE31	**Total Credits: 4**

Course Outcomes:

COs	CO Statement
CO1	Relate the basic parts of computer and its significance in data abstraction from biological data bases
CO2	Explain the type's biological database, tools used to integrate the alignments and data interpretation for macromolecules
CO3	Predict the methodologies used in bioinformatics and its application in recent day's research activities.
CO4	Compare the structure related prediction as well as the evolutionary aspects of analysis for interpreting the results in an accurate and meaningful way
CO5	Compile the overall techniques for the betterment of human survival and \ also develop skills about creating new bioinformatics tools

Unit I **(12 hours)**

History and development of computers; generations of computers, Modern input devices: OMR, Bar code reader, Output devices: Visual display unit (LCD & LED), Printers: (Dot Matrix and Laser), Storage devices: primary memory (RAM and ROM), Secondary memory: Magnetic storage (Hard disk), Solid state storage: (Pen drive & memory card).

Unit II **(12 hours)**

Bioinformatics: Introduction, Scope, objectives and applications. Introduction of Database related programs (brief description): DBMS & SQL and Classification of biological databases (generalized & specialized). Internet basics: World Wide Web, HTTP, HTML, Electronic mail and Intranet.

Unit III **(12 hours)**

Nucleotide sequence databases: NCBI - GenBank, EMBL and DDBJ, Sequence submission methods and tools (Bankit), alignment methods (Dot plot & Dynamic programming), Useful programs: BLAST, FASTA and Clustal-W, Significance of multiple sequence alignments.

Unit IV **(12 hours)**

Protein databases: Sequence file formats and tools: PIR, Swiss Prot and Expasy, Derived databases: Prosite, Pfam and PRINTS. Protein structural databases: PDB, Protein structural classification databases: CATH and SCOP, Secondary structure prediction: Chou Fasman, GOR.

Unit-V **(12 hours)**

Carbohydrate structure database: CCSD, Glycome DB, Metabolic databases: KEGG, Specialized database: EST & BRENDA, Evolutionary analysis: Cladistic methods (Maximum parsimony and Maximum likelihood) and Phenetic methods (UPGMA and Neighbor Joining). Phylogenetic analysis tools - Phylip.

Text books:

1. Sundaralingam, R., and Kumaresan, V. 2008. Bioinformatics, 1st edition. Nagarcoil:Saras Publication.
2. Ignacimuthu, S.J. 2009. Basic Bioinformatics, 1st edition. New Delhi: NarosaPublishing House.
3. Rajaraman,V. 2010. Fundamentals of computers, 5th edition. New Delhi: PHI Learning Pvt Ltd

Reference books:

1. Teresa Attwood, K., & David parry smith, J. 2006. Introduction to Bioinformatics,1st edition. London: Dorling Kindersley Pvt, Ltd.
2. Kuppuswamy, C. 2006. Bioinformatics, 1st edition. New Delhi: Dominant Publishers.
3. Subramanian, C. 2006. A textbook of bioinformatics, 8th edition. New Delhi:Dominant Publishers.
4. Srinivasa Rao, D. 2010. Bioinformatics, 1st edition. Hyderabad: Biotech Pharmapublications.
5. Ignacimuthu, S.J. 2009. Basic Bioinformatics, 1st edition. New Delhi: NarosaPublishing House.

IV SEMESTER

Course title: RESEARCH METHODOLOGY & BIOSTATISTICS	**Total hours : 75**
Subject Code: P24MBC41	**Total Credits:4**

Course Outcomes:

COs	CO Statement
CO1	Understand the principles of research and various research methods and their applications, principles of thesis writing.
CO2	Understand the basic Biostatistics and guidelines for writing a manuscript for a journal.
CO3	To impart information and standards on research paper publishing, patent forms, and kinds of application
CO4	To learn about the process of gathering data using statistical methods, to create diagrams using diagrammatic representation, and to calculate central tendency
CO5	Understand the ANOVA and chi-square tests to examine the correlation.

Unit I **15 Hours**

Introduction to Research: Objectives of Research - Important Ingredients for Research: componential theory of individual creativity - Types of Research: Basic Research, Applied Research, Descriptive Research, Analytical Research, Correlation Research, Qualitative Research, Quantitative Research, Experimental Research, Explanatory Research, Exploratory Research.

Unit II **15 Hours**

General Features of a Good Research Study, Resources of Literature Survey – Google scholar, ResearchGate, Pubmed. Reputed Journals/Impact Factor Journals: SCOPUS, SPRINGER, Science direct and Nature. General Phases of Research. Plagiarism tools – iThenticate, Turnitin and Urkund.

Unit III **15 Hours**

Presenting and Publishing the Research Findings: Contents of Research Paper and Thesis - Review System: Types of Peer Review. General Guidelines for selecting the research Journal. Identifiers to Identify Journals and Research Papers – ISSN, ISBN and DOI. Patent: general patent format and its types of applications.

Unit IV **15 Hours**

Introduction to Statistics – Collection of data: Primary and Secondary data – Classification and Tabulation of data – Diagrammatic representation: General rules for Constructing diagrams, Types of Diagrams: line, Bar, Pie and Pictograms. Measures of Central Tendency: Merits and Limitations of mean, median, mode, Standard deviation and Utility of standard error.

Unit V **15 Hours**

Correlation – Types and Merits. Chi-square test: Procedure and applications. Student's t-test: Procedure and applications. Analysis of Variance (ANOVA): Principles, classification and applications of ANOVA. Multivariate Analysis of Variance (MANOVA) – Principles and its applications.

Text books:

1. 1.Vinayak Bairagi and Mousami V. Munot., 2019, Research Methodology, A Practical and Scientific Approach, CRC Press, Taylor & Francis Group, New York, International Standard Book Number-13: 978-0-8153-8561-5.
2. S. Palanichamy., M. Manoharan., 2005, Statistical Methods for Biologists (Biostatistics), Palani Paramount Publications, Palani, ISBN 81-85517-53-3.

References:

1. Kothari, C.R., 2007, Research Methodology – Methods and Techniques, New Age International Publishers, New Delhi.
2. Montgomery, Douglas C, 2007, 5/e, Design and Analysis of Experiments, (Wiley India)
3. Jin Xiong: Essential Bioinformatics, Cambridge University Press Tramontano: Introduction to Bioinformatics, Chapman and Hall Series.
4. Prem S. Mann, 2004. Introductory Statistics. 5/e. John Wiley sons.
5. Sokal and Rohif, 1973 Introduction to Biostatistics - Toppan Co. Japan.
6. Gurumani, N, 2004, An Introduction to Biostatistics, 1/e, MJP Publishers, Chennai.
7. Attwood T.K. and D.J. Parry-Smith, 2001, Introduction to Bioinformatics Pearson Education, Asia.

Course title: FERMENTATION TECHNOLOGY	**Total hours :75**
Subject Code: P24MBE41	**Total Credits:4**

Course Outcomes:

Cos	CO Statement
CO1	To obtain the information of basic principle of fermentation process, industrially important microorganisms and their cultivation and maintenance.
CO2	To gain knowledge about various fermentors in industrial application and their utility.
CO3	To provide the knowledge in upstream processing and kinetics concerning with microbial growth and fermentation condition.
CO4	To know about the production of various fermented product and breweries.
CO5	To give detail account on downstream processing concerning with extraction and purification of fermented products.

Unit I **15 Hours**

Introduction to fermentation technology - Screening of industrial microorganisms: Primary Screening – crowded plate technique & Auxanography; Secondary screening – Giant Colony Technique. Strain development: Auxotrophic mutants & mutants resistant to analogues. Inoculum preparation, Maintenance and Preservation of Microorganisms.

Unit II **15 Hours**

Fermentor - Types of fermentor: Batch, Fed batch, Continuous stirred tank fermentor, Tubular fermentor and Tower fermentor. Types of fermentation process: Batch, Fed batch and Continuous fermentation, Submerged and solid-state fermentation.

Unit III **15 Hours**

Production Media – Characteristics of an ideal production medium, Raw materials: Saccharine, Starchy, Cellulosic materials. Fermentation kinetics - Factors affecting kinetics, Reynold number, Power number, Dimensionless number. Computer applications in Fermentation technology – Automation in penicillin fermentation.

Unit IV **15 Hours**

Downstream processing: Flocculation and flotation, Ultra filtration, Centrifugation, Cell disruption - Chromatography: Gel filtration, Ion exchange and affinity - Product extraction, and drying.

Unit V **15 Hours**

Industrial fermentation process: Antibiotics – Penicillin; Organic acid – Citric acid, Acetic acid; Enzyme – Amylase; Solvent – Ethyl Alcohol; Amino acid – Glutamic acid; Vitamin B_{12}, Fermented Foods – Yoghurt, Cheese; Single Cell Protein.

Text Books:

1. Patel. A.H. 2012. Industrial Microbiology. 2nd Edition, Published by Pan Macmillan India, limited
2. Casida.L.E. 1968. Industrial Microbiology.1st Edition, John Wiley & Sons Inc.
3. Sathyanarayana. 2013. Biotechnology, Books and allied (P) Ltd.
4. Crueger, W. and A. Crueger. Biotechnology,2003. A text book of industrial Microbiology, Panima publishers, New Delhi
5. Ajaykumar. Abhishek Awasthi,2009. Bioseparation Engineering.1st Edition, I.K International Publishing House. Ltd, New Delhi.

Reference Books:

1. Reed, G. Prescott and Dunn's 2003. Industrial Microbiology, 4th Edition, CBS Publishers and distributors, New Delhi
2. Stanbury, P.F., Whitaker, A, and Hall, S.J., 1997. Principles of fermentation technology, 2nd Edition, Aditya Books (P) Ltd, New Delhi.

e- Resources:

1. https://www.learninsta.com/screening-of-industrially-important-microorganism/#:~:text=1.,gain%20information%20about%20these%20organisms
2. https://www.slideshare.net/amjadkhanafridi4all/strain-development-techniques-of-industrially-important-microorganisms-70336759
3. http://www.vpscience.org/materials/Strain%20Improvment.pdf
4. https://fdocuments.in/document/development-of-inoculum-buildup.html
5. https://microbeonline.com/maintenance-and-preservation-of-pure-cultures-of-bacteria/
6. http://technologyinscience.blogspot.com/2012/08/different-types-of-fermentors.html#.YuTEwXZBzIU
7. https://www.differencebetween.com/difference-between-solid-state-fermentation-and-submerged

fermentation/#:~:text=The%20key%20difference%20between%20solid,which%20has%20more%20than%2095%25
8. https://essentialoil.wu.ac.th/wp-content/uploads/2019/07/Nutrient-Media.pdf
9. https://arxiv.org/pdf/q-bio/0509014.pdf#:~:text=Fermentation%20is%20generally%20modelled%20by,they%20are%20typically%20solved%20numerically.
10. https://cercell.com/media/13383/power-number-from-spencer.pdf
11. https://www.gsic.uva.es/uploaded_files/cep_final.pdf
12. https://microbiologynotes.org/downstream-processing-and-its-steps/
13. https://www.slideshare.net/HudaNazeer/penicillin-production
14. https://www.teagasc.ie/rural-economy/rural__development/diversification/production-of-yoghurt/#:~:text=The%20production%20of%20yoghurt%20is,it%20to%20clot%20or%20gel
15. https://www.biologydiscussion.com/industrial-microbiology-2/fermentation-industrial-microbiology-2/production-of-ethanol-microbiology/66072

Course title: Core – 17 - PROJECT/ INTERNSHIP	**Total hours :**
Subject Code: P24MB4PV	**Total Credits:10**

Course Outcomes:

COs	CO Statement
CO1	Have research skills involved execution of microbiological proposal
CO2	Make use of appropriate microbiological methods and lab equipment
CO3	Abide by safe microbiology, using appropriate protective, biosafety, and emergency procedures
CO4	Create document and report on experimental protocols, results, and conclusions.

Instruction

The aim of project work (lab work) is to inculcate students to learn adequate knowledge on research methodology in the subject and prepare them for pursuing research in experimental or computational areas of the subject. Student's allotment is done by lot system. The project work study is to be undertaken under the guidance of a Teacher Work. No teacher shall be permitted to guide more than three students in a semester for Project Work under his/her supervision. The project work will be evaluated by the external examiner of the Department. The guiding teacher will make continuous internal assessment of the Project.

1. Number of students who will be offered project work will vary batch to batch depending upon the infrastructural facilities and may vary each year.
2. Project work will involve experimental work and the student will have to complete this in stipulated time.
3. The final evaluation of the project work will be through a Panel involving internal and external examiners.
4. Students will be asked their choice for Project work at the beginning of IV semester and all formalities of topic and mentor selection will be completed. Project work will be offered in lieu of expertise and infrastructural facilities of the department and will be evaluated for 10 credits.

5. The distribution of marks for project work will be - Project work: 100 Marks (Internal: 40 marks for review 4x10=40, External: 40 marks for dissertation + 10 marks for research skills + 10 marks for research work presentation).
6. Minimum number of pages for M.Sc. Project thesis shall be 50
