Deccan Education Society's
Fergusson College (Autonomous)
Pune - 411004

Curriculum

as per guidelines of

NEP-2020

for

S. Y. M. Sc. (Microbiology)

With effect from Academic Year

2023-2024

Department wise Courses Titles as per NEP guidelines (Science faculty)

Semester	Paper Code	Paper Title	Credits
I	MIC- 601	Biophysics and Instrumentation	4
	MIC- 602	Pharmaceutical Microbiology	4
	MIC- 603	Bioprocess development	4
	MIC- 604	Advanced Molecular techniques	2
	MIC- 621	Practical course based on Pharmaceutical Microbiology and Bioprocess development	2
	MIC622	Advanced Molecular techniques	2
	MIC623	Practical course based on Microbial ecology and Food technology	2
			2
		Total Semester Credits	20
II	MIC- 651	Microbial Ecology	2
	MIC- 652	Regulation of Immunological processes	4
	MIC- 653	Food Technology	
	MIC- 654	MOOCS	
	MIC-655	Biostatistics	4
	MIC-656	IPR, Biosafety and Bioethics	
	MIC-657	MOOCS	
	MIC- 671	Dissertation -I	4
	MIC- 672	Dissertation -II	6
		Total Semester Credits	20
		Total PG-I Credits	40
		Total PG-II Credits	40

Teaching and Evaluation (Only for FORMAL education courses)

Course Credits	No. of Hours per Semester Theory/Practical	No. of Hours per Week Theory/Practical	Maximum Marks	CE 40 %	ESE 60%
1	15 / 30	1 / 2	25	10	15
2	30 / 60	2 / 4	50	20	30
3	45 / 90	3 / 6	75	30	45
4	60 / 120	4 / 8	100	40	60

Eligibility: As per the rules and regulations of Savitribai Phule Pune University (SPPU)

Program Outcomes (POs) for M. Sc. Programme	
PO1	**Disciplinary Knowledge:** **Demonstrate comprehensive knowledge of the discipline that form a part of a postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work.**
PO2	**Critical Thinking and Problem solving:** **Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.**
PO3	**Social competence:** **Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clear and concise and help reach conclusion in group settings.**
PO4	**Research-related skills and Scientific temper:** **Infer scientific literature, build sense of enquiry and able to formulate, test, analyze, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.**
PO5	**Trans-disciplinary knowledge:** **Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.**
PO6	**Personal and professional competence:** **Perform independently and also collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.**
PO7	**Effective Citizenship and Ethics:** **Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.**
PO8	**Environment and Sustainability:** **Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.**
PO9	**Self-directed and Life-long learning:** **Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.**
Program Specific Outcomes (PSOs) for M. Sc. Microbiology	

PSO No.	Program Specific Outcomes(PSOs) Upon completion of this programme the student will be able to
PSO1	**Academic Competence:** i. Describe microbial processes that can be used for the development of biochemical and immunological tools to improve the quality of human life. ii. Study the cytology, biochemistry, growth as well as application of environmentally and industrially important microbes with a specific emphasis on improving environmental sustainability and human health. **iii.** Describe and understand the concepts of role of microorganisms in geochemical processes like leaching of metals and bioremediation methods
PSO2	**Personal and Professional Competence:** i. Apply tools of molecular taxonomy and bioinformatics to the study of diverse microbial groups. ii. Evaluate industrially important microbial products in terms of their purity, safety and ethically acceptable application for the benefit of mankind. **iii.** Combine public presentation skills of effective articulation and nonverbal communication with a sound understanding of microbial science to effectively communicate ideas.
PSO3	Research Competence: i. Validate scientific hypothesis and editorialize experimental scientific data by using statistical tools applicable to biological sciences. ii. Integrate principles of biology and physical sciences to standardize detection and quantification methods using sophisticated techniques.
PSO4	**Entrepreneurial and Social Competence:** i. Employ skill sets related to Quality assurance and testing of pharmaceutically important products in accordance with internationally accepted standards. ii. Evaluate the importance of new groups of consumer goods such as prebiotics, probiotics and nutraceuticals. **iii.** Apply the concepts of microbial interactions in basic and advanced treatment of waste water treatment processes.

S.Y. M.Sc. Semester I		
Title of the Course and Course Code	**MIC- 601 Biophysics and Instrumentation**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Describe the theoretical aspects of UV-Visible, IR, NMR, XRD and mass spectroscopy.	
CO2	Articulate and differentiate working principles, instrumentation and applications of various techniques used to analyze properties and structures of biomolecules.	
CO3	Outline the importance of different biophysical techniques in microbiology.	
CO4	Analyse the structure of biomolecules using XRD and NMR.	
CO5	Review and characterize metal and magnetic nanoparticles using microorganisms.	
CO6	Plan and propose the techniques and underlying theory of UV-Visible, IR, NMR, XRD and mass spectroscopy used to study biomolecules.	

Unit No.	Topics	No. of lectures
1	**Bimolecular Separation and Detection** A. Chromatography- Partition Coefficient, Selectivity, Resolution, Column Efficiency, Van Deemter equation, Interpretation of chromatograms B. Principle, components of instrument, operation and application of: Gel filtration chromatography, Ion-exchange Chromatography, Affinity chromatography, Gas chromatography, High Performance Liquid Chromatography. C. Ultra centrifugation, Differential centrifugation, Isopycnic and Rate zonal centrifugation.	**15**
2	**Spectroscopies of Biomolecules** A. Electromagnetic spectrum, Atomic orbitals, Molecular orbitals, Electronic, Rotational and Vibrational transitions in spectroscopy, Interpretation of spectra. UV/Visible spectroscopy- Instrumentation, Molar Absorptivities, Beer and Lamberts Law, Bathochromic and hypsochromic shifts. B. Fluorescence spectroscopy- Instrumentation, Quantum Yield, Quenching, FRET, Binding and Folding studies, C. Infrared Spectroscopy-Principle, Instrumentation, Absorption bands, FTIR and its advantages,	**15**

	D. Circular Dichroism (CD) – Instrumentation, Circular polarization, Cotton Effect. E. Mass spectroscopy- Principles of operation, Ionization, Ion fragmentation, Mass Analyzers, GC-MS, MALDI-TOF	
3	**Biophysical Techniques** A. X-ray crystallography: Purification of proteins, Crystallization of proteins, Instrumentation, acquisition of the diffraction pattern, basic principles of x-ray diffraction, working and applications B. NMR spectroscopy: Basic Principles of NMR, Chemical shift, Intensity, Line width, Relaxation parameters, Spin coupling, Nuclear Overhauser Effect Spectroscopy, Correlation Spectroscopy, Approach to structure determination by2D-NMR	**15**
4	**Synthesis and Characterization of Bio-Nanoparticles** A. Biogenic nanoparticles – Synthesis and applications. B. Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; C. Significance of the physical properties of nanoparticles D. Characterization of nanoparticles, Imaging techniques like TEM (Transmission Electron Microscope), SEM (Scanning Electron Microscope), AFM (Atomic Force Microscopy), Dynamic Light Scattering (DLS), Scanning Probe Microscopy (SPM), EDAX analysis, Zeta analysis.	**15**

Learning Resources

1. Clive Dennison (2002) A guide to protein isolation, Kluwer AcademicPublishers.
2. Pattabhi, V. and Gautham, N. (2002) Biophysics. Kluwer AcademicPublishers, New York and Narosa Publishing House, Delhi.
3. David J Holme, Hazel Peck (1998) Analytical Biochemistry, 3rd ed.,Prentice Hall, Pearson Education Limited, Harlow England.
4. Nölting, B. (2006) Methods in modern biophysics. Second Edition.Springer, Germany.
5. Cotterill, R. M. J. (2002) Biophysics: An Introduction. John Wiley & Sons,England.
6. Pattabhi, V. and Gautham, N. (2002) Biophysics. Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
7. Cavanagh John et.al. (1995) Proteins NMR Spectroscopy: Principles and Practice, Academic Press.
8. Keeler, J. (2002) Understanding NMR Spectroscopy. John Wiley & Sons, England.
9. Drenth, J. (2007) Principles of protein X-ray crystallography. 3rd Ed. Springer, Germany.
10. Christof M. Niemeyer and Chad A. Mirkin (2000) Nanobiotechnology, John Wiley & Sons.
11. Daniel L. Feldheim and Colby A. Foss, Jr. (2002) Metal nanoparticles synthesis and characterization and application.
12. Marcel Dekker, Inc. MahendraRai and Nelson Duran (2011) Metal nanoparticles Microbiology, Springer Verlag Berlin Heidelberg.

S.Y. M.Sc. Semester I		
Title of the Course and Course Code	**MIC–602: Pharmaceutical Microbiology**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Describe contributions and state Paul Ehrlich postulates in the drug discovery process. Outline the process of drug discovery and development. Define lead compound and candidate drug	
CO2	Differentiate between conventional and rational drug discovery processes and explain different methods of drug discovery processes. Explain the process of purification of biomolecules and high throughput screening	
CO3	Classify different carriers and drug delivery systems needed in the Pharmaceutical industry. Explain different stages of clinical trials of drugs, types and phases of clinical research	
CO4	Categorize Adverse Drug Reactions into different types and explain bioavailability of drugs and careers in clinical research	
CO5	Compare between clinical research and clinical trials. Evaluate the effectivity of combinatorial synthesis and structure activity relationship	
CO6	Write a report on GMPs and GLPs required in the pharmaceutical industry. Design an experiment to understand different stages of clinical trials	

Unit No.	Topics	No. of lectures
1	A. **Introduction to Drug Discovery** i. Contributions and postulates of Paul Ehrlich ii. Significance of terms - Lead compound, Lead optimization Candidate selection B. **Drug Discovery:** **i. Conventional Process Bio-prospecting (Medicinal Chemistry) –** a. Extraction and purification principles b. Purification and characterization of bioactive molecules from natural sources	**15**

	C. **Rational Drug Design-** Principle- Structure activity relationship -SAR **Tools-** i. High Through Put Screening ii. Combinatorial synthesis, iii. Pharmaco-genomics iv. Immunoinformatics	
2	**Drug Development** A. Preclinical development: Toxicity testing – acute, sub-acute and chronic toxicity B. Clinical development: Clinical trials – (Aims, Objectives, Conduct): I, II, III and IV C. Drug development: ADME and Bioavailability studies D. Adverse Drug Reactions E. Role of FDA in drug development (INDA, NDA)	**15**
3	**Quality Assurance and Validation in Pharmaceutical Industry** A. Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical Industry B. Quality assurance and quality management in pharmaceuticals C. ISO, WHO and US certification D. Safety in microbiology laboratory E. Biopharmaceuticals –Regulations and Sources: Regulatory authorities and its role: FDA and Pharmacopeia (IP, UK, US) F. Drug formulations - Carriers and delivery systems, targeted drug delivery, sustained release	**15**
4	**Introduction to clinical research** A. Terminologies and definition in Clinical Research B. Origin and History of Clinical Research C. Difference between Clinical Research and Clinical Practice D. Types of Clinical Research E. Phases of clinical research F. Clinical Trial market G. Career in Clinical Research	**15**

Learning Resources

1. Agarwal S. S. and Paridhavi M. (2007), Herbal Drug Technology, Universities Press (India) Pvt. Ltd
2. Altreuter D., and D S. Clark, (1999), Combinatorial Biocatalysis: Taking the Lead from Nature, Curr. Opin. Biotechnol. 10, 130.
3. Burn J. H. (1957) Principles of Therapeutics, Blackwell Scientific Pub. O. Ltd. Oxford.

4. Chatwal G. P. (2003), Bio-pharmaceutics and Pharmacokinetics, Himalaya Publishing House, Mumbai.
5. Chorghade Mukund S. Drug discovery and development. Volume I: Drug Discovery, Wiley-Interscience, John Wiley and Sons Inc. USA, 17-102.
6. Franklin T. J. and Snow G. A., (1975), Biochemistry of Antimicrobial action, Chapman and Hall, London.

S.Y. M.Sc. Semester I		
Title of the Course and Course Code	**MIC- 603:Bioprocess development**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Describe the concept of primary (growth associated) and secondary (growth non-associated) metabolites and their control.	
CO2	Calculate OTR and OUR in the fermentation medium. Calculate mass transfer coefficient, Reynold's number, power number. Kinetics of growth and product formation (growth rate, yield coefficient, efficiency.	
CO3	Apply the knowledge of biosensors to a successful fermentation process, effect of morphology of producer strain on fermentation process	
CO4	Explain the process of formation of Teixobactin, Streptokinase, Pullulan and Hepatitis B vaccine.	
CO5	Compare the products formed by continuous, batch and fed batch fermentations	
CO6	Design different types of bioreactors, their configuration and working of CSTR, Immobilized cell reactor and air lift fermenter.	

Unit No.	**Topics**	**No. of lectures**
1	**Bioreactor design and operation** A. Designing of bioreactors i. Design aspects STRs: ii. The dimensional ratios of the outer shell iii. Operational parameters influencing structure and design of bioreactors iv. Baffles and impellers. B. The configuration (placement) of impellers in a vessel and the different types of impellers (types of turbines and propellers, and their combinations) **C.** Immobilized cell reactors and air-lift reactors – Design and operation.	**15**

	D. Batch, Fed-batch and Continuous operation: Applications, advantages and limitations of each type	
2	**Bioprocess Variables** A Aeration - Theory of oxygen transfer in bubble aeration, Oxygen transfer kinetics (Oxygen Uptake Rate –OUR; Oxygen Transfer Rate OTR; Ccrit), determination of KLa. B. Agitation - Functions of agitation. Flow patterns with different types of impellers. C. Fermentation broth rheology and power requirements for agitation – Concept of Newtonian and non-Newtonian fluids, effect of broth rheology on heat, nutrient and oxygen transfer, Reynold's number, Power number, Aeration number: working out examples D. Use of various types of sensors and biosensors for monitoring environmental parameters (pressure, pH, temperature, DO and DCO2), Basic principles of operation, types of biosensors	**15**
3	**Microbial Growth characteristics and product formation** A. Concept of primary (growth associated) and secondary (growth non-associated) metabolites and their control, B. Kinetics of growth and product formation (growth rate, yield coefficient, efficiency etc.) C. Effect of type of growth on fermentation: The type of growth (mycelial pellet form, mycelial filamentous form, free cell, cells producing exopolysaccharides) affects mass transfer of nutrients, oxygen and heat; as also cell proliferation can be affected by shearing of cells. At least one example of each type may be explained to show these effects in any suitable fermentation	**15**
4	**Microbial Processes** Upstream, fermentation and downstream processing for **A.** Antibiotics (Teixobactin) **B.** Recombinant enzymes (Streptokinase) **C.** Exopolysaccharide (Pullulan) **D**. Recombinant Vaccine (Hepatitis B)	**15**

Learning Resources

1. Ratledge C and Kristiansen B eds. (2001) Basic Biotechnology 2nd Ed. Cambridge Univ. Press.
2. Operational Modes of Bioreactors, (1992) BIOTOL series, Butterworth's Heineman Shuichi and Aiba. Biochemical Engineering. Academic Press. 19
3. Modern technology of Bioprocessing written by EIRI Board of consultants and engineers Published by Engineers India Research Institute.
4. Dubasi Govardhana Rao, Rao 2010 Introduction to Biochemical Engineering Tata Mcgraw- Hill Education
5. Peter F. Stanbury, A.Whitaker Principles Of Fermentation Technology, 2E, Elsevier (A Divisionof Reed Elsevier India Pvt. Limited), 2009,
6. Vijai Kumar Gupta, Monika Schmoll, Minna Maki, Maria Tuohy,Marcio Antonio Mazutt editors Applications of Microbial Engineering. CRC Press 2013
7. S.K. Mishra, Ed., Pascale Champagne Associate editor,Biotechnology applications. I.K. International
8. McDuffie N. G.(1991) Bioreactor Design Fundamentals 1st Edition, Elsevier: eBook ISBN: 9781483221083
9. Singh L., Mahapatra D. and Yousuf A. (2019). Bioreactors: Sustainable Design
10. And Industrial Applications in mitigation of GHG emissions. Elsevier. ISBN-0128212640, 9780128212646
11. Angela Jozala (2017) Fermentation Processes Publisher-BoD. Books on Demand. ISBN-9535129279, E-Book 9789535129271
12. Carl-Fredrik Mandenius. (2016) Bioreactors: Design, Operation and Novel Applications. Reprint. Publisher-John Wiley & Sons. ISBN 3527683372 E-Book-9783527683376
13. Larroche C., Sanroman M., Du G. and Pandey A. (Editors). (2016) Current Developments in Biotechnology and Bioengineering: Bioprocesses, Bioreactors and Controls. Publisher-Elsevier, ISBN 0444636749, E- Book-9780444636744

S.Y. M.Sc. Semester I		
Title of the Course and Course Code	**MIC- 604: Advanced Molecular Techniques**	**Number of Credits : 02**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	Describe the fundamentals of rDNA technology and the strategies involved in gene cloning.	
CO2	Compare the different types of vectors used in rDNA technology.	
CO3	Apply the data generated from different genome projects in diagnosis of genetic diseases and their therapy.	
CO4	Formulate the principles and applications of different molecular biology techniques.	
CO5	Compare the genome libraries and cDNA libraries and determine their use in various gene manipulation methods	
CO6	Organize various techniques in Molecular Biology for their applications in disease diagnosis	

Unit No.	Topics	No. of lectures
1	**Gene technology** A. Gene cloning strategies: preparation of gene, genome libraries, cDNA libraries, Library screening B. Site directed mutagenesis and protein engineering, C. Cloning and manipulating large fragments of DNA; YAC BAC HAC D. Transfer of modified genes to host cells; example of insulin gene, factor VIII gene E. Expression vectors; lac Z construct F. Ti plasmids and its applications G. Gene augmentation, Gene therapy	**15**
2	**Techniques in Molecular biology and diagnostic applications** A. PCR and its modifications, nested PCR, Hot start PCR, Reverse transcriptase based PCR (RT –PCR), Real time PCR (Q –PCR), Multiplex PCR B. DNA microarray and its applications C. Molecular diagnostic tools in detection of diseases	**15**

	D. Gene editing tool: CRISPR-Cas-9, Zinc-finger nucleases (ZFNs),Transcription activator-Like effector nucleases(TALENs) E. ChIP	

Learning resources

1. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick (2004) Molecular Biology of the Gene, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.
2. Lewin's Genes XI, (2014) Jones and Bartelett Publishers Inc.
3. S.B Primrose and R M Twyman 2006 7th edition. Blackwell publishing Discovering genomics, Proteomics and Bioinformatics, Malom Campbell and L. J. Heyer 2nd Edn., Pearson Publication, 2009.
4. Walker J.M., Rapley R. (eds.) Molecular Biology and Biotechnology, 4th Ed., 2009, Royal Society Press, U.K.
5. B. R. Glick, J.J. Pasterneck, Principles and applications of recombinant DNA, 3rd Edn., ASM press.
6. Weaver R., (2007) Molecular Biology, 4th Edition, McGrew Hill Science
7. W.S. Klug and M.R. Cummings, Concepts of Genetics (2005) Pearson education
8. Malom Campbell and L. J. Heyer Discovering genomics, Proteomics and Bioinformatics2nd Edn., Pearson Publication, 2009.

S.Y. M.Sc. Semester I		
Title of the Course and Course Code	**MIC-621 Practical course based on Pharmaceutical Microbiology and Bioprocess development**	**Number of Credits : 02**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	Describe methodology for preparation of Immobilized yeast cells and compare the activity of free cells and immobilized cells.	
CO2	Differentiate between synergistic and antagonistic action of drugs and compare the mode of action of drugs.	
CO3	Develop enzyme lipase from bacteria and apply the knowledge of fermentation parameters to compare the yield of the product.	
CO4	Compare different methods for sterility testing of anti-infective-direct inoculation and membrane filtration techniques.	
CO5	Write methodology involved in LAL test and interpretation of observations.	
CO6	Develop graph, bar charts, line graphs, pie charts, add error bars of experimental data	

Unit No.	Topics	No. of hours
1	**Pharmaceutical Microbiology** 1. Checking synergistic activity of antimicrobial combinations 2. Checking antagonistic action of antimicrobial combinations 3. Microbial limit test 4. Sterility testing by direct inoculation and membrane filtration 5. LAL test	**15**
2	**Bioprocess Development** 1. Study of immobilization of yeast cells by sodium alginate method. 2. Isolation of melanin produced by *Aspergillus fumigatus* 3. Isolation of Xylanase or lipase producing bacteria. 4. Determination of Total Volatile Fatty acids	**15**

	5. Extraction of PHB granules	

Learning Resources

1. Immobilization of enzymes by sodium alginate method.M.Kierstan, C.Bruke-Biotechnology and Bioengineering,1977- willy online library.
2. Studies on pigmentation of *Serratia marcescens*:RPWilliams,JAGreen,J.Bact 1956.
3. Synergistic and antagonistic action of antibiotic, Microbiological Assays: by Kavenagh et al
4. LAL test an alternative method for detection of bacterial endotoxins: R.Blechova,D.Pivodova Acta veterinaria Brno,2001-actavet.vfu.cz
5. Recent developments in food characterization and adulteration detection:C.Cordella,I Moussa, Agriculture and food microbiology 2002, ACS publication

S.Y. M.Sc. Semester I		
Title of the Course and Course Code	**MIC-622 Practical course based on Immunology and Advanced Molecular Techniques**	**Number of Credits : 02**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	Describe the different types of antigen - antibody interactions using simple immunological techniques	
CO2	Estimate the titres of isoantibodies to human blood group antigens	
CO3	Illustrate the sublethal concentrations of different types of plasmid curing agents and classify them based on their effectiveness.	
CO4	Analyze the use of enzymes used in rDNA technology.	
CO5	Estimate the concentration of unknown antigen using precipitation techniques	
CO6	Plan the experiments for plasmid curing and detection	

Unit No.	Topics	No. of hours
1	**Antigen –antibody Interaction** 1. Detection of antigen antibody specificity by Ouchterlony test 2. Determination of antigen concentration from the sample by using- Single Radial immunodiffusion test 3. Determination of antigen concentration from the sample by using Rocket Immunoelectrophoresis 4. Latex agglutination slide test for detection of IgM Rheumatoid factors in human serum 5. Titre determination of isoantibodies to human blood group antigens	**15**
2	**rDNA technology** 1. Blue white screening 2. Identification of recombinants 3. Agarose Gel Electrophoresis 4. Restriction digestion of DNA 5. Ligation of DNA	**15**

Learning Resources

1. K. Wilson and J. Walker, 'Principles and techniques of biochemistry and Molecular Biology', (2005), 7th Edition, Cambridge university Press
2. Sambrook and Russel, 'Molecular cloning: A laboratory manual', Volume 1, 2 and 3 (2001), 3rd Edition, Cold spring harbor laboratory press, New York.
3. D. Scott Witherow, H. Miller and Sue Carson, 'Molecular biology Techniques: A classroom laboratory manual', 3rd edition, Elsevier
4. Kindt T. J., Goldsby R. A., Osborne B. A., 2007, Kuby Immunology 6th Ed. W. H. Freeman & Co., New York
5. ACT Laboratory Procedure Manual, 1980, section 2, pgs.70-77 and 2nd edition, 1991, chapter 2 pg 24-30.

S.Y. M.Sc. Semester I		
Title of the Course and Course Code	**MIC-623 Practical course based on Microbial ecology and Food technology**	**Number of Credits : 02**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Identify the host microbe interaction and show its use in preparing consortium	
CO2	Explain and classify microbial diversity and interpret the effect of stress	
CO3	Demonstrate presence of Ca , Iron , phosphorus and Ash content of food and examine the food adulteration	
CO4	Apply the methods to assess microbial community changes and learn about the environment impact assessment tools**.**	
CO5	Determination of vitamin A and C from food	
CO6	Design an experiment for production of wine from grapes	

Unit No.	Topics	No. of hours
1	**Microbial Ecology** 1. Host microbe interaction: in situ observation of root nodules 2. Consortium preparation from natural samples 3. Effect of stress on microbial ecosystem: effect of different concentrations of phosphates, nitrates, 4. Effect of chlorides and heavy metals at different values of pH on microbial ecosystem 5. Calculation of dominance and diversity of microbial ecosystems upon exposure to stress	**15**
2	**Food Technology** 1. Determination of Ca, Iron, phosphorus and Ash content of food 2. Determination of acid value, saponification value and iodine number of fats. 3. Determination of vitamin C by DNPH method 4. Determination of vitamin A by spectrophotometer (in oil samples). 5. Production of wine from grapes by fermentation 6. Food adulteration testing	**15**

Learning resources

1. Purdom Daniel and Arthur T. Trese (1995) Morphological and Molecular Characteristics of Host-Conditioned Ineffective Root Nodules in Cowpea. 109: 239-244
2. Patowary K. (2016) Development of an Efficient Bacterial Consortium for the Potential Remediation of Hydrocarbons from Contaminated Sites. Frontiers in Microbiology, 1092
3. A Food Technology Lab Manual Rashida R. and Joy P.P.
4. Handbook of fruits science and tech. Salunkhe D.K. and Kadam S.S.
5. AOAC International. 2003. Official methods of analysis of AOAC
6. International. 17th Ed. Gaithersburg, MD, USA, Association of Analytical Communities.
7. Linden G. 1996. Analytical Techniques for Foods and Agricultural Products

S.Y. M.Sc. Semester II		
Title of the Course and Course Code	**MIC- 651: Microbial Ecology**	**Number of Credits : 02**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Describe how the environment interacts with the macro and microorganisms and the interactions amongst themselves.	
CO2	Discuss the interaction between animals and their systems with the microbes as well as the plant interactions with microbes.	
CO3	Analyze the mechanisms of quantitating ecological aspects, study the laws defining adaptability to environmental conditions and the effect of microbial interactions on different pollutants.	
CO4	Apply the methods to assess microbial community changes and learn about the environment impact assessment tools.	
CO5	Evaluate the structure and composition of the microbial community.	
CO6	Create data on unculturable bacteria, microbial number and microbial metabolism by using knowledge of microbiology and ecology.	

Unit No.	Topics	No. of lectures
1	**Interactions between environment and biota** A. Autecology and synecology of Macro and microorganisms: definitions, terminology, concepts B. Concept of habitat and ecological niches: niche width and overlap; fundamental and realized niche C. Community: Structure, composition and stratification. Development of microbial community D. Ecological succession: types and mechanisms of succession and concept of climax E. Species interactions: Plant microbe interaction (Root symbionts, Agrobacterium, Phytopathogenic organisms, Mycorrhizal fungi), Animal-microbe interaction (Gastrointestinal system, Skin, Upper respiratory tract, Genital tract, termite Gut, Rumen)	**15**

2	**Applied Ecology and Environment impact assessment** A. Quantitative ecology: Sample collection, Sample processing, Detection of microbial populations using different methods, B. Adaptation to environmental conditions: Abiotic limitations to Microbial growth; Liebig's law of the minimum and Shelford's law of tolerance, Environmental determinants. Methods for investigating microbial community changes- Microscopy, SIP, NanoSIMS, FISH probes C. Microbial interactions with Xenobiotic and inorganic pollutants: Persistence and biomagnification of xenobiotic molecules, Microbial interactions with inorganic pollutants D. Environment Impact Assessment: i. Types of Impacts and their attributes. Determining the most significant impacts ii. Phase I studies: Initial inquiries iii. Phase II studies: Full EIA study iv. Arriving at the findings (identify, predict and judge)	**15**

Learning Resources:

1. Dash, M.C. (1993). Fundamentals of Ecology. Tata McGraw Hill Publishing Hill Co. Ltd., New Delhi 2
2. Macan, T. T. (1974). Freshwater Ecology. Longman GroupLtd., London
3. Meadows, P. S. and Campbell. (1978). An introduction to Marine Science. Blackie and Sons Ltd., Glasgow
4. Gurdeep Rastogi and Rajesh K. Sani (2011), Molecular Techniques to Assess Microbial Community Structure, Function, and Dynamics in the Environment, Microbes and Microbial Technology: Agricultural and Environmental Applications, 10(2):29-57
5. Wagner et al. (2003), Fluorescence in situ hybridisation for the identification and characterisation of prokaryotes, Current Opinion in Microbiology, 6:302–309
6. Yin Chen and J. Colin Murrell (2010), When metagenomics meets stable-isotope probing: progress and perspectives, Trends in Microbiology, 18 (4):157-163
7. Musat et al. (2016), Tracking microbial interactions with NanoSIMS, Current Opinion in Biotechnology, 41: 114-121

8. Holger Daims and Michael Wagner (2007), Quantification of uncultured microorganisms by fluorescence microscopy and digital image analysis, Applied Microbiology and Biotechnology, 75(2):237-48

9. John Glasson and Riki Therivel (2005), Introduction to Environmental Impact Assessment, Oxford, 3rd Ed.

10. Lei Han (2004), GMM Development and Applications, The GMO Handbook: Genetically Modified Animals, Microbes, and Plants in Biotechnology, 29-51

S.Y. M.Sc. Semester II		
Title of the Course and Course Code	**MIC-652: Regulation of Immunological Processes**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Describe different cell surface molecules, receptors and label different proteins involved in signal transduction pathways. List different proteins involved in complement pathway and regulation of complement pathway	
CO2	Represent T and B cell receptors, G protein coupled receptors diagrammatically. Explain different mechanisms of immunological tolerance induction, network theory	
CO3	Classify different methods for regulation of immune response. Outline the pathways involved in signal transduction pathways	
CO4	Analyse different methods for regulation of the complement system. Differentiate between different types of tumors and BRMs foe cancer treatment	
CO5	Review different escape mechanisms of tumor from the host cells and methods for diagnosis of tumor.	
CO6	Write a report on different immunodeficiency disorders, mechanisms and theories of autoimmunity and different methods for tumor diagnoss	

Unit No.	Topics	No. of lectures
1	**Cell cell interaction through surface receptors and signal transduction pathways** **A.** Structure and function of Toll-like receptors, Cytokine receptors, T Cell receptor, B Cell Receptor, Tyrosine kinase linked receptors, adhesion molecules in immune activation **B.** TCR-CD3 complex, Signal transduction pathways: IL-2 pathway (JAK/STAT and Ras/MAP Kinase Pathways), BCR mediated signal transduction, TLR mediated signal transduction	**15**
2	**Regulation of Immune response** A. Immunological tolerance and suppression: Negative regulation - Immunological tolerance, Mechanisms of tolerance induction (related experimentation using transgenic animals), T cell	**15**

	mediated suppression of immune response B. Network theory and its experimental evidence C. Cytokine mediated cross regulation of immune response - Regulation of T_H subsets(TH1-TH2) D. Regulation of complement system – Classical and alternative pathway E. Immunomodulation: BRMs for therapy	
3	**Tumor Immunology** A. Cellular transformations during neoplastic growth, Classification of tumors based on histological, physiological, biochemical and immunological properties, Tumors of lymphoid system (lymphoma, myeloma, Hodgkin's disease) B. Escape mechanisms of tumor from host defense, Host immune response to tumor – Effector mechanisms, Immuno- surveillance theory C. Diagnosis of tumors – biochemical and immunological tumor markers Zpproaches in cancer immunotherapy: Immune adjuvant and tumor vaccine therapy	**15**
4	**Immunological disorders** A. Autoimmunity- Mechanism, theories, pathophysiology and therapeutic approaches for Rheumatoid arthritis, Systemic Lupus Erythematosus (SLE), Neurologic disease- Myasthenia gravis B. Pathophysiology, diagnosis, prognosis and therapeutic approaches to: Immunodeficiency disorders – humoral deficiencies, T-cell deficiencies, and combined deficiencies, complement deficiencies	**15**

Learning Resources

1. Akihiko Yoshimura, Tetsuji Naka and Masato Kubo, (2007), *SOCS proteins, cytokine signaling and immune regulation*, Nature Reviews, Immunology, **7:**454-465
2. Christopher K. Garcia and Erin J. Adams, (2005), How the T Cell Receptor Sees Antigen—A Structural View, Cell, Vol. 122: 333– 336, Elsevier Inc.
3. Gangal Sudha and SontakkeShubhangi (2013), Textbook of Basic and Clinical Immunology Paperback, University Press, India
4. Kindt, Osborne, Goldsby, (2006), *Kuby Immunology*, 6th Ed., W. H. Freeman & Co.
5. Abbas A. K. and Litchman A. H. (2004), *Basic Immunology, Functions and Disorders of Immune System*, 2nd Ed., Elsevier Inc.
6. Roitt I. M. (1988) *Essentials of Immunology*, ELBS, London

S.Y. M.Sc. Semester II		
Title of the Course and Course Code	**MIC- 653: Food Technology**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Recall principles of Food Analysis and quality maintenance.	
CO2	Understand the concept of chemical analysis and characterization of food constituents.	
CO3	Apply Principles of food protection, nutraceuticals and hurdle technology.	
CO4	Analyze the risk associated with food additives and processing toxins.	
CO5	Evaluate the potential benefits and risk of nutraceuticals.	
CO6	Propose innovative strategies for improving food standards and hygiene practices.	

Unit No.	Topics	No. of lectures
1	**Food Analysis** A. Principles, Types of samples analysis, steps in analysis, choice of methods; sampling procedures, considerations and sample preparation; Evaluation of analytical data – accuracy and precision, sources of errors, specificity, sensitivity and detection limits, regression analysis, reporting results. Analysis of chemical constituents, their characterization and significance- moisture, ash, minerals, lipids, fat, proteins, fibre, titratable acidity, starch, reducing sugars. B. Introduction to food safety and security: Hygienic design of food plants and equipments, Food Contaminants (Microbial, Chemical, Physical), Food Adulteration (Common adulterants), Food Additives (functional role, safety issues)	**15**
2	**Nutraceuticals** A. Introduction to Nutraceuticals as Science Historical perspective, classification, scope & future prospects. Applied aspects of the Nutraceutical Science. Sources of Nutraceuticals. Study of various Nutraceuticals Properties, structure and functions of Glucosamine, Octacosanol, Lycopene, Carnitine, Melatonin. Use of proanthocyanidins, flaxseed oil as Nutraceuticals. B. Food as remedies Nutraceuticals bridging the gap between food and drug, Nutraceuticals in treatment for cognitive decline, Nutraceutical	**15**

	remedies for common disorders like Arthritis, Bronchitis, circulatory problems, hypoglycemia, Nephrological disorders, Liver disorders, Osteoporosis, Psoriasis and Ulcers. Nutraceutical rich supplements e.g. Bee pollen, Caffeine, Green tea, Lecithin, Mushroom extract, Chlorophyll, Kelp and Spirulina.	
3	**Food Protection and Toxicology** A. General principles of food protection: methods of food protection, asepsis, maintenance of anaerobic conditions, protection by use of high temperature, protection by use of low temperatures. B. Introduction to food toxicology: classification, dose, determination toxins in food, naturally occurring toxins from animals, bacterial and fungal and sea food sources. Food additives as toxicants: artificial colors, preservatives, sweeteners; toxicants formed during food processing such as nitrosomines, maillard reaction products acrylamide, benzene, heterocyclic amines and aromatic hydrocarbons and irradiation, risk of genetically modified food, food supplements, persistant organic pollutants	**15**
4	**Food standards and Hurdle Technology** A. FPO, PFA, Agmark, ISI, HACCP, food plant sanitation and cleaning in place (CIP), FAO in India, Technical Cooperation programmes. B. Bio-security in Food and Agriculture Hurdle technology: Principles and applications, Hurdle effect in fermented foods, shelf stable products, intermediate moisture foods, application of hurdle technology. C. Modern ICT tools in Food and dairy extension.	**15**

Learning Resources:

1. Food and Packaging Interactions by Risch. S.H. Publisher American chemical society, Washington (1991).
2. Rathore, N.S.et al. 2008.Fundamentals of Dairy Technology- Theory & Practices. Himanshu Publn.
3. AOAC International.2003. Official methods of analysis of AOAC International. 17th Ed. Gaithersburg, MD, USA, Association of Analytical Communities.
4. The food safety information handbook by Cynthia A. Robert, 2009.
5. Postharvest biotechnology of vegetables, Salunkhe D.K. Handbook of fruits science and tech. Salunkhe D.K. and Kadam S.S.
6. Food and Packaging Interactions by Risch. S.H. Publisher American chemical society, Washington (1991).
7. Cereal Processing and Technology, Gavin Owens 8. Rathore,N.S.et al. 2008.
8. Fundamentals of Dairy Technology- Theory & Practices. Himanshu Publn.
   Linden G. 1996. Analytical Techniques for Foods and Agricultural Products

MIC654- MOOCS

S.Y. M.Sc. Semester II		
Title of the Course and Course Code	**MIC655 Biostatistics**	**Number of Credits: 04**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	Describe the method to collect samples in the most appropriate way to carry out desired experiments. Record the data obtained in the experiment in a suitable way	
CO2	Design the experiments based on the different principles.	
CO3	Apply the measures of central tendency, dispersion to the data and calculate the probability of obtaining the expected results in the experiments.	
CO4	Analyze large data to get a meaningful inference from it	
CO5	Compare the different methods of measuring central tendency and evaluate the best suitable one for a particular data	
CO6	Formulate a hypothesis for the experiment as well as test it using appropriate methods.	

Unit No.	Topics	No. of hours
1	**Introductory Biostatistics, Data Representation and Interpretation** A. Importance of statistics in Biology, Samples and Population B. Types of data, Random sampling methods and sampling errors, Scales and Variables, Accuracy and precision, Collection and Organization of data, tabulation, diagrammatic representation (Simple bar diagram, percentage bar diagram, multiple bar diagram, sub-divided bar diagram and pie diagram, pictogram). C. Graphical representation (Histogram, frequency polygon and ogive curves survival curves)	**15**
2	**Descriptive Statistics and Probability** A. Measures of central tendency–Mean (arithmetic, geometric, harmonic) median, mode, quartiles, percentiles B. Measures of dispersion–Mean deviation Standard deviation and Variance; C. Measures of skewness; D. Regression and correlation E. Concept of Probability – classical definition, discrete and continuous random variable, notion of density/ mass function F. Probability distribution – Normal (x-scale and z-scale), Binomial and Poisson distributions	**15**
3	**Testing of Hypothesis - I** A. The concepts of null hypothesis, alternative hypothesis, significance B. level, type I and type II errors, p-value, one tailed and two tailed tests C. Distribution of sample means, standard error and confidence interval, Degrees of freedom D. Equality of two population means - t-tests and z - test, z proportions, E. paired t test	**15**

	F. Non Parametric Tests – Median Test, Mann Whitney U Test, Wilcoxon Signed Rank Test G. $\chi 2$(chi square) test –test for goodness of fit, independence	
4	**Testing of Hypothesis – II** A. Concept of Design of Experiments B. Principles of Design – Replication, Randomization, Local Control (Blocking) C. Concept of ANOVA for comparison of three or more samples (one way and two way) D. Factorial Designs, analyzing 22 and 23 designs using Yates table E. Plackett Burman Design	**15**

Learning Resources:

1. Goon, Gupta and Dasgupta Fundamentals of Statistics, World Press Kolkata
2. Gupta S. P. Statistical methods, Sultan Chand &Sons Publisher, New Delhi
3. Irfan Ali Khan and Atiya Khanum, Fundamentals of Biostatistics. 3rdEd.Ukaaz,
4. Publications, Hyderabad
5. Bernard Rosner Fundamentals of Biostatistics, 5thEd. Duxbury
6. Norman T.J. Bailey Statistical methods in biology, 3rdEd. Cambridge University Press

S.Y. M.Sc. Semester II		
Title of the Course and Course Code	**MIC656 IPR, Biosafety and Bioethics**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Describe Intellectual property rights and its types. Define bioethics and biosafety	
CO2	Discuss concepts of patents and bioethics	
CO3	Illustrate different biosafety regulations, Classify different types of patents	
CO4	Analyse the process of patenting in India and abroad, Explain ethical conflicts in research	
CO5	Compare patents and trademarks	
CO6	Write the concept of copyright and copyright act	

Unit No.	Topics	No. of hours
1	**Introduction to Intellectual property** A. Introduction and the need for intellectual property right (IPR) B. Types of intellectual property rights C. International organizations - World Intellectual Property D. Organisation (WIPO) E. IPR in India & abroad F. Some important examples of IPR **Copyright** A. Concept of copy right B. Copyright Act of 1957 C. Originality of material & rights of reproduction	**15**
2	**Patents** A. Introduction & foundation of patent laws B. The different layers of the international patent system (national, regional and international options) C. Patent document D. Searching, drafting and filing of a patent E. Ownership rights and transfer of patent **Trademarks** A. Concept of trademark B. Types of trademark C. Protection & registration of trademark 4. Indian trademark law & trademark act of 1999	**15**
3	**Bioethics** A. Concept of ethics and bioethics with respect to microbiological and biotechnological research B. Human and animal ethics C. Social and ethical issues Principles of bioethics.	**15**

	D. Ethical conflicts in microbiological and biotechnological Research E. interference with nature F. Bioethics vs business ethics.	
4	**Biosafety** A. Definition and importance of biosafety- individuals, institutions, society, region, country and world B. Laboratory associated infections and hazards C. Bio safety regulation: handling of recombinant DNA products D. and process in industry and in institutions E. Organizations involved in biosafety activities F. Cross border movement of germplasm	15

Learning Resources:

1. Balasubramaniam, C.F.A. Bryce, K. Dharmalingam, J. Green and K. Jayaraman,Concepts in Biotechnology, University Press (Orient Longman Ltd.), 2002
2. Bourgagaize, Jewell and Buiser, Biotechnology: Demystifying the Concepts, WesleyLongman, USA, 2000.
3. AjitParulekar and Sarita D' Souza, Indian Patents Law – Legal & BusinessImplications; Macmillan India ltd , 2006
4. B.L.Wadehra; Law Relating to Patents, Trade Marks, Copyright, Designs &Geographical Indications; Universal law Publishing Pvt. Ltd., India 2000
5. P. Narayanan; Law of Copyright and Industrial Designs; Eastern law House, Delhi, 2010
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.Thomas, J.A., Fuch, R.L. (2002). Biotechnology and safety Assessment (3 rd Ed) Academic press
8. P.N. Cheremisinoff, R.P. Ouellette and R.M. Bartholomew,Biotechnology Applicationsand Research, Technomic Publishing Co., Inc. USA, 1985

MIC 657 MOOCS

S.Y. M.Sc. Semester II		
Title of the Course and Course Code	**MIC671 Dissertation I**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	List the objectives and state the hypothesis of the research project	
CO2	Outline the methodology that will be followed to achieve the listed objectives	
CO3	Organize the research project objectives	
CO4	Arrange different methodologies to be followed to perform the experiments	
CO5	Demonstrate capacity to lead and manage change through collaboration with others.	
CO6	Write the plan for daily routine to be followed during project work.	

S.Y. M.Sc. Semester II		
Title of the Course and Course Code	**MIC672 Dissertation II**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Carry out a substantial research based project.	
CO2	Demonstrate capacity to improve achievement, engagement and retention.	
CO3	Demonstrate an understanding of the ethical issues associated with the research	
CO4	Use research finding to advance education theory and practice	
CO5	Report the research finding in written and verbal form	
CO6	Analyse the data and synthesize research findings.	