Deccan Education Society's
FERGUSSON COLLEGE (AUTONOMOUS), PUNE

Syllabus

for

M. Sc. (Microbiology) Part II

(Semester-III and Semester-IV)

[Pattern 2019]

from Academic Year

2020-21

Program Structure of M.Sc. (Microbiology) Part-II

Particulars	Paper	Paper code	Title of Paper	Type of Paper	No. of Credits
M.Sc. Semester-III	Paper- 1	MIC5301	Biostatistics	Special-1	4
	Paper - 2	MIC5302	Bioprocess development	Special-2	4
	Paper - 3	MIC5303	Practical course based on Biostatistics, Microbial Ecology and Applied Molecular Biology	P-Special-1	4
	Paper -4	MIC5304	Practical course based on Bioprocess development, Food technology and Pharmaceutical Microbiology	P-Special-2	4
	Paper -5	MIC5305	D: Microbial Ecology and Environmental Microbiology	Elective-3	4
		MIC5306	G: Applied Molecular Biology		
		MIC5307	M: MOOCS		
	Paper -6	MIC5308	D: Pharmaceutical Microbiology	Elective-4	4
		MIC5309	G: Food Technology		
		MIC5310	M: MOOCS		
M. Sc. Semester-IV	Paper -1	MIC5401	Project work and Dissertation-1	P-Special-3	4*
	Paper - 2	MIC5402	Project work and Dissertation-2	P-Special-4	4*

Guidelines for MIC 5401 and MIC 5402 [8 credits]

Microbiology Project (8 Credits)

- Students can select project in outside research institutes or can-do projects in the department itself.
- The total project work is of 200 marks and divided as 50 percent internal and 50 percent external assessment.
- It is expected to spend 5-6 hours per credit ie. For 8 credit course 40-48 hours per week. Therefore, a student working on project in department or in institute is expected to spend 40-48 hours on project work.
- Weekly reporting of the progress of the work should be done to the Faculty mentor of the department for student working outside the department. In house students are expected to report every day to their project guide.
- 100 internal plus 100 externals = 200 marks evaluation.
- The external examiner assesses the student for 50 marks based on his/her dissertation report and presentation skills. The internal examiner will assess for 50 marks for the same components. The project guide will examine the student for 100 marks during the entire semester. During this assessment student will present his or her work twice, the literature survey will be evaluated, student writes the review article on the topic related to their project work, their attendance and working in the laboratory is also considered for their evaluation for 100 marks.

	(Course Outcomes)	
S.Y. M.Sc. Semester III		
Title of the Course and Course Code	**Biostatistics (MIC5301)**	**Number of Credits : 04**
Course Outcomes (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.	Title of Unit and Contents
I	**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). Graphical representation (Histogram, frequency polygon and ogive curves survival curves),
II	**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.

III	**Testing of Hypothesis - I** **A.** The concepts of null hypothesis, alternative hypothesis, significance level, type I and type II errors, p-value, one tailed and two tailed tests **B.** Distribution of sample means, standard error and confidence interval, Degrees of freedom **C.** Equality of two population means - t-tests and z - test, z proportions, paired t test **D.** Non Parametric Tests – Median Test, Mann Whitney U Test, Wilcoxon Signed Rank Test **E.** χ^2 (chi square) test –test for goodness of fit, independence
IV	**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 2^2 and 2^3 designs using Yates table **E.** Plackett Burman Design

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, Publications, Hyderabad
4. Bernard Rosner Fundamentals of Biostatistics, 5thEd. Duxbury
5. Norman T.J. Bailey Statistical methods in biology, 3rdEd. Cambridge University Press

Title of the Course and Course Code	**Bioprocess development (MIC5302)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe different types of bioreactors, their configuration and working of CSTR.	
CO2	Explain the principle of transfer of oxygen in the fermentation medium and how agitation helps in it.	
CO3	Apply the knowledge of biosensors to a successful fermentation process, learn the concept of primary, secondary metabolites and demonstrate it at industrial level.	
CO4	Analyze the products formed by continuous batch and fed batch fermentations.	
CO5	Evaluate the production of growth associated and growth non -associated products. Differentiate between primary and secondary metabolites and determine the microbial growth kinetics and apply it to industrial fermentation.	
CO6	Produce pullulan an exopolysaccharide, the antibiotic TEIXOBACTIN produced by VBNC, streptokinase, a lifesaving drug in heart attacks produced by Streptococcus and recombinant vaccine for Hepatitis B.	

Unit No.	Title of Unit and Contents
I	**Bioreactor design and operation** **A.** Designing of bioreactors i. Design aspects STRs: ii. The dimensional ratios of the outer shell iii. Operational aspects such as working volume, 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. **D.** Batch, Fed-batch and Continuous operation: Applications, advantages and limitations of each type

II	**Process 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.
III	**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.
IV	**Microbial Processes** Upstream, fermentation and downstream processing for **A.** Antibiotics (Teixobactin) **B.** Recombinant enzymes (Streptokinase) **C.** Exopolysaccharide (Pullulan) **D.** Recombinant Vaccine (Hepatitis B)

Learning Resources:

1.Doran Pauline (1995) Bioprocess Engineering Principles, Academic Press.

2.Lydersen B., N. a. D' Elia and K. M. Nelson (Eds.) (1993) Bioprocess Engineering: Systems, Equipment and Facilities, John Wiley andSons Inc.

3.Ratledge C and Kristiansen B eds. (2001) Basic Biotechnology 2nd Ed. Cambridge Univ. Press.

4.Operational Modes of Bioreactors, (1992) BIOTOL series, Butterworths Heinemann.

5.Shuichi and Aiba. Biochemical Engineering. Academic Press. 1982

6.Modern technology of Bioprocessing written by EIRI Board of consultants and engineers Published by Engineers India Research Institute.

7.Dubasi Govardhana Rao, Rao 2010 Introduction to Biochemical Engineering Tata Mcgraw-Hill Education

8.Peter F. Stanbury, A.Whitaker Principles Of Fermentation Technology, 2E, Elsevier (A Divisionof Reed Elsevier India Pvt. Limited), 2009,

9.Vijai Kumar Gupta, Monika Schmoll, Minna Maki, Maria Tuohy,Marcio Antonio Mazutt editors Applications of Microbial Engineering. CRC Press 2013

10. C.S.K. Mishra, Ed., Pascale Champagne Associate editor,Biotechnology applications. I.K. International Pvt. Ltd. 2009 Sudhir U. Meshram, Ganghdhar B Shinde, Applied biotechnology.I.K. International Pvt. Ltd. 2009

Title of the Course and Course Code	**Practical Course based on Biostatistics, Microbial Ecology and Applied Molecular Biology (MIC5303)**	**Number of Credits : 04**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Describe the sublethal concentrations of different types of plasmid curing agents and classify them based on their effectiveness.	
CO2	Explain the features of programming software R or PAST and its application in data analysis.	
CO3	Demonstrate the use of enzymes used in rDNA technology.	
CO4	Test statistical tools for data analysis with the help of t test, ANOVA, Chi square test, F test using computer softwares.	
CO5	Organize the experimental biological data obtained and validate it using different statistical tools.	
CO6	Develop graph, bar charts, line graphs, pie charts, add error bars.	

Unit. No.	Title of Unit and Contents
I	**Biostatistics I** **A.** Computer applications: using datasheets, sorting data with different parameters **B.** Plotting graph, bar charts, line graphs, pie charts, adding error bars **C.** Statistical analysis of data – students t test, ANOVA, Chi square test, F test using computer softwares (Eg Microsoft Excel)

II	**Biostatistics II** **A.** Introduction to programming software R or PAST **B.** Correlation and linear regression analysis **C.** Fitting of distributions – Binomial, Poisson and Normal distributions

III	**Microbial Ecology I** **A.** Host microbe interaction: in situ observation of root nodules **B.** Consortium preparation from natural samples OR **Applied Molecular Biology I** **A.** Determination of sub-lethal concentration of different plasmid curing agents **B.** Plasmid curing
IV	**Microbial Ecology II** **A.** Effect of stress on microbial ecosystem: effect of different concentrations of phosphates, nitrates, chlorides and heavy metals at different values of pH **B.** calculation of dominance and diversity of microbial ecosystems upon exposure to stress OR **Applied Molecular Biology II** **A.** Polymerase chain reaction **B.** Restriction digestion of DNA Ligation of DNA

Learning Resources:

1. Irfan Ali Khan and Atiya Khanum, Fundamentals of Biostatistics. 3rd Ed. Ukaaz, Publications, Hyderabad
2. Wardlaw A.C. (1985) Practical Statistics for Experimental Biologists. John Wiley and Sons
3. Purdom Daniel and Arthur T. Trese (1995) Morphological and Molecular Characteristics of Host-Conditioned Ineffective Root Nodules in Cowpea. 109: 239-244
4. Patowary K. (2016) Development of an Efficient Bacterial Consortium for the Potential Remediation of Hydrocarbons from Contaminated Sites. Frontiers in Microbiology, 1092 (7)
5. K. Wilson and J. Walker, 'Principles and techniques of biochemistry and Molecular Biology', (2005), 7th Edition, Cambridge university Press
6. Sambrook and Russel, 'Molecular cloning: A laboratory manual', Volume 1, 2 and 3 (2001), 3rd Edition, Cold spring harbor laboratory press, New York.
7. D. Scott Witherow, H. Miller and Sue Carson, 'Molecular biology Techniques: A classroom laboratory manual', 3rd edition, Elsevier

Title of the Course and Course Code	**Practical course based on Bioprocess Development, and Pharmaceutical Microbiology (MIC5304)**	**Number of Credits : 04**
Course Outcomes (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	Analyze the pigment produced by bacteria, fungi and characterize them.	
CO5	Compare different methods for sterility testing of anti-infective-direct inoculation and membrane filtration techniques.	
CO6	Write methodology involved in LAL test and interpretation of observations.	

Unit.No.	Title of Unit and Contents
I	**A.** Study of immobilization of yeast cells by sodium alginate method. **B.** Effect of immobilization on enzyme activity **C.** Effect of change in concentration of calcium chloride **D.** Effect of change in concentration of sodium alginate. **E.** Effect of change in cell concentration on enzyme activity.
II	**A.** Isolation of pigment producing organisms **B.** Isolation of the pigment produced by *Serratia marcescens* **C.** Isolation of melanin produced by *Aspergillus fumigatus* **D.** Characterization of the pigments
III	**A.** Isolation of xylanase or lipase producing bacteria. **B.** Production of enzymes in shake flask. **C.** Effect of different fermentation parameters like Temperature,pH, agitation,aeration on yield and activity of enzyme. **D.** Production of wine from grapes by fermentation. Study of single cell protein.
IV	**Pharmaceutical Microbiology** **A.** Checking synergistic and antagonistic action of drugs **B.** Microbial limit test **C.** Sterility testing by direct inoculation and membrane filtration **D.** LAL test

	OR **Food technology** **A.** Determination of Ca, Iron, Phosphorus and Ash content of food. **B.** Determination of acid value and saponification value of fats. **C.** Determination of vit. C by DNPH method. **D.** Food adulteration testing. **E.** Estimation of fat content of milk/meat. **F.** Estimation of moisture content of food.

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

Title of the Course and Course Code	**Microbial Ecology (MIC5305)**	**Number of Credits : 04**
Course Outcomes (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.	Title of Unit and Contents
I	**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 and animal microbe interaction, mutualism, commensalism, competition, predation, trophic interaction
II	**Applied Ecology** **A.** Quantitative ecology: Sample collection, Sample processing, Detection of microbial populations, Determination of microbial numbers, Detecting nonculturable bacteria, Determination of microbial biomass, Measurement of microbial metabolism **B.** Adaptation to environmental conditions: Abiotic limitations to Microbial growth; Liebig's law of the minimum and Shelford's law of tolerance, Environmental determinants. **C.** Microbial interactions with Xenobiotic and inorganic pollutants: Persistence and biomagnification of xenobiotic molecules, Microbial interactions with inorganic pollutants, Biochemistry and Genetics of 2,4-D biodegradation
III	**Environment impact assessment and tools** **A.** Methods for investigating microbial community changes- Microscopy, SIP, NanoSIMS, FISH probes **B.** Environment Impact Assessment: i. Introduction: What is EIA and its need ii. Types of Impacts and their attributes. Determining the most significant impacts iii. Phase I studies: Initial inquiries iv. Phase II studies: Full EIA study v. Arriving at the findings (identify, predict and judge) **C.** Genetically Modified Organisms
IV	**Host- microbe interaction** A. Animal- microbe interaction: i Gastrointestinal System ii Skin iii Upper respiratory tract iv Genital tract v Gut (termite) vi Rumen B. Plant- microbe interaction: i Root symbionts ii Agrobacterium iii Phytopathogenic organisms iv mycorrhizal fungi

	v	nitrogen-fixing bacteria
	vi	Plant-Growth-Promoting Rhizobacteria(PGPR)

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. A. K. Shrivastava (2007), Environmental Impact Assessment, APH Publishing,1-163
11. Lei Han (2004), GMM Development and Applications, The GMO Handbook: Genetically Modified Animals, Microbes, and Plants in Biotechnology, 29-51
12. Pandeya et al. (2012), Host-microbial interaction in the mammalian intestine and their metabolic role inside, Biomedical Research, 23 (1): 9-21
13. Nina N. Schommer and Richard L. Gallo (2013), Structure and function of the human skin microbiome, Trends in Microbiology, 21(12): 660–668
14. Martin Clémence et al.(2014), Host–microbe interactions in distal airways: relevance to chronic airway diseases, Chronic Airway Diseases, 24: 78–91
15. Ma Bing et al. (2012), The vaginal microbiome: rethinking health and diseases, Annual Reviews in Microbiology, 66: 371–389
16. Krishnan Muthukalingan et al. (2014), Insect gut microbiome - An unexploited reserve for biotechnological application, Asian Pacific Journal of Tropical Biomedicine, 4: S16-S21

17. Henderson Gemma et al. (2015), Rumen microbial community composition varies with diet and host, but a core microbiome is found across a wide geographical range, Scientific Reports, 5
18. Sandy Primrose, Richard Twyman, Bob Old (2001), Principles of Gene Manipulation, Blackwell Science Ltd.,6th Edition
19. Vejan Pravin et al. (2016), Role of Plant Growth Promoting Rhizobacteria in Agricultural Sustainability—A Review, Molecules,21
20. N.S. Subbarao (1999), Soil Microbiology, Science Publishers Technology & Engineering, 4th Edition

Title of the Course and Course Code	**Applied Molecular Biology (MIC5306)**	**Number of Credits : 04**
Course Outcomes (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	Demonstrate the use of transgenic plants and animals in production of industrially important products.	
CO5	Compare different molecular diagnostic techniques for detecting different diseases.	
CO6	Formulate the principles and applications of different molecular biology techniques.	

Unit. No.	Title of Unit and Contents
I	**Gene technology** **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
II	**Transgenic plants and animals** A. Genetically modified organisms- social and ethical issues B. Transgenic animals and their applications in medicine – prevention, early

	detection and cure of diseases C. Transgenic plants: and their applications in agriculture D. Examples of transgenic plants and animals: advantages and disadvantages E. Producing useful molecules with examples
III	**Genome projects** A. Concept and meaning of genome projects and their applications. B. Introduction to Genome projects of *E. coli*, Yeast, Plasmodium, Fruit fly, Mouse, Drosophila and Rice and comparative genomics C. Gene annotation D. Human Genome project and its applications
IV	**Techniques in Molecular biology and diagnostic applications** A. PCR and its modifications, nested PCR, Hot start PCR, Reverse transcriptase based PCR (RT –PCR) and Real time PCR (Q –PCR) B. DNA microarray and its applications C. Molecular diagnostic tools in detection of diseases D. Gene editing tool: CRISPR-Cas-9 E. ChIP F. RFLP G. Designing and detection of probe H. Knockout mice I. Phage expression system J. Yeast two and three hybrid assay K. Measuring transcription rates

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.

Title of the Course and Course Code	**Pharmaceutical Microbiology (MIC5308)**	**Number of Credits : 04**
Course Outcomes (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.	
CO2	Differentiate between conventional and rational drug discovery processes and explain different methods of drug discovery processes.	
CO3	Classify different carriers and drug delivery systems needed in the pharmaceutical industry.	
CO4	Categorize Adverse Drug Reactions into different types and explain different types of clinical trials of drugs.	
CO5	Compare different methods for evaluation and mechanism determination of anti-infective.	
CO6	Write a report on GMPs and GLPs required in the pharmaceutical industry.	

Unit. No.	Title of Unit and Contents
Unit I	**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 **C. Rational Drug Design** – Principle (Structure activity relationship -SAR) and Tools (applications of High Through Put Screening, Combinatorial synthesis, Pharmaco-genomics)
Unit II	**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)
Unit III	**Discovery of anti-infectives** **A. Evaluation and mechanism determination of anti-infectives using biochemical and microbiological techniques.** i. Direct counts (Counting chambers, calibrated smears,proportionate counts), ii. Turbidometry iii. Nephalometry, iv. Electrical Resistance v. Electrical impendence vi. Microcalorimetry vii. Flow cytometry viii. Radiometric methods ix. Radiolabelling techniques **B. Laboratory methods to assess activity of antimicrobial combinations** i. Antagonism ii. Synergism
nit IV	**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

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. Paul W. Erhardt, (2006), Medicinal Chemistry in the New Millennium: A Glance into the Future, Ed.

6. Chorghade Mukund S. Drug discovery and development. Volume I: Drug Discovery, Wiley-Interscience, John Wiley and Sons Inc. USA, 17-102.
7. Dewick Paul M., (2002), *Medicinal natural products: A biosynthetic approach*, 2nd Ed., John Wiley and Sons.
8. Satoskar R. S. & S. D. Bhandarkar (1991). Pharmacology and Pharmacotherapeutics, 12th Ed., Vol. 1 & 2, Popular Prakashan, Mumbai
9. John O. and Pieter H. Joubert, (1997), Handbook of Phase I / II clinical drug trials, CRC Press
10. Vyas S. P and Dixit V. R. (2002), Pharmaceutical Biotechnology, CBS Publishers and Distributors, New Delhi
11. Lorian V., (1986), *Antibiotics in laboratory medicine*, 2nd Ed, Williams & Wilkins Publication
12. Franklin T. J. and Snow G. A., (1975), *Biochemistry of* Antimicrobial action, Chapman and Hall, London.

Title of the Course and Course Code	**Food Technology (MIC5309)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe the. Food standards and quality maintenance: FPO, PFA, Agmark, ISI, HACCP, food plant sanitation and cleaning in place (CIP), FAO in India, Technical Cooperation programmes, Bio-security in Food and Agriculture.	
CO2	Explain the Principles of Food Analysis: Types of samples analysed, steps in analysis, choice of methods; sampling procedures, considerations and sample preparation	
CO3	Apply Food as remedies, nutraceuticals bridging the gap between food and drug, nutraceuticals in treatment for cognitive decline, nutraceutical remedies for common disorders like Arthritis, Bronchitis, circulatory problems, hypoglycaemia, Nephrological disorders, Liver disorders, Osteoporosis, Psoriasis and Ulcers etc	
CO4	Analyze chemical constituents, their characterization and significance- moisture, ash, minerals, lipids, fat, proteins, fibre, titratable acidity, starch, reducing sugars.	
CO5	Evaluate the data of the food analysis– 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	
CO6	Produce some Nutraceutical rich supplements using, Bee pollen, Caffeine, Green tea, Lecithin, Mushroom extract, Chlorophyll, Kelp and Spirulina etc	

Unit I	**FOOD PRODUCTS TECHNOLOGY** **1.** Principles of Food Analysis: Types of samples analysed, 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. **2.** 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)
Unit II	**NUTRACEUTICALS** **1.** Introduction to Nutraceuticals as Science Historical perspective, classification, scope &future prospects. Applied aspects of the Nutraceutical Science. Sources of Nutraceuticals. Relation of Nutraceutical Science with other Sciences: Medicine, Human physiology, genetics, food technology, chemistry and nutrition. **2.** Study of various Nutraceuticals Properties, structure and functions of Glucosamine, Octacosanol, Lycopene, Carnitine, Melatonin. Use of proanthocyanidins, flaxseed oil as Nutraceuticals. **3.** Microbial Nutraceuticals Concept of prebiotics and probiotics - principle, mechanism, production and technology involved, applications - examples of bacteria used as probiotics, use of prebiotics in maintaining the useful microflora - extraction from plant sources.
Unit III	Food as remedies Nutraceuticals bridging the gap between food and drug, Nutraceuticals in treatment for cognitive decline, Nutraceutical remedies for common disorders like Arthritis, Bronchitis, circulatory problems, hypoglycemia, Nephrological disorders, Liver disorders, Osteoporosis, Psoriasis and Ulcers etc. Brief idea about some Nutraceutical rich supplements e.g. Bee pollen, Caffeine, Green tea, Lecithin, Mushroom extract, Chlorophyll, Kelp and Spirulina etc.
Unit IV	Food standards and quality maintenance: FPO, PFA, Agmark, ISI, HACCP, food plant sanitation and cleaning in place (CIP), FAO in India, Technical Cooperation programmes, 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.

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.Fundamentals of Dairy Technology- Theory & Practices. Himanshu Publn.
9. Linden G. 1996. Analytical Techniques for Foods and Agricultural Products.

Title of the Course and Course Code	**Project work and Dissertation-1 (MIC5401) and Project work and Dissertation- 2 (MIC5402)**	**Number of Credits : 04**
Course Outcomes (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	Employ the finalised methodology to solve the problem which has been undertaken.	
CO4	Analyse the data which has been generated by carrying out several experiments.	
CO5	Evaluate the data – accuracy and precision, sources of errors, specificity, sensitivity and detection limits, regression analysis, reporting results.	
CO6	Organize the inferences to prove the hypothesis.	