M.Sc Academic year

2023-2025

Bharatiya Vidya Bhavan

BHAVAN'S VIVEKANANDA COLLEGE OF SCIENCE, HUMANITIES AND COMMERCE, SAINIKPURI, SECUNDERABAD.

Autonomous College

Affiliated to Osmania University, Hyderabad.

(Reaccredited with 'A' grade by NAAC)

Department of Microbiology

M.Sc. Microbiology CBCS Syllabus

Effective for 2023 -25

M.Sc. Microbiology Semester I

Syllabus Ref No	Subject	Credits	Teaching Hours	Marks		
				Internal Assessment	Semester Exam	Total
THEORY						
PMB 101	General Microbiology& Microbial Physiology **(Core)**	3	4	30	70	100
PMB 102	Virology **(Core)**	3	4	30	70	100
PMB 103	Research Methodology &Techniques **(Core)**	3	4	30	70	100
PMB 104	Microbial Biochemistry **(Core)**	3	4	30	70	100
PRACTICALS						
PMB 151	General Microbiology & Microbial Physiology	2	4	-	50	50
PMB 152	Virology	2	4	-	50	50
PMB 153	Research Methodology& Techniques	2	4	-	50	50
PMB 154	Microbial Biochemistry	2	4	-	50	50
	Total	**20**	32	**120**	**480**	**600**

Dr. SANDEEPTA BURGULA
Professor of Microbiology
Osmania University
Department of Microbiology
Hyderabad-500 007.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

Bharatiya Vidya Bhavan

BHAVAN'S VIVEKANANDA COLLEGE OF SCIENCE, HUMANITIES AND COMMERCE, SAINIKPURI, SECUNDERABAD.

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M.Sc. Microbiology Semester II

Syllabus Ref No	Subject	Credits	Teaching Hours	Marks		
				Internal Assessment	Semester Exam	Total
THEORY						
PMB 201	Molecular Biology and Microbial Genetics (Core)	3	4	30	70	100
PMB 202	Immunology (Core)	3	4	30	70	100
PMB 203	Industrial Microbiology (Core)	3	4	30	70	100
PMB 204	Pharmaceutical Microbiology (Core)	3	4	30	70	100
PMB 205	Seminar, Research paper presentation	-	2	-	-	-
PRACTICALS						
PMB 251	Molecular Biology and Microbial Genetics	2	4	--	50	50
PMB 252	Immunology	2	4	--	50	50
PMB 253	Industrial Microbiology	2	4	--	50	50
PMB 254	Pharmaceutical Microbiology	2	4	--	50	50
	Total	**20**	**34**	**120**	**480**	**600**

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

Bharatiya Vidya Bhavan

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M.Sc. Microbiology Semester III

Syllabus Ref No	Subject	Credits	Teaching Hours	Marks		
				Internal Assessment	Semester Exam	Total
THEORY						
PMB 301	Environmental and Agricultural Microbiology(Core)	3	4	30	70	100
PMB 302	Medical Bacteriology (Core)	3	4	30	70	100
PMB 303	Elective 1 A: Molecular Biotechnology & AI in Biology B: Microbial Proteomics	3	4	30	70	100
PMB 304	Elective II A: Entrepreneurship in Microbial sciences B: Applied Biotechnology	3	4	30	70	100
PMB 305	MOOCS	2	4	-	50	50
PRACTICALS						
PMB 351	Environmental and Agricultural Microbiology(Core)	2	4	-	50	50
PMB 352	Medical Bacteriology (Core)	2	4	-	50	50
PMB 353	Elective 1 A: Molecular Biotechnology & AI in Biology B: Microbial Proteomics	1	2	-	25	25
PMB 354	Elective II A: Entrepreneurship in Microbial sciences B: Applied Biotechnology	1	2	-	25	25
	Total	**20**	**32**	**120**	**480**	**600**

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

Bharatiya Vidya Bhavan

BHAVAN'S VIVEKANANDA COLLEGE OF SCIENCE, HUMANITIES AND COMMERCE, SAINIKPURI, SECUNDERABAD.

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Effective for 2023 -25

M.Sc. Microbiology Semester IV

SEMESTER – IV						
Syllabus Ref No	**Subject**	**Credits**	**Teaching Hours**	**Marks**		
				Internal Assessment	**Semester Exam**	**Total**
THEORY						
PMB 401	Food Microbial Technology (core)	3	4	30	70	100
PMB 402	Medical Virology & Parasitology(core)	3	4	30	70	100
PMB 403	Elective 1 A: Microbial Ecology: Host microbiome interactions(HMI), B: Nanobiotechnology and Bioinformatics	3	4	30	70	100
PMB 404	Project work	5	10	50	100	150
PRACTICALS						
PMB 451	Food Microbial Technology (core)	2	4	--	50	50
PMB 452	Medical Virology & Parasitology(core)	2	4	--	50	50
PMB 453	Elective 1 A: Microbial Ecology: Host microbiome interactions(HMI), B: Nanobiotechnology and Bioinformatics	2	4	--	50	50
	Total	**20**	**34**	**140**	**460**	**600**

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

Bharatiya Vidya Bhavan

BHAVAN'S VIVEKANANDA COLLEGE
OF SCIENCE, HUMANITIES & COMMERCE
Sainikpuri, Secunderabad – 500094
Autonomous College - Affiliated to Osmania University
(Reaccredited with 'A' grade by NAAC)

Department of Microbiology

PROGRAM NAME: M.Sc. MICROBIOLOGY (2023-25)

SEMESTER END EXAMINATION

M.Sc (Microbiology)

Choice Based Credit System (CBCS Syllabus)
2023-25

SEMESTER III & IV

Scheme of Examination

Semester End Examination- **Max. Marks: 70** **Time: 3 Hours**

Internal Examination- **Max. Marks: 30**

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

M.Sc. (Previous) I Semester (CBCS)
Paper I PMB 101 General Microbiology and Microbial physiology (Theory) (Core) (CBCS) (3 HPW-3 Credits)

Overall Course Objectives: This paper provides overview on history, taxonomy and fundamental concepts in microbial techniques.

Objectives:

Cob1. Describe the history of microbiology; learn principles of microscopy and microbial identification.
Cob2. Outlines of bacterial taxonomy& concept of microbial growth and factor effecting growth.
Cob3. Discuss microbiological culturing and preservation methods.

Unit I

15 Hrs

Pioneers of Microbiology. - Anton Van Leeuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Winogradsky, Biejerinck, Alexander Flemming, Selman Walkmann.	3 Hrs
Microscopy - Principles, working and applications of bright field microscope, fluorescent microscope, phase contrast microscope, electron microscope	3 Hrs
Microbial Cell Structure: Prokaryotic cell, Eukaryotic cell, Organization and function of cellular organelles.	2 Hrs
Bacterial endospore structure, biochemistry and genetics of sporulation.	1 Hrs
Microbial identification: Staining methods and microscopic; Molecular and genetic characteristics (16srRNA)	2 Hrs
General characters of actinomycetes, fungi, protozoa and algae	4 Hrs

Unit II

15 Hrs

Principles of bacterial taxonomy and classification: - Numerical taxonomy, Bergey's manual and its importance, general properties of bacterial groups.	2 Hrs
Microbial nutrition and metabolism: autotrophy – Photoautotroph and bacterial photosynthesis, Chemoautotrophy and heterotrophic metabolism.	2 Hrs
Microbial growth: The concept of growth and definition, formation of protoplasm, building of macromolecules from elemental nutrients, supramolecules, organelles of cell and cellular components.	3 Hrs
Cell cycle in microbes and generation time.	1 Hrs
Growth phases of bacteria and importance of each growth phase.	1 Hrs
Synchronous cultures – Methods of synchronous culturing, Continuous culturing methods.	2 Hrs
Factors effecting growth	2Hrs
Methods of growth measurement	2Hrs

Dr. Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

CHAIRPERSON
BOS In Microbiology
Bhavan's Vivekananda College
Sainikpuri

Unit III **15 Hrs**

Methods of sterilization and disinfection: Physical methods and chemical methods, Containment facility.	3 Hrs
Microbiological media - Autotrophic media, defined synthetic mineral media, heterotrophic media. The concept of prototrophs and auxotrophs, prototrophic (minimal media) complex media (undefined media).	3 Hrs
Cultivation of Bacteria, Fungi and Algae: Routine and special culture methods (agar slant, agar stab, agar plate, roll tube, shake flask, aerobic and anaerobic culturing).	4 Hrs
Isolation of pure cultures.	2Hrs
Preservation and Maintenance of Microbial Cultures: Routine methods and Liquid nitrogen preservation, freeze-drying (Lyophilization), etc.	3Hrs

Course Outcomes:

Students will be able to

PMB 101 CO1. Apply concepts of microscopy and identifying various microbes.
PMB 101 CO2. Distinguish bacteria based on taxonomy& summarize bacterial growth.
PMB 101 CO3. Adapt various microbiological techniques &microbial culturing techniques.

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

CHAIRPERSON
BOS In Microbiology
Bhavan's Vivekananda College
Sainikpuri

I Semester Practical Paper I(CBCS)
PMB 151 General Microbiology and Microbial Physiology (4 HPW-2 Credits)

1. General instructions, Microbiology laboratory and its discipline
2. Handling of microscopes, Calibration and measurement of microscopic objects
3. Staining techniques for bacteria – simple, differential and special staining
4. Sterilization procedures/methods
5. Preparation of microbiological media. Autotrophic media, minimal media, basic media, Enriched media, enrichment media, and differential media.
6. Isolation and cultivation of pure cultures
7. Identification methods of bacteria: Biochemical & Molecular (demonstration)
8. Isolation and culturing of fungi (yeasts and molds) and algae
9. Culturing methods of microbes – slant and stab cultures, tube culture, flask cultures, shake flask cultures
10. Anaerobic culturing methods – anaerobic jar and its use, pyrogallol method, thioglycolate media culturing, anaerobic glove box and its application
11. Microbial growth experiments – Viable count of growing cultures and generation time determination
12. Study of bacterial growth curve
13. Factors effecting the microbial growth (pH and temperature)

Recommended books

1. Microbiology by Pelczar M.J., Ried, RD and Chan, ECS.
2. Microbiology by Gerard J. Tortora, Berdell Ra. Funke and Christine L. Case. Publ: Pearson Education Inc.
3. Text book of Microbiology by M. Burrows
4. General Microbiology by Stainier, Deudroff and Adelberg Review of medical microbiology by Jawitz, Melnick and Adelberg
5. Bacterial and Mycotic infections of man. Ed. Dubos and Hirst Lipincott
6. Principles of Microbiology and Immunology by Davis, Dulbecco,Eison, Ginsberg and Wood.
7. Microbiology by Pelczar M.J., Ried, RD and Chan, ECS.
8. Microbial Physiology by Moat, Brock's Biology of Microorganisms by Madigan, MT et al
9. Biochemistry of bacterial growth by Mandelstum, Mc Quillon and Dawes;
10. Bacterial Metabolism by Dwellely
11. Photosynthesis by Dewlin and Barker;
12. Laboratory Experiments in Microbiology by Gopal Reddy et al.
13. Microbes in Action by Seoley HW and Van-Demark, PJ
14. Biology of microorganisms by Madigan, MT et al

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

Dr Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

M.Sc. (Previous) I Semester Microbiology (CBCS)
Paper II PMB 102Virology (Core) (CBCS)
(3 HPW-3 Credits)

Overall Course Objectives: This course provides knowledge on structure, replication, and recombination in viruses and summarizes the applications of viruses in various fields.

Objectives:

Cob1. Describe virus classification, structure, detection methods and replication

Cob2. Comparison of lytic and lysogenic viruses and various replication strategies of viruses

Cob3. Outline the concepts of recombination in phages and discuss applications of viruses in various areas.

Unit-1 **15 Hours**

History of virology (latest Scientific investigations), Viral classification: Baltimore. Recent changes to virus taxonomy, ICTV-Virosphere and Hierarchical ranks	3
Viral metadata resource, viral metagenomics -Virome	1
Virus structure and morphology	1
Detection of viruses: physical, biological, serological and molecular methods. Cultivation and quantification of bacteriophages, plant and animal viruses	2
Sub-viral particles: structure, replication and diseases caused by satellites virus, viroids and prions	2
Significance of emerging viruses: Ebola, Nipah, Hantavirus, Zika virus.	3
General idea about cyanophages, actinophages and mycophages	3

Unit-2 **15 Hours**

Viral replication Strategies: Cellular interactions---Clatherin coated pits, lipid rafts, endocytosis and virus uncoating mechanisms	3
Host response to viral infection-apoptosis, necrosis, stress response. Cellular basis of transformation, types of cytopathic effects.	2
Structure, characteristics and replication strategies of Bacteriophages: T2 and Lambda	2
Structure, characteristics and replication strategies of ds DNA viruses-Adenoviridae, Baculovirdae	2
SS DNA virus Geminiviridae, Nanoviridae-BBTV	2
SS DNA/dS DNA virus-Pleolipoviridae, Reverse transcribing DNA/RNA virus-Hepadnaviridae-HBV, Retroviridae-HIV	2
dS RNA viruses Reovirales; positive sense RNA virus-Virgaviridae-TMV, Coronaviridae- SARS-CoV-2; negative sense RNA virus-paramyxoviridae	2

Dr. Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

Unit-3 **15 Hours**

Recombination in phages, multiplicity reactivation and phenotypic mixing	3
General account of Tumor virus (RNA and DNA)	3
Viral Interference and Interferons. Classification of Interferons. Antiviral agents (chemical) and their mode of actions	3
Different types of viral vaccines	3
Viral vectors used for cloning and sequencing: Lambda phage, M 13, Retro viruses, CaMV 35S promoter and its application.	3

Course Outcomes:

Students will be able to

PMB 102 CO1. Classify the virus based on structure, and replication
PMB 102 CO2. Distinguish lytic and lysogenic viruses and interpret replication strategies.
PMB 102 CO3. Interpret concepts of recombination in phages and Summarize applications of viruses in various areas

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

I Semester Practical Paper II
(CBCS) PMB 152 Virology (4 HPW-2 Credits)

1. Isolation of E.coli phage from soil
2. Isolation of E.coli phage from sewage
3. Isolation of phages from contaminated food samples
4. Application of bacteriophages as food preservatives
5. Quantification of phages
6. Cultivation and preservation of phages
7. Growth phages of phage and burst size (Demonstration)
8. Phage induction demonstration
9. Cultivation of animal viruses in egg allantoic, amniotic and CAM
10. Symptomatic observations of plant viral infections
11. Demonstration of cytopathological changes of animal virus
12. Study of pathogenic lesions of animal virus diseases through slides.
13. Application of NPV and its role as biopesticide.
14. Visit to lab for NPV production
15. Awareness and participation in vaccination programs (extension activity).

Recommended Books

1. Recent publications: Research papers and review articles from Google search engine
2. General Virology by Luria and Damel .
3. Basic Virology. E.K. Wagner .
4. Virology and Immunology by Jokli .
5. Laboratory manual of Microbiology and Biotechnology by Aneja, I(R . Text book of Virology by Rhodes and Van Royen
6. Plant Virology by Smith
7. Genetics of bacteria and their viruses by W. Hayes
8. Molecular Biology of the gene by Watson, Roberts, Staitz and Weiner . A laboratory guide in virology by Chjarles H. Lunningham
9. Basic lab procedures in diagnostic virology by Marty Christensen
10. Review of medical microbiology by Jawitz et al
11. Medical laboratory manual for tropical countries Vol I & II by Monica Cheesbrough .
12. Text Book of Microbiology by Ananthanarayanan and Jayaram Paniker
13. Text book of Virology by Rhodes and Van Royan
14. Principles of Virology: Molecular Biology, pathogenesis and control of animal viruses

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

Dr. Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

M.Sc. (Previous) I Semester (CBCS)
Paper III PMB 103 Research Methodology and Techniques (Theory)
(Core) (CBCS) (3 HPW- 3 Credits)

Overall Course Objectives: This paper provides knowledge about some of the important bioanalytical techniques and their instruments, biostatistics, and computer-based tools that are required for the preparation of manuscripts.

Objectives:

Cob1. Present principles of various optical methods and separation techniques such as electrophoresis, centrifugation, and chromatography, and techniques that involve radioisotopes and stable isotopes.
Cob2. Teach descriptive as well as inferential statistics for biological data.
Cob3. Outline computer-based tools that are useful in writing scientific manuscripts.

Unit I	**15 Hrs**
Optical methods: colourimetry and spectrophotometry, fluorimetry, polarimetry (optical rotation), circular dichroism, NMR, ESR spectroscopy, X-ray diffraction, types of mass spectrometry.	5 Hrs
Electrophoretic techniques and application	2 Hrs
Chromatographic techniques: HPLC, FPLC, paper, thin layer, ion-exchange, gel-filtration and Affinity-chromatography. Counter current distribution.	2 Hrs
Diffusion, dialysis, cell disruption methods, cell-free protein synthesis, centrifugation techniques.	3 Hrs
Radio isotopes -Detection and Measurement of Radioactivity (Scintillation counter and Geiger-Mueller counter), autoradiography. Radiation safety. Stable isotopes and their use.	3Hrs

Unit II	**15 Hrs**
Population, sample and sampling procedures, types of variables, and frequency distributions.	3 Hrs
Descriptive statistics: Measures of Central Tendency and Dispersion.	3 Hrs
Elements of probability, Gaussian or Normal distribution, Binomial distribution, Poisson distribution, t-distribution, F-distribution and Chi-square distribution.	2 Hrs
Inferential statistics: Types of t-tests, ANOVA, and Chi-square tests. Post-hoc tests (e.g. DMRT). Correlation and linear regression.	5 Hrs
Design of Experiments (DoE) using statistical tools.	2Hrs

Dr. Hameeda Beevi
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

Unit III **15Hrs**

Introduction to Computers and Windows	2 Hrs
Introduction to disk operating systems (DOS); Sample commands, DIR-CD-RD-DEL-COPYMOVE-REN-TYPE-EDIT (Editor) CE-DATE and TIME.	3 Hrs
MS-Word and MS-Excel	3 Hrs
Data presentation, Manuscript preparation, and Plagiarism	2 Hrs
QA,QC, GLP, GMP, Research ethics, Patents & IPR.	3 Hrs
Introduction to Machine Leaning and Artificial Intelligence in Microbiology/Biological Sciences	2 Hrs

Course Outcomes:

Students will be able to…

CO1. Select the right bioanalytical technique for studying the biochemical sample and for separating the desired molecules from a mixture.
CO2. Describe and statistically analyze biological data.
CO3. Write organized scientific manuscripts including a master's thesis.

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BOS in Microbiology
Bhavan's Vivekananda Co
Sainikpuri

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

I Semester Practical Paper III (CBCS)
PMB 153 Research Methodology and Techniques (4 HPW- 2Credits)

1. Creating documents using MS-Word.
2. Usage of spreadsheet (MS-Excel) for biological applications.
3. Biostatistics (problems).
4. Absorption maxima of proteins, nucleic acids, tyrosine, and riboflavin (determination of molar extinction coefficient, calculations based on Beer Lambert's Law).
5. Estimation of DNA and protein concentration by UV-Vis spectrophotometry.
6. Estimation of protein concentration by Folin's-Lowry method.
7. Demonstration of differential centrifugation.
8. Paper chromatography of amino acids.
9. Dialysis for desalting of proteins.
10. Demonstration of Gel-filtration technique.
11. Demonstration of electrophoresis of DNA and proteins.
12. Estimation of phosphorous by Fiske-Subba Rao method

Recommended Books

1. Biochemistry by Lehninger.
2. Outlines of Biochemistry by Cohn and Stumph.
3. Biological Chemistry by Mullar and Cards.
4. Biochemistry by White, Handler and Smith.
5. Methods in Enzymology series.
6. The Cell - BratchamdMirsky series.
7. Laboratory experiments in Microbiology by Gopal Reddy et al.
8. Biochemistry lab manual by Jayararnan.
9. Introduction to the theory of statistics by Alexander, M Mood and Franklin.
10. Fundamentals of Biometry by L.N.Balam.
11. Statistical methods by Snedecor and Cochran.
12. Introduction to computer and its application by ChaeC.Chien.
13. Basic Programming language by Bajaraman.
14. Biostatistics - A manual of statistical methods for use in Health, Nutrition and Anthropology by K. Vishveshwar Rao.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

Dr. Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

Unit III **15 Hrs**

Mechanism of enzyme action – Action of Hydrolases (RNase), Oxidases (Cytochrome Oxidase) and reductases (Ribonucleotide reductase).	3
Coenzyme catalysis (Pyridoxal phosphate and TPP).	2
Isoenzymes.	2
Competitive and non-competitive inhibition.	3
Methods for increased microbial enzymes production and activity. Enzyme engineering.	3
Control and Regulation of enzyme activity: Allosteric enzymes and feedback mechanisms	1
Metabolic compartmentalization in relation to enzyme,	1
Enzymes and secondary metabolites	

Course Outcomes:

Students will be able to

PMB 104 CO1. Determine pH of solutions and prepare Buffers for laboratory work
PMB 104 CO2. Analyze the biomolecules by carrying out qualitative analysis.
PMB 104 CO3. Perform enzyme assay and calculate enzyme activity and Identify enzymes from various sources and purify them.

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

I Semester Practical Paper III
(CBCS) PMB 154 Microbial Biochemistry
(4 HPW- 2Credits)

1. Safety and good lab practices, Biochemical calculations
2. Preparation of buffers and adjustment of pH
3. Qualitative tests for carbohydrates and analysis of unknowns
4. Qualitative tests for amino acids and analysis of unknowns
5. Tests for lipids (qualitative)
6. Quantitative estimation of glucose and fructose
7. Determination of Saponification value of fats
8. Partial purification of enzymes (β-amylase, urease and Catalase)
9. Effect of substrate concentration, pH, time and temperature on enzyme activity
10. Calculation of Km for partially purified enzyme
11. Study for inhibition of enzyme activity

Recommended Books

1. Biochemistry by Lehninger
2. Outlines of Biochemistry by Cohn and Stumph
3. Biochemistry of Nucleic acids by Davidson
4. Biological Chemistry by Mullar and Cards
5. Biochemistry by White, Handler and Smith
6. Methods in Enzymology series
7. The Cell – Bratch and Mirsky series
8. Biochemistry lab manual by Jayaraman

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

Dr Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

M.Sc. Microbiology (CBCS)
Value added course
Proteomics

Course Objective:

The student will be able to

Cob1. Acquaint with basic knowledge on Proteomics and Update with current separation techniques practiced by the industry.
Cob2. Understand the clinical importance of proteins in drug designing and Correlate the importance of protein sequence in bioinformatics.

Unit I	**15 hrs**
Protein structure and conformations	1
Protein Folding and unfolding	1
Protein functions: structural, storage, transport, hormonal, receptor, contractile, defensive, Catalytic functions	2
Separation techniques – 2-D gel and Polyacrylamide gel electrophoresis (PAGE)	2
Biological mass spectrometry -MALDI-MS, ESI-MS, LC-MS	3
Protein identification – Peptide mass fingerprinting (PMF),	3
Electro blotting and sequencing	3

Unit II	**15 hrs**
Determination of 3-D structures by X-ray crystallography	2
NMR and Homology modeling	2
Methods of to study Protein-Protein interaction, Protein-DNA interactions	3
Protein microarrays- Protein Markers, Clinical Proteomics, Small peptides	3
Personalized medicine	2
Protein engineering	2
Drug design.	1

Course Outcomes:

The student will be able to

1. Explain the fundamentals of Protein structure and Function and Describe the protein separation techniques and identification methods
2. Understand significance of Protein-Protein, Protein-DNA interactions and Understand significance of Clinical Proteomics, Protein engineering, Drug design

Dr. Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

M.Sc. Microbiology (CBCS)
Value added course
Artificial Intelligence in Biology

Course Objectives:

The student will be able to

Cob1: Understand the overview on basics in AI, ML, DL and Applications of AI in Medicine.
Cob 2: Understand the role of AI in Pharmaceutical Industry, Agriculture and Bioinformatics.

Unit 1	**15 Hours**
Introduction to AI in Biology	2
Biological Intelligence vs Artificial Intelligence	2
AI Basics: Concepts, terminologies and Work flow	2
Basics of Machine Learning (ML) and Deep Learning (DL)	3
AI in Medicine	2
Recent advancements in Health care through AI	2
AI and medical Imaging	2

Unit 2	**15 Hours**
Applications of AI in Pharmaceutical Industry	2
AI in drug design and Clinical trials	3
AI for Biomarker discovery	2
AI in Future of Bioinformatics	3
AI and Synthetic Biology	2
Applications of AI in Agriculture	2
Risks and Ethical Concerns involved	1

Course Outcomes:

The student will be able to

CO1: Apply the knowledge of AI, ML, DL in analyzing the data in Medicine and Health care.
CO2: Analyze and visualize the data in Bioinformatics, Agriculture and Pharmaceutical Industry.

HEAD
Department of Microbiology
Osmania University
Hyderabad-500007

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

SN Hameeda Bee,
Associate Professor

M.Sc. (Previous) Microbiology II Semester (CBCS)
Paper I MB 201 Molecular Biology & Microbial Genetics (core)
(3 Hrs per week = 3 credits)

Overall Course Objectives: This paper provides knowledge in Structure of Nucleic Acids, Gene expression and regulation, Mutational biology and Bacterial genetic recombination.

Objectives:

Cob1. Describe DNA structure and genome organization and Illustrate DNA replication, transcription, translation and gene regulation
Cob2. Outline mutations types, DNA damage and repair mechanisms.
Cob3. Present Bacterial Recombination and Genetic mapping and Gene cloning in *E.coli* and Yeast

Unit I **15Hrs**

Detailed structure of DNA, Z-DNA, A & B DNA, Denaturation and melting curves.	2
Genome organization in prokaryotes and eukaryotes	3
DNA replication- Meselson and Stahl Experiment. Mechanism of Semi conservative replication. Rolling circle model, theta model. Etc. Enzymology of DNA replication	3
Eukaryotic telomere and its replication	
Prokaryotic and eukaryotic transcription	2
Structure and processing of m-RNA, r-RNA t-RNA	2
Ribozyme, Genetic code and Wobble hypothesis	1
Translation in Prokaryotes and eukaryotes, Post translational modifications.	2

Unit II **15Hrs**

Concept of gene, Benzer's fine structure of gene – muton, cistron, recon. Types of genes – structural, constitutive, regulatory	2
Gene regulation and expression – Lac operon, arabinose and tryptophan operons, Gene regulation in eukaryotic systems, repetitive DNA, gene rearrangement, promoters, enhancer elements	3
Mutation: Molecular basis of mutations, Physical, chemical and biological mutagens.	2
Detection and analysis of mutations (Replica plating, Antibiotic enrichment, Ames test, etc).	2
DNA damage and repair mechanisms	1
Bacterial Recombination -Discovery, gene transfer, molecular mechanism, detection, efficiency calculation and applications.	1
Bacterial transformation- Competency and resistance.	1
Bacterial conjugation – Sex factor in bacteria, F and HFR transfer, linkage mapping	1
Bacterial transduction – transduction phenomenon, methods of transduction.	2
Transposable elements – Definition, detection of transposition in bacteria, types of bacterial transposons and applications of transposons.	

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

Dr. Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

Unit III

	15Hrs
Principles of genetic engineering: Vectors: Plasmids, phagemids / viral vectors, cosmids, Artificial chromosomes.	4
Restriction Enzymes, Polymerases, ligases, etc	1
General methods of gene cloning: Cloning Techniques: cloning in *E-coli*, Cloning in *Bacillus subtilis*, Cloning in Yeast,	3
Selection of recombinants, blue white selection, Expression and detection of cloned genes.	2
Polymerase chain reaction and Quantitative real time PCR.	2
rRNA/ Genomic/ c DNA Library construction and screening.	3

Course Outcomes:

Students will be able to

PMB 201 CO1. Compare the structural variations of DNA and genome organization and Illustrate Replication, Transcription, translation and gene regulation

PMB 201CO 2. Differentiate the types of mutations, DNA damage and repair mechanisms.

PMB 201 CO3. Solve problems in genetic mapping, apply the methods of gene cloning, PCR and molecular library constructions .

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BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

II Semester Practical Paper I (CBCS)

II Semester Practical Paper I (CBCS)

PMB 251 Molecular Biology and Microbial Genetics (CBCS) - Paper I (4HPW-2Credits)

1. Isolation of genomic DNA from E.coli
2. Isolation of genomic DNA from Yeast.
3. Estimation of DNA (Colorimetry)
4. Estimation of RNA
5. Estimation of protein by Folin's method
6. Induction of mutations by physical mutagens (UV) and chemical mutagens (EMS, etc.)
7. Screening and isolation of mutants by Replica plating technique
8. Digestion of DNA by restriction endonucleases
9. Determination of molecular weight of DNA resolved on Agarose gel electrophoresis
10. Induction of Lac operon (Demonstration by kit or tutorial mode)
11. Demonstration of Transformation in bacteria using $CaCl_2$ heat shock method

Recommended books

1. Molecular Biology by Upadhyay and Upadhyay
2. Molecular biology by David Freifelder
3. Microbial genetics by David Freifelder
4. Cell and Molecular Biotechnology by Darnell, Lodish and Baltimore
5. Molecular biology of the gene by Watson et al
6. Principles of Biochemistry by Lehninger
7. Molecular biotechnology by Primrose
8. Genes IX by Benjamin Lewin
9. Molecular Biotechnology by Bernard R. Glick and Jack J Pasternak
10. Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness
11. Cell Biology by Geoffrey Cooper and Robert Hausman

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

Dr. Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

M.Sc. (Previous) Microbiology II Semester (CBCS)
Paper II PMB 202 Immunology (Core) (CBCS)
(3 HPW-3Credits)

Overall Course Objectives:

This paper provides knowledge on components of immune system, mechanisms involved in inducing immune response, immunological techniques, concept of vaccines and immune diagnosis and therapy of Cancer.

Objectives:

Cob1. Describe the Antibody structure and diversity and types of immunity
Cob2. Outline immunological techniques, Hypersensitivity and autoimmunity
Cob3. Review on relationship between Hypersensitivity, Autoimmunity, Cancer and immunology

Unit 1 — **15 Hrs**

History of immunology. Haematopoeisis, Cell lineage, components of immune system, cells and organs of immune system	2
Antigens –Nature, properties and types. Haptens	2
Antibody - Structure, functions and classification. Isotypes, allotypes and idiotypes	2
Immunoglobulin genes. Generation of antibody diversity. Clonal nature of the immune response - Clonal selection theory.	2
Generation of T cell receptor diversity by genomic rearrangement	3
Structure of B and T cell receptors	1
Overview of Innate and adaptive immunity	1
Toll-like receptors, cell-mediated and humoral immune responses, inflammation	1
Role of inflammasome in innate immune response	1

Unit 2 — **15 Hrs**

Major Histocompatability Complex (MHC)- MHC restriction and processing and presentation of antigen by MHC	2
Transplantation immunology: MHC, types of grafts, grafts rejection, GVH reactions, mechanism of graft rejection, and prevention of graft rejection	2
Immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, Congenital and acquired immunodeficiencies	2
Immunological tolerance-central and peripheral	2
Antigen and antibody reactions–Agglutination, Precipitation, neutralization, and function. Labeled antigen-antibody reactions- ELISA, RIA, immune blotting, CFT, immunofluorescence. Flow cytometry (Fluorescence activated cell sorter) and its applications in Immunology. Development Of immuno diagnostic kits	4
Classical, Alternate and Lectin mediated Complement pathways	3

Dr. Nameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

Unit 3

	15 Hrs
Hypersensitivity - immediate and delayed type hypersensitivity reactions	2
Autoimmunity – systemic and localized autoimmune disorders	2
Types of conventional vaccines and principles of Immunization	2
Modern vaccines; peptide, DNA, recombinant / vector, and anti-idiotypic vaccines	1
Schedules of common vaccination, Benefits and adverse consequences of vaccination	1
Production of polyclonal antibodies; Animals models for production of antibodies	1
Hybridoma techniques and monoclonal antibody production. Applications of monoclonal antibodies in biomedical research, clinical diagnosis and treatment. Chimeric Antibodies	2
Immuno suppression and its mechanism of action	1
Immune evasion by bacteria and viruses	1
Tumor immunology. Immuno diagnosis and immune therapy of cancer	2

Outcomes:

Students will be able to

PMB 202 CO1. Illustrate the Antibody structure and diversity and Summarize the types of immunity
PMB 202 CO2. Apply immunological techniques practically and complement pathways
PMB 202 CO3. Apply the concepts of Autoimmunity, Hypersensitivity and Relate between cancer and immunology,

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

II Semester MB 252 Immunology Practicals (CBCS) - Paper II

1. Demonstrating identification of Blood groups
2. Agglutination reactions – WIDAL test- slide and tube agglutination method
3. Diagnosis of syphilis by VDRL (Flocculation test)
4. Single Radial Immunodiffusion and Ouchterlony double diffusion test
5. Rocket Immunoelectrophoresis
6. WBC count and RBC count
7. Differential Leukocyte Count
8. Separation of serum and plasma proteins
9. Blot transfer and detection of protein on blot by staining (Demonstration by kit or tutorial mode)
10. Demonstration of ELISA technique
11. Lymphocyte culture, staining and Heamocytometer count.
12. Indirect agglutination (Pregnancy hCG Ag)

Recommended Books

1. Immunology by Janice Kuby
2. Cellular and molecular immunology by Abul K. Abbas et al
3. Test book of Immunology by Barrett
4. Immunology – The science of self-non self-discrimination by Jan Klein
5. Essential Immunology by Roitt, IM
6. Immunology by Tizard
7. Medical Microbiology by Ananthanarayan and Jayaram Panicker
8. The elements of Immunology by Fahim Halim Khan

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

Dr. Hameeda Bee
Associate Professor
Department of Microbiology

M.Sc. (Previous) Microbiology II Semester (CBCS)
Paper III PMB 203 Industrial Microbiology (Core) (CBCS)
(3 HPW-3Credits)

Objectives:

Cob1: Learn Strain improvement strategies and types of fermentation
Cob2: Understand fermentative production of alcohol, beer and wine making
Cob3: Gain knowledge on large scale production and applications of penicillin, tetracycline and Immobilization methods

Unit 1 **15 Hrs**

Introduction to industrial microbiology. Screening and selection of microorganisms for industrially important products like amylase, organic acid, antibiotic, amino acid and vitamins. 4

Strain improvement strategies. Environmental and genetic factors for strain improvement. Inoculum media, inoculum preparation 3

Upstream strategies and raw materials for fermentation process. Cost economics and use of low-cost agro-industrial wastes 3

Fermentation media and sterilization 2

Types of fermentations processes – Solid state, surface and submerged fermentations 3

Unit 2 **15 Hrs**

Design of fermentor, types of fermentor, agitation, aeration, antifoam, pH and temperature control. Inoculum media and seed culture preparation and frozen stocks. Batch, fed batch and continuous fermentations. Direct, dual or multiple fermentations. 4

Fermentative production of industrial alcohol, uses, raw materials, microorganisms, inoculum preparation, preparation of wort, fermentation and recovery 3

Fermentative production of beer – Medium components, malt, malt adjuncts, hops, water. Preparation of wort, mashing, wort boiling, microorganism, inoculum preparation, fermentation, cold storage maturation, carbonation, packing and preservation. 4

Principles of wine making – Fruit selection, picking, crushing, sulphite addition, processing, fermentation, aging and bottling 4

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

Dr. Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

Unit 3

15 Hrs

Microorganisms involved, Media preparation, Fermentation and recovery process of Antibiotics – Commercial production of benzyl penicillin, and semi-synthetic penicillins.	4
Fermentative production of tetracyclines – uses, chlortetracycline, oxy-tetracycline, tetracycline and semi-synthetic tetracyclines	3
Downstream strategies for product recovery. Detection and assay of fermentation products. Physico-chemical methods and biological assays	4
Immobilization methods used in industries – Absorption, covalent linkage, entrapment and cross linkage, types of carriers, advantage and disadvantages	4

Course Outcomes:

The student will be able to

PMB 203 CO1. Explain different types of fermentation and strain improvement strategies

PMB 203 CO2. Describe the fermentative production of fermentative production of alcohol, beer and wine making

PMB 203 CO3. Discuss large scale production and applications of penicillin, tetracycline and Immobilization methods

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Department of Microbiology
Osmania University
Hyderabad-500 007.

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BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

II Semester MB 253 Industrial Microbiology Practicals (CBCS) - Paper II

1. Isolation and screening for amylase producing microorganisms
2. Isolation and screening for lipolytic microorganisms
3. Isolation of antibiotic producing microorganisms by crowded plate technique
4. Estimation of glucose
5. Estimation of maltose
6. Estimation of ethanol by dichromate method
7. Production of ethanol by flask fermentation, recovery of ethanol by distillation and calculation of fermentation efficiency.
8. Preparation of wine from grapes/fruits by fermentation
9. Isolation of *Penicillium* spp. from different source samples
10. Production of Penicillin by fermentation process
11. Characterization of antibiotic produced by *Penicillium* spp.
12. Immobilization of microbial cells by entrapment method

Recommended Books

1. Industrial Microbiology by Casida, LE
2. Industrial Microbiology by Prescot and Dunn
3. Microbial Technology by Peppler, JH and Perlman, D.
4. Biochemistry of Industrial Microorganisms, by Rainbow and Rose
5. Economic Microbiology by Rose Vol I – V
6. Microbial Enzymes and Biotechnology by Fogarty WM and Kelly, CT
7. Comprehensive Biotechnology, All volumes Ed. Murray Moo-Yong
8. Biotechnology (A text book of industrial Microbiology) Ed. Cruger & Cruger
9. Advances in Applied Microbiology Ed. Perlman Series of volumes
10. Recent Published papers on advances in relevant area to be referred

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

Dr. Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07

M.Sc. Microbiology II Semester (CBCS)
Paper IV 204 Pharmaceutical Microbiology (Core)
(3 HPW-3 credits)

Overall Course Objectives: This paper provides knowledge on microbial spoilage, preservation, GMP, principles of chemotherapy, drug resistance and cosmetic microbiology.

Objectives:

Cob1. Present concepts in microbial spoilage, prevention and preservation of pharmaceutical products, GMP and Discuss concepts of chemotherapy and anti-microbial agents.

Cob2. Relate the principles of Chemotherapy and important antibiotic drugs in therapy.

Cob3. Review the methods of microbiological assays in Cosmetic microbiology and pharmaceutical industry.

Unit I **15 Hrs**

Pharmaceutical industry. Importance of various pharmacopeias with special reference to Indian pharmacopeia, British pharmacopeia, United States pharmacopeia and international pharmacopeia	2
Design and layout of sterile product manufacturing unit	1
Microbiological issues for inspection of pharmaceutical facilities: Sterilization (D value, z value, F value, F_0 value, survival curve), Depyrogenation, Environmental monitoring, Room design and Equipment,	4
Water purification and Delivery system, Personnel, Product sampling, Method suitability test, Sample analysis (Bioburden, Sterility test. Concept of GxP and Quality Assurance in pharmaceuticals.	2
Introduction to FDA's CAPA (Corrective and Preventive action) steps requirements and regulations, OOPs, SOPs. ISO, WHO and US certification	2
Understanding the changing dynamics of pharma ecosystem.	1
Digitization of equipment, instrument, air and water systems.	1
Adherence to guidelines like GAMP (Good automated manufacturing practice and 21 CFR (Code of federal regulations).	2

Unit II **15 Hrs**

History of chemotherapy –Paul Ehrlich and his contributions. Arsenicals as therapeutics.	2
Medicinal plants derived natural products Classification of antimicrobial agents. Drugs, Semi-synthetic drugs and Antibiotics,	2
Topical agents. Choice of drug, dosage, route of administration, combined/mixed multi drug therapy.	1
Selective toxicity, molecular principles of drug targeting	3
Development of synthetic drugs: Sulphanamides, Chloramphenicol, Antitubercular compounds, Quinolinones, Metronidazole, Anti-tumor drugs.	3
Mode of action of important drugs – Cell wall inhibitors (Betalactam – eg. Penicillin), membrane inhibitors (Polymyxins), macromolecular synthesis inhibitors (streptomycin).	

Dr. Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

CHAIRPERSON
BOS in Microbiology
Phavan's Vivekananda College
Sainikpuri

Macrolides and antifungal antibiotics (Nystatin).
Drug metabolism and Response; Pharmacokinetics (ADME), Pharmacodynamics, Pharmacogenomics 2
Emerging antimicrobial resistance (AMR) and antimicrobial resistance genes (ARG) in different environments 2

Unit III

15Hrs

Antimicrobial Effectiveness Testing (AET): Microbial contamination and spoilage of certain pharmaceutical products sterile injectable, non-injectable, ophthalmic preparations, implants 5
Cosmetic products and preservatives (PET), Bacterial endotoxin testing 2
Non antibiotic antimicrobial compounds: Metals and Biocides (Phenol coefficient/RWC). 3
Drug sensitivity testing methods and their importance. 2
Antibiotic potency tests / Microbial assays for antibiotics – Determination of MIC, the liquid tube assay, solid agar tube assay, agar plate assay (disc diffusion, agar well and cylinders cup method). 3

Course Outcomes:

Students will be able to

PMB 204 CO1. Analyze microbial spoilage, prevention and preservation of pharmaceutical products, GMP and Discriminate the mode of actions of various anti-microbial agents.
PMB 204 CO2. Use Practical skills in preservation and testing of various industrial products.
PMB 204 CO3. Perform microbiological assays in pharmaceutical industry.

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Department of Microbiology
Osmania University
Hyderabad-500 007.

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BOS in Microbiology
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II Semester MB 254 Pharmaceutical Microbiology Practicals (CBCS) - Paper II

1. Bioburden testing methods for pharmaceutical and cosmetic products
2. Sterility testing by *Bacillus stearothermophilus* or any other method
3. Sampling of pharmaceuticals for microbial contamination and load (syrups, suspensions, creams and ointments, ophthalmic preparations).
4. Determination of D value, Z value for heat sterilization in pharmaceuticals.
5. Determination of antibacterial spectrum of drugs/antibiotics
6. Testing for antibiotic/drug sensitivity/resistance
7. Determination of MIC, LD 50 of antimicrobial chemicals
8. Microbiological assays for antibiotics (Liquid tube, agar tube, agar plate assays)
9. Antimicrobial effectiveness testing
10. Bioassay with Chloramphenicol
11. Bacterial endotoxin test (Demonstration through kit or tutorial mode)
12. Bioassays with any plant / microbial secondary metabolites against Gram positive and Gram negative bacteria
13. Tests for disinfectants : Phenol coefficient/RWC
14. Treatment of bacterial cells with Cetrimide, phenol and detection of Leaky substances.
    (Demonstration or tutorial mode)

Recommended Books

1. Disinfection, sterilization and preservation. Block, S.S. (ed). Lea and Febigor, Baltimore
2. Pharmaceutical Microbiology. Huge, W.B. and Russel, AD.Blackwell Scientific, Oxford
3. Principles and methods of sterilization in health sciences. Perkins, JK. Pub: Charles C. Thomos, Springfield.
4. Compendium of methods for the microbiological examination of foods. Vanderzant, C. and Splittstoesser, D. Pub: American Public Health Association, Washington, D.C.
5. Disinfectants: Their use and evaluation of effectiveness. Collins, CH., Allwood, MC., Bloomfield, SF. And Fox, A. (eds). Pub: Academic Press, New York
6. Inhibition and destruction of microbial cell by Hugo, WB. (ed). Pub: Academic Press,NY
7. Manual of Clinical Microbiology. Lennette, EH. (ed).Pub: American Society for Microbiology, Washington.
8. Principles and Practices of disinfection. Russell, AP.,Hugo,WB., and Ayliffe, GAJ.(eds). Publ. Blackwell Sci.
9. Biochemistry of antimicrobial action. Franklin, DJ and Snow, GA.Pub:Chapman & Hall.
10. Antibiotics and Chemotherapy. Garrod, L.P., Lambert, HP. And C'Grady, F. (eds). Publ: Churchill Livingstone.
11. Antibiotics. Lancini, G. and Parenti, F. publ: Springer-Verlag.
12. The Molecular Basis of antibiotic action. Gae, EF. Et al. Publ: Wiley, New York.
13. Antimicrobial Drug action. Williams, RAD., Lambart, PA. & Singleton, P. Pub:Bios Sci.
14. Microbiological Assays. Hewitt.
15. Indian Pharmacopea; United States Pharmacopea; British Pharmacopea

Dr. Hameeda Bee
Associate Professor
Department of Microbiology
Osmania University, Hyd-07.

HEAD
Department of Microbiology
Osmania University
Hyderabad-500 007.

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BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

M.Sc. Microbiology II Semester (CBCS)
MB 205: Seminar: Review Paper Presentation

All the students have to make power point presentation of the Review or Research article of area of their interest in Microbial Sciences. The focus of presentation can be towards the Project work that would be taken up during IV semester.

Note:

However, there are no credits and internal assessment can be done by the faculty members.

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Bhavan's Vivekananda College of Science, Humanities and Commerce

DEPARTMENT OF MICROBIOLOGY
M.Sc MICROBIOLOGY (2023-25)

M.Sc. (Final) Microbiology III Semester (CBCS)
Paper I PMB 301 Environmental and Agricultural Microbiology (Core: 3 credits)

Overall Course Objective: To discuss concepts of environmental microbiology (such as the role of microbes in air, water, and soil, water quality, wastewater treatment, microbial decomposition, nutrient cycling, bioremediation, and waste management), and agricultural microbiology (such as production and significance of biopesticides and biofertilizers).

Objectives:

Cob 1. Describe the importance of microbes in air, and water.
Cob 2. Discuss the concepts of nutrient cycling, decomposition and bioremediation.
Cob 3. Determine the role of biofertilizers and biopesticides.

Unit I (Environmental Microbiology)	**15 Hrs**
Microbes in air and their significance: active and passive methods for microbiological quality of air.	**2 Hrs**
Role of microbes in climate change. IPCC. Mitigation of green house gases and carbon sequestration.	**1 Hrs**
Distribution of microbes in fresh and marine water ecosystems. Water-borne pathogenic microbes and their transmission.	**2 Hrs**
Microbiological analysis of drinking water (MPN, membrane filtration, and P-A test).	**2 Hrs**
Wastewater treatment (primary treatment: screening and sedimentation; secondary oxic treatment: oxidation tank and activated sludge tank, trickling filter; facultative aerobic lagoon; secondary anoxic treatment: anaerobic sludge digester; tertiary treatment: disinfection). Septic tank. Purification of drinking water (sedimentation, coagulation, filtration, chlorination, reverse osmosis)	**3 Hrs**
Introduction to Microbial Ecology and Microbial Diversity. Methods to analyze microbial community diversity (DGGE, T-RFLP, ARISA, NGS). Diversity indices (Shannon and Simpson)	**3 Hrs**
Types of microbial interactions: Positive interactions (Mutualism, Synergism, Commensalism); Negative interactions (Competition, Amensalism, Parasitism, and Predation).	**2 Hrs**

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

Unit II (Environmental Microbiology)

Physical, chemical and biological properties of soil. Role of soil microbes. Methods for measuring activity of microbes in soil. Methods for enumeration of microbes in soil.	**15 Hrs** **3 Hrs**
Biochemistry of decomposition of carbonaceous materials (cellulose, hemicelluloses and lignin) in soil. Factors governing the decomposition. Soil humus formation. Composting. Biogas production.	**3 Hrs**
Microbiology and Biochemistry of Ammonification, Nitrification, and Denitrification. Factors affecting nitrification and denitrification. Nitrate pollution.	**2 Hrs**
Bioremediation, Biostimulation, and Bioaugumentation.	**1 Hr**
Plastic degrading microbes.	**1 Hr**
Microbial remediation of environmental pollutants - Xenobiotics.	**1 Hr**
Microbial degradation of organic pollutants (focus on pesticides like DDT and 2,4-D).	**1 Hr**
Microbial enhanced oil recovery, bioleaching of copper, gold and uranium.	**2 Hrs**
Management of biohazardous waste.	**1 Hr**

Unit III (Agricultural Microbiology)

15 Hrs

Agronomy and production of important crop plants, Green revolution.	**1 Hr**
Nitrogen fixation: Asymbiotic and symbiotic nitrogen fixation; microbes capable of nitrogen fixation; Biochemistry, Genetics, and Regulation of nitrogen fixation; measurement of nitrogen fixation; Ecological and economic importance of nitrogen fixation.	**4 Hrs**
Biofertilizers: Types of bio-fertilizers, Screening, selection, and establishment.	**2 Hrs**
Mass-production and quality control of rhizobial and cyanobacterial inoculants, BIS standards. Methods of bio-fertilizer application (or inoculation).	**2 Hrs**
Biocontrol Agents and their scope in the control of plant diseases.	**2 Hrs**
Integrated plant pest management (IPPM), concept and components of IPPM.	**2 Hrs**
Microbial pesticides – *Bacillus thuringiensis,* structure of BT toxin and their mode of action. Production technology for BT and Baculovirus based pesticide.	**2 Hrs**

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

III Semester - Paper I Practicals (CBCS)
PMB 351 Environmental and Agricultural Microbiology (Core: 2 credits)

1. Isolation and observation of air, water and soil microbes.
2. Enumeration of soil microorganisms (bacteria, actinomycetes, fungi) by standard plate count.
3. Estimation of soil microbial activity by CO_2 evolution.
4. Estimation of COD and BOD.
5. Testing for microbial sanitary quality of water (MPN of coliforms).
6. Measurement of Total solids (TS), Mixed Liquor Suspended Solids (MLSS), Mixed Liquor Volatile Suspended Solids (MLVSS) of waste water.
7. Isolation of cellulose decomposing microbes and estimation of cellulase activity.
8. Isolation and culturing of *Rhizobium* sp. from root nodules and *Azospirillum* from grasses (Cyanodon).
9. Isolation and observation of phyllosphere and rhizosphere microflora.
10. Observation of beneficial fungi/algae for biofertilizer application: *Trichoderma.*
11. Observation of cyanobacteria (blue green algae).
12. Observation of VAM.

Reference Books

1. Soil Microbiology by Alexander Martin
2. Microbial ecology, Fundamentals and Applications Ed. Benjamin-Cummings
3. Environmental Biotechnology-Fundamentals and applications. By Parihar (Agrobiosindia – publishers)
4. Soil Microbiology by Singh, Purohit, Parihar published by student edition.
5. Soil Microbiology and Biochemistry by Paul E. and PE Clank
6. Soil Microorganisms and Plant Growth by N.S. Subba Rao.
7. Laboratory experiments in microbiology by Gopal Reddy et al
8. Experiments in Microbiology, Plant pathology, Tissue culture and Mushroom production technology by K R Aneja
9. Biofertilizers for sustainable Agriculture by Arun K. Sharma
10. Brock Biology of Micro organisms by Madigan et al
11. Biodegradation and Bioremediation second edition by Martin Alexander (Academic Press 2001)
12. Bioremediation - Principles and Applications by Ronald L Crawford and Don L Crawford ,Cambridge University Press
13. Kannaiyan. S. (2002), Biotechnology of Biofertilizers, Alpha science international, 1stedition.
14. Bagyaraj D.G. and Rangaswami. G. (2005). Agricultural Microbiology, Prentice- Hall of India, 2nd edition, New Delhi.
15. Neelima Rajvaidya and Dilip Kumar Markandey. (2006). Agricultural Applications of Microbiology, Nangia S.B. and A.P.H. publishing corporation, New Delhi.
16. Soil Fertility and Fertilizers by Tisdale et.al. (2003)Prentice Hall of India Pvt. Ltd.
17. Recent Published papers on advances in relevant area to be referred

Dr. SANDEEPTA BURGULA
Professor
Microbiology
Hyd-07.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

Course Outcomes:
Students will be able to
PMB 301 CO1. Construct a mind map on the role of microbes in air and water pollution.
PMB 301 CO2. Summarize the role of microbes in bioremediation technologies.
PMB 301 CO3. Interpret the role of microbes in decomposition.
PMB 301 CO4. Apply the concepts of biopesticides and biofertilizers for sustainable agriculture.

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

M.Sc. (Final) Microbiology III Semester (CBCS)
Paper II PMB 302
Medical Bacteriology (Core: 3 credits)

Overall Course Objective: To summarize on clinical significance of pathogenic bacteria

Course Objectives:

The student will be able to

Cob 1 Understand medical importance and Classification of microorganisms, Normal flora of human body: Discuss basic concept on Properties of pathogenic microorganisms and infections. Introduction to Diagnostic microbiology

Cob 2 Describe Bacterial air borne infections and sexually transmitted diseases caused by bacteria

Cob 3 Understand Systematic bacteriological study on Water borne infections and Wound infections

Unit I **15Hrs**

Principles of Medical Microbiology: Classification of medically important microorganisms	**3 Hrs**
Normal flora of human body – Origin of normal flora, factors that influences normal flora, role of the resident flora, effect of antimicrobial agents on normal flora, characteristics of normal flora	**2 Hrs**
Distribution and occurrence of normal flora (Skin, conjunctiva, nose, nasopharynx, sinuses, mouth, upper respiratory tract, intestinal tract, urogenital tract)	**2 Hrs**
Bacteria in the blood and tissues.	**1 Hr**
Properties of pathogenic microorganisms. Factors that influence pathogenicity	**2 Hrs**
Type of infections, source of infections, different modes/means of infections	**2 Hrs**
Diagnostic microbiology – Types of specimen, specimen collection, transportation of specimen, processing, laboratory investigations, specific lab. Tests, non-specific lab tests, diagnosis and report.Use of lab animals in diagnostic microbiology	**3 Hrs**

Unit II **15Hrs**

Systematic bacteriology – Detailed study of morphology, cultural characteristics, antigenic structure, pathogenesis, diagnostic lab tests (conventional and molecular), epidemiology, prevention and treatment of the following bacterial pathogens	**1 Hr**
Bacterial air borne infections – β-Haemolytic Streptococci	**2 Hrs**
Pneumococci	**2 Hrs**
Corynebacterium diphtheriae,	**2 Hrs**
Mycobacterium tuberculosis, Mycobacterium leprae	**2 Hrs**
Neisseria meningitides	**1 Hr**
Haemophilus influenzae	**1 Hr**
Sexually transmitted diseases caused by bacteria, *Treponema pallidum,*	**2 Hrs**
Neisseria gonorrhoeae.	**2 Hrs**

Dr. SANDEEPTA BURGULA
Professor
Microbiology
Hyd-07

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
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Unit III

Systematic bacteriology – Detailed study of morphology, cultural characteristics, antigenic structure, pathogenesis, diagnostic lab tests (conventional and molecular), epidemiology, prevention and treatment of the following pathogenic bacteria — **15Hrs**

Water borne infections – *E.coli* — **1 Hr**

Salmonella typhi — **2 Hrs**

Shigella dysenteriae — **2 Hrs**

Vibrio cholerae — **2 Hrs**

Wound infections – *Staphylococcus aureus* — **2 Hrs**

Clostridium tetani, Clostridium welchii,. — **2 Hrs**

Pseudomonas aeruginosa — **2 Hrs**

III Semester - Paper II Practicals (CBCS)
PMB 352 Medical Bacteriology (Core: 2 credits)

1. Preparation of different types of culture media/observation. Blood Agar, Chocolate Agar, Mannitol salt agar, Baird Parker medium, MacConkey agar, Lowenstein-Jenson medium, Wilson Blair Bismuth sulphite medium, Biochemical media, etc.
2. Gram's staining of bacteria
3. Acid Fast staining of *M. tuberculosis*
4. Albert Staining for *C. diptheriae*
5. Capsular staining of *K. pneumoniae*
6. Isolation and identification of various pathogenic bacteria by microscopic, macroscopic, biochemical, enzymatic and serological tests (IMViC Tests)
7. Kirby-Bauer Disc Diffusion method for testing antibiotic sensitivity of pathogens from clinical samples
8. WIDAL Test for diagnosis of typhoid
9. Coagulase test for detection of pathogenic *S. aureus*
10. Catalase test
11. Detection of syphilis by VDRL test
12. Bacteriological examination of urine from a UTI patient
13. Examination of pathogenic bacteria /permanent slides
14. Bacteriological examination of pus from wound infection and throat swab etc from patient suffering with throat infection
15. PCR based diagnosis of TB

Recommended Books

1. Review of Medical Microbiology by Jawitz, Melnick and Adelberg
2. Diagnostic Microbiology by Bailey and Scott
3. Medical Microbiology by Cruckshanak et al Vol I & II
4. Text book of Microbiology by Ananthanarayanan and JayaramPaniker
5. Microbiology by Greenwood, Slack and Peutherer

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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Course Outcomes:

The student will be able to

PMB 302 CO1	Explain the clinically important microorganisms and Normal flora of human body. Describe the nature and basic concepts of pathogenic microorganisms, infection and process of diagnosis and perform the requisite diagnostic protocols
PMB 302 CO2	Discuss of air borne and sexually transmitted bacterial pathogens bacterial pathogens.
PMB 302 CO3	Illustrate water borne bacterial pathogens and wound infections of bacteria.

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

CHAIRPERSON
BOS in Microbiology
Bhavan's Vivekananda College
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M.Sc. (Final) Microbiology III Semester (CBCS)
Paper III PMB 303
Molecular Biotechnology and AI in Biology (Elective I A: 3 credits)

Overall Course Objective:

This paper is designed to lay foundation in principles and application of cell cycle regulation and cancer induction, r DNA technology, and modern methods used in molecular diagnosis and therapy. Introduction of Artificial Intelligence in Biology .

Course Objectives:

The student will be able to

Cob 1 Acquaint with concepts in cell cycle regulation, Programmed cell death, Cancer biologyand Insight into Signal transduction pathways.

Cob 2 Understand DNA/Protein Interactions, Principle and applications of Molecular Techniques for Gene Silencing, Gene therapy and Emerging omics techniques

Cob 3 Learn Basics of Artificial Intelligence, methods and their applications in Biology

Unit I **15Hrs**

Cell cycle: Cell division regulation and cancer. 2 Hrs

Cancer biology and genetics: role of oncogenes and tumor suppressor genes – examples, Myc, ras, src, p53, RB, BCR-Abl, 3Hrs

Role of protein Kinases in cell cycle. 1 Hr

Programmed cell death 2 Hrs

Geno toxicity assays 2 Hrs

Signal transduction: G- Protein linked receptors 2 Hrs

Concept of second messenger cAMP and GMP. 2 Hrs

Steroid/peptide hormone regulation, tissue specific regulation. 1 Hr

Unit II **15Hrs**

Protein folding and the roles of Molecular chaperones. 2 Hrs

Analysis of Protein-protein and protein-DNA interactions 2Hrs

Biochips (DNA chips and Protein chips) 1 Hr

DNA fingerprinting and DNA markers: RAPD, RFLP, AFLP, Simple sequence repeat (SSR) markers 2 Hrs

Site directed mutagenesis 1 Hrs

Reverse Genetics, 1 Hr

Gene knock out – RNAi and Gene silencing 2 Hrs

Gene therapy 1 Hr

Emerging omics techniques: Metagenomics, Transcriptomics and proteomics; Methodology and Applications 3Hrs

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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Unit III **15Hrs**

Introduction to Artificial Intelligence(AI) in Biology	2 Hrs
Biological Intelligence vs Artificial Intelligence,	2Hrs
AI Basics: Concepts, terminologies and Work flow	1 Hr
Basics of Machine Learning (ML) and Deep Learning (DL)	2 Hrs
Applications of AI - Health care	1 Hrs
Applications of AI - Pharmaceutical Industry; Drug design and Clinical trials	2 Hr
Applications of AI - Biomarker discovery	2 Hrs
Applications of AI - Bioinformatics; Synthetic Biology; Agriculture	2 Hr
Risks and Ethical Concerns	1Hrs

III Semester - Paper III Practicals (CBCS)
PMB 353: Molecular Biotechnology & AI in Biology (Elective I A: 1credit)

1. Isolation of Plasmid DNA from *E. coli*
2. Isolation of nucleic acids, proteins from *E. coli* through tutorial mode
3. Demonstration of mitosis in onion root bud
4. Restriction mapping. Method and problems
5. Preparation of competent cells and transformation of *E. coli* cells and PCR
6. Gene cloning in bacteria (Demonstration) and Recombinant confirmation (blue white selection).
7. Demonstration of RFLP , AFLP
8. Demonstration of workflow in AI

Recommended Books

- Molecular biology by Robert Weaver
- Molecular biology by David and Freifelder
- Microbial genetics by David and Freifelder
- Molecular biotechnology by Chanarayappa
- Methods in Molecular Cloning by Sambrook.
- Genetics of bacteria and their viruses by William Hayes
- Molecular biology of the gene by Watson et al
- Cell and Molecular Biotechology by Darnell, Lodish and Baltimore
- Genes IX by Benjamin Lewin
- The Biochemistry of nucleic acids by Davidson JN
- Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B.
- Molecular Biotechnology by Bernard R. Glick and Jack J Pasternak
- DNA Microarrays Ed. M. Schena

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
University, Hyd-07.

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BOS in Microbiology
Bhavan's Vivekananda College
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- Dr.Parag Suresh Mahajan (2019)Artificial intelligence in healthcare,2nd Edition
- Artificial Intelligence in Agriculture (Co-Published With CRC Press-UK) (English, Hardcover, Singh Rajesh Singh, Anita Gehlot, Mahesh Pratap Gehlot, Bhupendra)
- Mullaicharam Bhupathyraaj, K. Reeta Vijaya Rani, Musthafa Mohamed Essa (2023) Artificial intelligence in Pharmaceutical Sciences

Course Outcomes:
The students should be able to

PMB 303 CO1	Describe the mechanism of cell cycle regulation, apoptosis and Cancer induction & inheritance, Signal transduction pathways
PMB 303 CO2	Comprehend DNA/Protein Interactions, Principle and applications of Molecular Techniques for Gene Silencing, Gene therapy and Emerging omics techniques.
PMB 303 CO3	Explain the work flow of Artificial Intelligence, methods and their applications in Biology

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

CHAIRPERSON
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M.Sc. (Final) Microbiology III Semester (CBCS)
Paper III PMB 303
Microbial Proteomics (Elective I B: 3 credits)

Overall Course Objective:

The course aims to provide students with a comprehensive understanding of proteomics, including its evolution from protein chemistry, protein structure, analysis, and functions to advanced techniques in protein separations, quantitative proteomics, functional proteomics, protein-protein interactions, post-translational modifications, structural proteomics, and applications in various fields such as personalized medicine, drug design, and diagnostics. Additionally, students will explore the role of bioinformatics in proteomics research and the challenges and future prospects of the field.

Course Objectives:

The student will be able to

Cob 1 To introduce students to the fundamental concepts of proteomics, including protein Structure, function, and interaction in cellular processes.

Cob 2 To familiarize students with protein separation techniques, quantitative proteomics methods, and functional proteomics approaches

Cob 3 To delve into advanced topics in proteomics such as protein-protein interactions, post- translational modifications, and their applications in medicine and biotechnology

Unit I	**15Hrs**
An introduction to proteomics: Evolution from protein chemistry to proteomics	**2 Hrs**
Protein structure – Different levels of protein structure	**2Hrs**
Protein Folding and unfolding	**2 Hr**
Active sites and effects of pH, temperature, substrate concentrations, inhibitors and activators on activity.	**3 Hrs**
Protein Analysis and functions For e.g. structural, storage, transport, hormonal, receptor, contractile, defensive, enzymatic.	**3 Hrs**
Protein interaction in cell signaling neurotransmitters and membrane channel opening and closing.	**3 Hrs**

Unit II	**15Hrs**
Protein separations, protein analyses	**1 Hrs**
Quantitative proteomics - stable isotope labeling by amino acids in cell culture (SILAC), isotope-coded affinity tag (ICAT), isobaric tagging for relative and absolute quantitation (iTRAQ)	**2Hrs**
Identification and analysis of proteins by Two-dimensional fluorescence difference in-gel electrophoresis (DIGE), 2D gel electrophoresis, Isoelectric focusing	**2 Hr**

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
University, Hyd-07.

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Spot visualization and picking, Tryptic digestion of protein and peptide fingerprinting; Mass spectrometry **3 Hrs**

Functional proteomics: Recombinational cloning, Interactomics - techniques to study protein-protein interactions, yeast two-hybrid, immunoprecipitation, protein microarrays, Nucleic Acid Programmable Protein Array (NAPPA), Label-free nanotechnologies in proteomics, Surface Plasmon Resonance (SPR). **3 Hrs**

Proteomics of *Saccharomyces cerevisiae*-cell wall & transport, differential expression in stress. **2 Hrs**

Proteomics of probiotic lactobacilli-intestinal epithelial cells interactions, Lantibiotics and Immunomodulators. Microbial pathogenesis: Studies at proteome level. Proteomic Identification of *Mycobacterium tuberculosis.* **2 Hrs**

Unit III

15Hrs

Strategies and studies on Protein-Protein interaction, Protein-DNA interactions. Yeast two hybrid system.) **2 Hrs**

Nucleic Acid Programmable Protein Array (NAPPA), Label-free nanotechnologies in proteomics, Surface Plasmon Resonance (SPR **2Hrs**

Modificomics: understanding post-translational modifications; **2 Hr**

Structural proteomics ; Protein micro arrays- Protein Markers, Clinical Proteomics, Small peptides, Personalized medicine **2 Hrs**

Protein engineering. Application of machine learning in protein engineering. **2 Hrs**

Drug Design, Proteomics based plasma markers, molecular markers and cancer diagnostics **2Hr**

Bioinformatics in proteomics, proteome databases; Challenges and future prospects of proteomics research. **2 Hrs**

Prions **1Hrs**

Semester III - Paper III Practicals (CBCS)
PMB 353 Microbial Proteomics (Elective 1B:1 credit)

1. Protein isolation from *E coli*
2. Isolation of proteins from *Bacillus*
3. Isolation of proteins from Yeast.
4. Sequence analysis of proteins (by BLAST, ClustalW and Phylip).
5. Protein structure prediction by Homology modeling.
6. Demonstration of *In silico* translation of protein
7. Overexpression of heterologous protein in *E.coli.*
8. Purification of cloned protein in *E.coli.*
9. Protein identification by immunoblotting
10. Separations of Proteins by Column chromatography

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Professor
Department of Microbiology
Osmania University, Hyd-07.

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Reference Books

1. Principles of Protein structure, Schultz, G. E., and Schirmer, R. H. Dr. ShaktiSahi
2. Proteomics, Daniel C. Leibler
3. Introduction to Proteomics: Tools for the New Biology. Totowa, NJ: Humana Press. Liebler, D. C.
4. Microbial Proteomic, MarjoPoutanen
5. Proteins: Structures and Molecular Principles (2d ed.), TE Creighton
6. Organic spectroscopy, William Kemp
7. Proteome Research: Two-Dimensional Gel Electrophoresis and DetectionMethods (Principles andPractice), T. Rabilloud (Editor), 2000, Springer Verlag
8. Introduction to Protein Architecture: The Structural Biology of Proteins, M.Lesk, 2001, Oxford University Pres
9. Campbell, A. M., &Heyer, L. J. Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings

Course Outcomes:

PMB 303 CO1	Describe the different levels of protein structure, protein functions and protein interactions in cell signaling, neurotransmitters, and membrane channel opening and closing
PMB 303 CO2	Explain various protein separation techniques, and analyze proteomics studies related to microbial pathogenesis
PMB 303 CO3	Discuss strategies and techniques for studying protein-protein and protein-DNA interactions such as yeast two-hybrid, NAPPA, label-free nanotechnologies, SPR and future prospects in the field of proteomics research, including prions

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Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

M.Sc. (Final) Microbiology III Semester (CBCS)
Paper IV PMB 304
Entrepreneurship in Microbial Sciences (Elective II A: 3 credits)

Overall Course objective: To provide an overall knowledge on understanding of microbial entrepreneurship focusing on regulatory protocols and familiarize with IPR, bioethics and biosafety principles

Course Objectives:

The student will be able to

Cob1. To provide students with a comprehensive understanding of entrepreneurship, including the process, competencies, financial management, and the differences between general and biotechnology entrepreneurship

Cob2. To equip students with the necessary knowledge and skills in microbial entrepreneurship, including bio based technology, waste management, and setting up clinical diagnostic centers, focusing on practical aspects and regulatory protocols

Cob3 To familiarize students with intellectual property rights (IPR) and regulatory issues relate to microorganisms and biotechnology processes/products, along with funding procedures and commercialization aspects, emphasizing bioethics and biosafety principles

Unit I **15Hrs**

Entrepreneurial society Entrepreneur development – activity – Institutions involved – Government contributions to entrepreneurs – risk assessment **2 Hrs**

Entrepreneur, Entrepreneurship, MSMEs, Enterprise &Startups Process of Entrepreneurship Competencies & Skills/ Qualities of an Entrepreneur **2Hrs**

Types of Entrepreneurs & Enterprise. Approaches to manage capital & cost of capital . **2 Hr**

Working capital & cash flow planning.

Financial Planning & Budgets Measuring &reporting financial performance. **3 Hrs**

Entrepreneur management and case studies **3 Hrs**

Biotechnology entrepreneurship versus general entrepreneurship. Biotech and Pharma industries. Indian and Global scenario and market. **3Hr**

Unit II **15Hrs**

Microbial Entrepreneurship: Biobased technology. Use of microorganisms for different industrial products **2 Hrs**

CRISPR based technologies for metabolic engineering **1Hr**

Biomass resources, renewable feed stocks, agro- lignocellulosic residual material for valorization. **2 Hrs**

Circular economy and sustainable development goals. **1 Hr**

Practical aspects to set up of Labs for soil and water analysis. Management of drinking **2 Hrs**

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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water plant. Sources of contamination

Management of drinking water plant. Sources of contamination. Management strategies for wastes generated from different urban locations and industries for renewable products. Annamox process and waste water treatment. **3Hrs**

Documentation, Accreditation and permission protocols to set up clinical diagnostic centre **1Hr**

Practical aspects, considerations and challenges faced to set up clinical microbiology lab. Handling of samples: Serological, Microbial, Urine and stool. PCR and other diagnostic procedures. Documentation and report analysis of hematology, serology and pathology. **3Hrs**

Unit III **15Hrs**

IPR and regulatory issues in relation to microorganisms and / or products / processes;; **2 Hrs**

Architecture of a typical patent application. Regulations of National Biodiversity authority (NBA) and Features of Biological Diversity Act 2002. **2Hrs**

Documentation and deposition of potential microbial strains for patent application. **2 Hr**

Funding procedures for Start ups. Typical stages in commercialization aspects of biotechnology processes / products; Financial appraisal of biotechnology projects. **3Hrs**

TRIPS (Trade – Related Aspects of Intellectual Property Rights) agreement; Alternative models of technology transfer and licensing; Funding mechanisms of commercial projects. **3 Hrs**

Bio safety principles; Bio ethics. Regulations and Bioethical committee. **3Hrs**

Semester III - Paper IV Practicals (CBCS)

PMB 354 - Entrepreneurship in Microbial Sciences (Elective IIA: 1 credit)

1. Visit to industry for making biofertilizers and report writing
2. Visit to food and dairy industry and report writing
3. Visit to pharma sector and report writing
4. Visit of drinking water plant and checking for sources of contamination and report writing
5. Visit to Medical Diagnostic lab and report writing
6. Production of bio-fertilizer in flask level.
7. Production and characterization of different microbial metabolites
8. PoC of the project idea
9. Application and project proposal writing for translation research
10. Demonstration of Sustainability and Life cycle assessment in biotech industry
11. Lab set up and diagnostic studies

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Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

Recommended Books

1. Industrial Microbiology- L.E.Casida, jr, New age International publication.
2. Entrepreneurial Development in India- By Arora
3. Experiments in Microbiology, Plant pathology, Tissue culture and Mushroom production technology- K.R.Aneja, New age International publication.
4. Bioentrepreneurship development Ms Shreya Singh
5. Dynamics of Entrepreneurial development and management by Vasant Desai
6. Recent Research and Review Papers

Course outcomes:

PMB 304 CO1 Students will gain entrepreneurship expertise, enabling critical evaluation and pursuit of ventures, particularly in biotech and pharma, on local and global scales

PMB 304 CO2 Students will be capable in utilizing microbial resources for industrial applications, managing environmental challenges through sustainable practices, and navigating regulatory frameworks for establishing clinical diagnostic facilities, thus preparing them for careers in the field of microbial entrepreneurship

PMB 304 CO3 Students will possess a comprehensive grasp of IPR regulations, funding mechanisms, and commercialization strategies in biotechnology, facilitating effective navigation of legal and ethical challenges and responsible contribution to the industry's growth

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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M.Sc. III Semester Microbiology (CBCS)
Paper IV PMB 304 Applied Biotechnology (Elective II B: 3 credits)

Overall Course Objective: To provide an overall knowledge on applications of industrial products and acquire knowledge on animal cell culture techniques and stem cell technology

Course objectives:

The student will be able to

Cob 1 Understand the principles and applications of microbial biotechnology, focusing on the production of small and macromolecules

Cob 2 Explore the utilization of plants as bioreactors, with a focus on Arabidopsis thaliana as a model plant, morphogenesis, and organogenesis

Cob 3 Acquire knowledge and skills in animal tissue culture techniques, stem cell technology, and tissue engineering principles

UNIT I — 15Hrs

Microbial biotechnology. Microbial production of small and macromolecules	2Hrs
Qualitative and quantitative assays for detection of enzymes, amino acids, organic acids, vitamin B12, steroids.	4Hrs
Designing microbial cell factories for production of different chemicals and Biofuels.	2Hrs
Bio-transformations used in microbial process.	2Hrs
Production of monoclonal antibodies and antimicrobial peptides at industrial level.	2Hrs
Microbial nanotechnology. Bio-fabrication of nanoparticles and characterization studies.	3Hrs

UNIT II — 15Hrs

Plants as bioreactors. Importance of *Arabidopsis thaliana* as a model plant.;	1Hr
Morphogenesis and organogenesis in plants (*A. thaliana*). Special features and organization of plant cells; Totipotency; Regeneration of plants from leaves, roots, stem etc	3Hrs
Plant cell culture studies for natural products of industrial importance.	2Hrs
CRISPR based gene editing for agriculture.	1Hr
Transgenic plants, Biosafety concerns of transgenic plants.	1Hr
Manipulation of plants for —Photosynthesis, Nitrogen fixation, Nutrient uptake efficiency.Quality improvement-Protein, Lipids, carbohydrates, vitamins and minerals., Biotic Stress Tolerance- Herbicide resistance, Glyphosate, Insect Resistance, Bt toxin, Disease Resistance, Virus resistance. Abiotic Stress Tolerance-Drought, Flooding, Salt and temperature	7Hrs

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Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
University, Hyd-07.

UNIT III

Animal Tissue Culture: Primary culture, Organ culture, Embryo Culture.. 15Hrs
Established Cell lines and their propagation. Scale-up of cell culture processes; 2Hrs
Cryopreservation, Culture Collections. 3Hrs
Stem Cell Technology- adult and embryonic stem cells., Risks and Safety, Bioethics 2Hrs
Genome editing tools CRISPR/Cas9, retroviral methods, DNA microinjection 2Hrs
method, etc and their applications (gene therapy).
Transgenics and knockouts: Transgenic cattle, Transgenic birds, Transgenic fish, 2Hrs
Transgenic mice.
Tissue Engineering: cells, scaffold, growth factors and mechanical environment. 4Hrs
Types of tissue engineering

Semester III -Paper IV - Practicals (CBCS)

PMB 352 Applied Biotechnology (Elective IIB: 1credit)

Production of citric acid by fungal fermentation, recovery and estimation

1. Production of amino acid (Glutamic acid/lysine) by fermentation
2. Production of amylase, cellulose, protease by fermentation, recovery and estimation
3. Scale up of fermentation demonstration studies
4. Bio-fabrication of nanoparticles through demonstration.
5. Plant tissue culture and Hairy root culture demonstration
6. Terminology, Laboratory design of Animal tissue culture laboratory
7. Preparation of medium for cell culture and sterility checking
8. Demonstration of chick embryo fibroblast culture, viable staining.

Books Recommended

1. Industrial Microbiology by Casida, LE
2. Industrial Microbiology by Patel, AH
3. Industrial Microbiology by Miller, BM and Litsky
4. Industrial Microbiology by Prescot and Dunn
5. Microbial Technology by Peppler, JH and Perlman, D.
6. Biochemistry of Industrial Microorganisms, by Rainbow and Rose
7. Economic Microbiology by Rose Vol I – V
8. Microbial Enzymes and Biotechnology by Fogarty WM and Kelly, CT
9. Comprehensive Biotechnology, All volumes Ed. Murray Moo-Yong

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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10. Biotechnology (A text book of industrial Microbiology) Ed. Cruger&Cruger
11. Advances in Applied Microbiology Ed. Perlman Series of volumes
12. Plant Biotechnology: The genetic manipulation of plants,2005,A.Slater ,N.Scott&
13. M.Fowler, Oxford Univ Press, Oxford.
14. Introduction to Plant Biotechnology(3rd Edtn), H.S. Chawla
15. Roberta Smith, Plant Tissue Culture: Techniques and Experiments,2ndEdtn,Academic
16. Press,2000
17. H.K.Das(ed),Textbook of Biotechnology,Wiley India,2004
18. J.H.Hammond, P.Mcgarvey, and V.Yusibov(eds), Plant Biotechnolgy,Springer
19. Verlag,Heidelberg,2000
20. Animal Cell Culture by Ian Freshney
21. Basic Cell Culture.Ed.J.M.Davis 2nd.Ed 2007. Oxford press
22. Animal Cell Culture SudhaGangal
23. Principles of biotechnology and applications-Glick and Pasternack

Course Outcomes:

PMB 304 CO1	Students will gain skills in designing microbial cell factories for chemical and biofuel production, and conducting assays for detecting various biomolecules and will also learn about bio-transformations and industrial-level production of specific bioproducts like antibodies, peptides, and nanoparticles
PMB 304 CO2	Students will acquire expertise in plant regeneration, cell culture for industrial applications, CRISPR-based gene editing, biosafety considerations, and plant manipulation for quality enhancement and stress tolerance
PMB 304 CO3	Students will gain knowledge on a range of techniques in animal tissue culture as well as propagation of established cell lines and scale-up processes while understanding the ethical considerations of stem cell technology, genome editing, transgenics, and tissue engineering principles

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Dr. SANDEEPTA BURGULA.
Professor
Department of Microbiology
Osmania University, Hyd-07.

M.Sc. III Semester Microbiology (CBCS)
Paper V PMB-305 MOOCS on line course (2 Credits)

Students will be allowed to opt relevant online MOOC's course and follow the SWAYAM guidelines for completion of course

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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BOS in Microbiology
Bhavan's Vivekananda College
Sainikpuri

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DEPARTMENT OF MICROBIOLOGY
MSc MICROBIOLOGY (2023-25)

M.Sc. (Final) Microbiology IV Semester (CBCS)

Paper I PMB 401 Food Microbial Technology (Core: 3 Credits)

Overall Course Objectives: To provide students with comprehensive knowledge and understanding of the microbiological aspects of food, including the identification, significance, and control of microorganisms in various food products, as well as the principles and methods of food preservation, safety, and quality control.

The students should be able to

Cob 1 To understand the microbial habitat, adaptations, and changes in various food materials, as well as the principles of food preservation and factors influencing microbial growth in food.

Cob 2 To explore dairy microbiology, fermented foods, and the health aspects of fermented products, as well as the production and significance of fermented foods in various cultures.

Cob 3 To understand food spoilage, foodborne diseases, detection methods for food borne microorganisms, and principles of quality control and food safety standards.

Unit I **15Hrs**

Food associated molds, yeasts, yeast-like fungi and bacteria. **2 Hrs**

Microbial habitat of specific food materials, adaptations and changes in microbiome of vegetables, fruits, milk, fermented and non-fermented milk products, fresh meats, poultry and non-dairy fermented foods. **3Hrs**

Principles of food preservation -Bacteriological examination of fresh and canned foods; **2 Hrs**

Detection of pathogens in foods. Asepsis – Removal of microorganisms,(anaerobic condition, high temperatures, low temperatures, drying, etc). **2 Hr**

Factors influencing microbial growth in food: Extrinsic and intrinsic factors. **2 Hrs**

Chemical food preservatives and additives. **2 Hrs**

Canning and processing for Heat treatment. **2 Hrs**

Unit II **15Hrs**

Dairy Microbiology - Types of microorganisms in milk and their significance **1 Hrs**

Microbial products of milk -Acidophilus Milk, Bifidus Milk, Bulgarian milk, Kefir, Kumiss **1Hrs**

Microbiology of cheese, butter, yogurt. Microbiological examination of milk, control of microbial flora of milk. **2 Hrs**

Fermented foods - Understanding benefits of traditional and non-traditional fermented **1Hr**

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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foods

Health aspects of fermented foods. Production of fermented milk and milk products, plant-based products - Sauerkraut and pickles, cereal and legume based fermented products, bread, soya sauce, tempeh,, fish products, meat products etc. **2 Hrs**

Microbiology, processing and fermentation of bread and idly. **2 Hrs**

Production and significance of Silage. **2 Hrs**

Production of Vinegar and concept of bioactive compounds from fermented foods **1Hr**

Microorganisms as food – single cell proteins, sea weed (algae), Mushrooms **2Hr**

Prebiotics, Probiotics and their screening methods. Beneficial effects of prebiotics, probiotics and postbiotics as nutraceuticals. **1Hr**

Unit III **15Hrs**

Spoilage of raw and processed/canned foods, detection of food spoilage **1 Hrs**

Significance of food borne diseases, Microbial food poisoning and intoxications: *Botulism, Listeriosis, Bacillus* cereus food poisoning **2Hrs**

Food borne Gastroenteritis by *Salmonella, Shigella, Vibrio, Campylobacter* and *Yersinia, Staphylococcus*. **2 Hrs**

Effect of different mycotoxins on human and animal health and their detoxification methods (Physical, Chemical and biological). **1Hr**

*Detection of food-borne microorganisms:*Culture, Microscopic and Chemical: Thermostable nuclease *Limulus* Lysate for Endotoxins, Nucleic Acid (DNA) probes, DNA Amplification (PCR), Immunological Methods: Fluorescent Antibody, Enrichment Serology, Salmonella 1-2. Test **2 Hrs**

Biosensors to detect food borne pathogens **2 Hrs**

Principles of quality control and microbiological criteria, Indicators of product quality and microbiological safety of foods, Hazard analysis, critical control points (HACCP), Good manufacturing practices (GMP) Microbiological standards Codex Alimentarius and Food legislation with respect to FSSAI, NABL and ISO. **3 Hrs**

Introduction to 3D printing technologies in foods, its nutritional value, microbial contamination and regulatory frameworks **2Hr**

IV Semester- Paper I Practicals (CBCS)

PMB 451 Food Microbial Technology (Core: 2 Credits)

1. Microbiological examination of fresh fruits, vegetables and juices
2. Microbiological examination of spoiled and canned foods
3. Bacterial examination of potable water by MPN and membrane filters technique
4. Microbiological examination of Milk by Breeds method and quality assessment by MBRT test
5. Isolation, Screening and Identification of bacterial (LAB) and yeast probiotics
6. Extraction of Mycotoxins (aflatoxin) from contaminated grains/foods and Detoxification of mycotoxins
7. Determination of TDT (Thermal death time) and TDP (Thermal death point)
8. Sterilization techniques of food products: Filtration, Pasteurization and Tyndallization

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
University, Hyd-07.

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9. Food preservation methods i) Pickle preparation. ii) Squash (pulp) preparation. iii) Jam preparation.
10. Isolation and observation of mushroom fungi

Reference books:

1. Food Microbiology by W.C. Frazier, D.C. Westhoff , K.N. Vanitha. 5th edition. McGraw Hill Education. 2013.
2. Biotechnology: Food Fermentation : Microbiology, Biochemistry, and Technology by VK Joshi and Ashok Pandey
3. Food Microbiology by M. R. Adams, M. O. Moss, P. McClure. 4th edition. Royal Societyof Chemistry. 2015
4. Food Microbiology: An Introduction by T. Montville, K. Matthews, K.Kniel. 4th edition ASM press. 2017.
5. Bibek Ray and ArunBhunia (2008) Fundamental Food Microbiology 4th Ed. CRC Press.
6. Adams M R and Moss M O (2008) Food Microbiology 3rd Ed. RSC Publishing.
7. Brock's Biology of Micro organisms by Madigan et al
8. Probiotics 3 by R. Fuller, G. Perdigon (Kluwer Academic Publishers)
9. Probiotics and Prebiotics: Scientific Aspects by Gerald W. Tannock University of Otago, Dunedin, New Zealand (Caister Academic Press)
10. Laboratory experiments in microbiology by Gopal Reddy et al
11. Foodborne Pathogens and Food Safety by Md. Latiful Bari, Dike O. Ukuku (CRC Press)
12. Ahmed E.Y. and Carlstrom C. 2003 Food Microbiology: A Laboratory Manual, John Wiley and Sons, Inc. New Jeresy.
13. Sperber, William H., Doyle, Michael P. (Eds.). 2010. Compendium of the Microbiological Spoilage of Foods and Beverages. Springer.
14. Stephen J. Forsythe. 2010. The Microbiology of Safe Food, 2nd Edition. Wiley-Blackwell.
15. Fundamental Food Microbiology by B. Rayand A. Bhunia. 5th edition. CRC press. 2013.
16. Frazier W.C. and Westhoff C.D. 2008 Food Microbiology. Tata McGraw Hill Publishing Company Limited, New Delhi. IndianEdition.
17. Recent Published papers on advances in relevant area to be referred

Course Outcome:

The student will be able to

PMB 401 CO1. Identify different food-associated molds, yeasts, yeast-like fungi, and bacteria, the significance of fermented foods in daily lives

PMB 401 CO2. Identify types of microorganisms in milk, microbial products of milk, and various fermented foods.

PMB 401 CO3. Assess the microbiological standards, indicators of product quality and safety, and regulatory frameworks including Codex Alimentarius, Food legislation, and the introduction of 3D printing technologies in foods.

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Sainikpuri

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

M.Sc. (Final) Microbiology IV Semester (CBCS)
Paper II PMB 402 Medical Virology and Parasitology (Core: 3 Credits)

Overall Course Objective: To summarize on clinically significant of viruses and parasites

Course Objectives:
The students should be able to

Cob 1 Understand diagnostic microbiology and describe study on viral air borne infections
Cob 2 Perform Systematic study on water borne, zoonotic and sexually transmitted diseases viral infections
Cob 3 Gain knowledge on Parasitic and Mycotic infections

Unit I **15Hrs**

Diagnostic virology – Cultivation of pathogenic viruses in lab animals and tissue culture	2Hrs
Identification of pathogenic viruses and establishment of viral etiology	2Hrs
Structure, cultivation, pathogenicity, lab diagnostics, prevention and control of air borne viral infections	1Hr
Influenza virus	2Hrs
Rhinovirus,	1Hr
Corona virus	2Hrs
Rubella virus	1Hr
Adenovirus (type 2),	2Hrs
Mumps virus	1Hr
Measles virus	1Hr

Unit II **15Hrs**

Structure, cultivation, pathogenicity, lab diagnostics, prevention and control of viruses transmitted by water - Hepatitis (HAV),	2Hrs
Polio mellitus	2Hrs
Structure, cultivation, pathogenicity, lab diagnostics, prevention and control of viruses transmitted by Zoonosis – Rabies,	2Hrs
Dengue	1Hr
Japanese encephalitis	1Hr
Structure, cultivation, pathogenicity, lab diagnostics, prevention and control of contact and sexually transmitted viral diseases – Small pox	1Hr
Herpes (Herpes simplex virus),	2Hrs
Hepatitis viruses	2Hrs
Acquired immunodeficiency syndrome (AIDS)	2Hrs

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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Unit III **15Hrs**

Structure, cultivation, pathogenicity, lab diagnostics, prevention and control of Malaria	2Hrs
Amoebiasis	1Hr
Trichomoniasis	1Hr
Helminthic infections	1Hr
Round worms	1Hr
Hook worms	1Hr
Medical Mycology- Dermatomycosis, Systemic mycosis. Types, pathogenesis and diagnostics	5Hrs
Fungal infections associated with COVID19. Precaution and management	3Hrs

IV Semester- Paper II Practicals (CBCS)
PMB 452 Medical Virology and Parasitology (Core: 2 Credits)

1. Cell culture techniques (demonstration)
2. Virus cultivation methods using embryonated eggs and plants
3. Microscopic studies of viruses infected materials (demonstration)
4. Examination of pathogenic fungi
5. Examination of stool sample for Hookworm and Round worm
6. Examination of stool sample for *Entamoeba histolytica*
7. Examination of blood smear by Leishman stain for Malarial parasites
8. Immunodiagnostics - Tridot test for HIV
9. Immunodiagnostics – Hepatitis B test for HBV
10. ELISA for diagnosis of HIV
11. Examination of urine sample for fungal infection
12. Demonstration of laboratory animals and their handling
13. PCR based diagnosis of HIV
14. Rapid diagnosis of Covid19 (demonstration)
15. Diagnosis of Dengue by detection of IgG & IgM antibody & NS1 antigen (Demonstration)

Recommended Books

1. Review of medical microbiology by Jawetz et al
2. Medical laboratory Manual for tropical countries Vol I & II by Monica Cheesbrough
3. Text Book of Microbiology by Ananthanarayanan and JayaramPanicker
4. Viral and Ricketsial infections of Man by Horsfall and Jam
5. Text book of Virology by Rhodes and Van Royan
6. Virological Procedures by Mitchalhasking
7. Virology by Wilson and Topley

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
University, Hyd-07.

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Course Outcomes:

The students should be able to

PMB 402 CO1 Explain the process of diagnosis and perform the requisite diagnostic procedures for identification of viruses and list out air borne viral pathogens

PMB 402 CO2 Classify and understand water borne viral pathogens, zoonotic viral pathogens and sexually transmitted viral pathogens

PMB 403 CO3 Categorize parasitic and mycotic infections

M.Sc. (Final) Microbiology IV Semester (CBCS)
Paper III PMB 403 Microbial Ecology: Host Microbe Interactions
(HMI) - (ElectiveIII A: 3Credits)

Overall Course Objective: To create awareness on Microbial biodiversity & methods of analysis in natural environments, explore plant microbe interactions to develop microbial formulations for plant growth promotion and illustrate molecular mechanism of Quorum sensing, plant immunity and resistance

Course Objectives:

The students should be able to

Cob 1 Understand concepts of microbial distribution and diversity in natural environments and molecular methods for microbial diversity analysis and microbial ecology

Cob 2 Appreciate the Role of PGPR and PGPM in agriculture, application of Microbial formulations and detection of bioinoculants. Understand molecular interactions between plant & microbe, two-component Signalling, systemic and induced resistance, Quorum sensing Systems in Microorganisms and their role in Pathogenesis

Cob 3 Understand animal microbe interactions – Human microbiome, microbiota distribution, role of Microbiome in infections and disease, Gut Brain axis and immunity Microbiome modulation therapies and trends in Microbiome research. .

Unit I **15Hrs**

Microbial ecology: Concept of habitat and niche; population and community, biome. **2Hrs**

Microbial signaling and Quorum sensing **2Hrs**

Planktonic growth and Biofilm formation, Nature of microbial communities **1Hr**

Microbial growth curve representing r and k reproductive strategies. **2Hrs**

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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Microbial diversity

Phylogenetic based approach (16S rRNA, Internal transcribed region), Sequence based approach (NGS)., Alpha and beta diversity, — 1Hr, 2Hrs

Species diversity, Richness and evenness — 1Hr

operational taxonomic unit (OTU) Diversity indices (Shannon, Simpson's). — 2Hrs

Ecological succession and comparative analysis of microbial communities. — 1Hr

Climax community. Key stone species — 1Hr

Unit II — 15Hrs

Host (Plant) –microbe interactions. Epiphytes and Endophytes, — 1 Hr

Role of Soil microbiome vs plant — 1Hr

Plant growth promoting rhizobacteria (PGPR): Direct and indirect mechanisms of microorganisms to promote soil and plant health — 2Hrs

Microbiomes for plant health — 1Hr

Plant microbe beneficial interactions with Pseudomonas, Bacillus and Trichoderma — 2 Hrs

Role of biotic and abiotic factors in plant- microbe interactions — 1Hr

Two-component regulatory system (Gac S and Gac A) in plant growth promoting bacteria — 1Hr

Microbial formulations(peat, lignite, talc) and mode of inoculation.Detection of microbial inoculants by staining, biochemical and molecular methods — 1Hrs

Plant -pathogen interactions: Bacterial (*Xanthomonas*) and (Fungal) *Macrophomina* infection in plants. — 1Hrs

Plant pest (Helicoverpa) nematode (Meloidogyne). — 1Hr

Root exudates and their role in recruitment of beneficial microbiome. — 1Hr

Basic concept of plant immunity (MAMPs, PAMPs). Plant defense mechanisms: induced systemic resistance (ISR); systemic acquired resistance (SAR). — 2Hrs

15Hrs

Unit III

Host (Animal) microbe interactions: Introduction to Microbiome studies of insects, Zebra fish, Rumen and Human. — 2 Hrs

Microbiota transmission in Humans: pregnancy and birth. — 2Hrs

Microbiome of oral cavity, naso-pharynx and respiratory tracts

Role of human microbiome in infectious, inflammatory non communicable diseases. — 2Hrs

Human Gut microbiota (Gut Brain Axis): Health and immunity. — 3Hrs

Eubiosis and Dysbiosis

Microbiome modulation therapies. Transient shift of microbiome, Stabilization, Evenness of healthy microbiome — 2 Hrs

Microbiome Engineering and Restoration 2 Hrs
Emerging studies on Microbiome and One Health concept. 2Hrs

Semester IV - Paper III Practicals (CBCS)

PMB 453 -Microbial ecology: Host Microbe Interactions (HMI) -Elective III A: 2 Credits)

1. Isolation of plant growth promoting bacteria (PGPB) from diversified sources
2. Isolation and characterization of PGPB for ammonia production, P, Zn-solubilization,
3. Characterization of Siderophore production on selective medium
4. Isolation of Pseudomonas on Kings B medium and microscopic identification
5. Isolation of actinomycetes on selective medium and microscopic identification
6. Isolation of trichoderma on selective medium and microscopic identification
7. Isolation of bacteria with ability to produce plant growth hormone indole acetic acid (IAA)
8. Quantification of IAA by spectrophotometric method
9. Quantification of phosphate by spectrophotometric method
10. Screening for biosurfactant activity.
11. Isolation of antagonistic microbes using dual-culture method
12. Demonstration of Plant microbiome studies with wild and cultivated varieties to explain microbiome restoration.
13. Demonstration and comparison of culturable and metagenomic studies of insects, zebra fish etc
14. Demonstration of microbiome studies using faecal sample and faecal microbiota transplant (FMT)

Recommended Books / Research articles

1. Toole 'O' George, H. B. Kaplan, R. Kolter,(2000) Biofilm formation as microbial development Annual Review of Microbiology, Vol. 54, 49-79 Melissa B. Miller and Bonnie L. Bassler (2001) Quorum sensing in bacteria. Annu. Rev. Microbiol. Vol. 55, 165–99.
2. Sonali Shinde and Aparna. 2021. Microbial Diversity and Ecology in Hotspots. Elsevier publications
3. Christopher M. Waters and Bonnie L. Bassler (2005) Quorum sensing:cell-to-cell communication in bacteria. Annu. Rev. Cell Dev. Biol. Vol. 21, 319–46.
4. Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, Fourth edition,
5. W. H. Freeman & Co. New York. MunehikoAsayama and Yasuo Kobayashi (1993) Signal transduction and sporulation in *Bacillus subtilis*: autophosphorylation of SpoOA, a sporulation initiation
6. PGPR: biocontrol and biofertilization by Zaki A. Siddiqui, Plant-bacteria interactions: strategies and techniques to promote plant growth by Iqbal Ahmad, John Pichtel, S. Hayat Biochemical and genetic mechanisms used by plant growth-promoting bacteria by Bernard R. Glick
7. Plant-microbe interactions, Volume 1 by Gary Stacey and Noel T. Keen
8. Sabu Thomas. 2022. Human Microbiome: Clinical Implications and Therapeutic Interventions, Springer Nature

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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M.Sc. (Final) Microbiology IV Semester (CBCS)
Paper III –PMB 403 Nanobiotechnology and Bioinformatics (ElectiveIII B: 3 Credits)

Overall Course Objective:

To provide students with a foundational understanding of bioinformatics, nanobiotechnology, and emerging nanostructures, including their applications in various fields, and to equip them with computational and experimental skills necessary for research in biological and nanotechnology-related disciplines.

Cob 1 To introduce students to basic concepts of nanobiotechnology, including nanoparticle synthesis, characterization, and applications.

Cob 2 To explore emerging nanostructures and their applications in various fields,emphasizing biomimetics and nanotechnology's role in diverse sectors

Cob 3 To introduce students to bioinformatics basics, including computational tools, database concepts, sequence analysis, and structural bioinformatics

Unit I	**15Hrs**
Basic concepts of Nanobiotechnology	**2 Hrs**
Nanoparticles -Origin and their classification, Nanoscale systems	**2Hrs**
Nano particles: Synthesis, Bottom up and Top down approach.Synthesis of nanoparticles – physical, chemical and biological methods and their characterization	**2Hrs**
Methods of biological synthesis- Use of plants, bacteria, algae, fungi, fermented metabolites	**3Hr**
Characterization techniques for nano materials. Optical- UV–Visible spectroscopy, zeta potential, X-ray diffraction, FTIR.	**3 Hrs**
Imaging and Size- Scanning Electron Microscope (SEM), Transmission. Electron Microscopy (TEM), Atomic Fluorescence Microscopy (AFM)	**3 Hrs**

Unit II	**15Hrs**
Emerging Nano structures and their applications -Carbon nanotubes, quantum dots, Semiconductor nanoparticles, metal based nanostructures, nanowires- polymer based nanostructures, gold nanostructures.	**3 Hrs**
Nano – Biomimetics. Biomimicry in nanotechnology	**2Hrs**
Use of nanotechnology in multiple platforms: Agriculture and food sector,	**2Hrs**
Electronics and devices	**2Hr**
Health care and drug delivery	**2 Hrs**
Textiles and fabrics	**2Hrs**
Sports Equipment, Material Science, Environment conservation etc	**2Hrs**

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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Unit III

15Hrs

Bioinformatics Basics: Use of computational tools in biology and diagnostic studies.	**1Hr**
Introduction to Unix and Linux systems and basic commands	**2Hrs**
DNA sequence studies. Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools. NCBI, EMBL, DDBJ, EBI.	**2Hrs**
Identification of protein sequence from DNA sequence; database mining tools.	**1Hr**
Multiple sequence analysis: use of CLUSTALW and CLUSTALX.	**2 Hrs**
Submitting DNA and protein sequence to databases	
Primer Designing	**2Hrs**
Phylogenetics analysis and Tree construction (Distance Matrix, UPGMA based tree construction, Neighbor Joining Method); Structure Based Drug Design and Ligand Based drug Design	**2Hrs**
Docking studies (AutoDock, GOLD);	**1Hr**
In silico ADME	**1Hr**
Basic softwares and programs needed for Machine learning and Deep learning to use in biological studies	**1Hr**

Semester IV - Paper III Practicals (CBCS)
PMB 453 Nanobiotechnology and Bioinformatics (Elective IIIB : 2 Credits)

1. Chemical Synthesis of Nano Biomaterials
2. Microbiological Synthesis of Nano Biomaterials
3. Green synthesis of metal nanoparticles - Copper, Zinc and Silver using plants extracts
4. Characterization of Nanoparticles by UV spectrometry
5. Demonstration of characterization of nanoparticles by zeta potential and SEM studies
6. Demonstration of biosynthesis of quantum dots and their uses
7. Database searching
8. BLAST and MSA
9. Primer Design
10. Protein Modeling
11. Submission of DNA and protein sequences
12. Phylogenetic tree construction
13. Protein Ligand Docking

Recommended Books

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Recommended Books

1. Lesk M.A. (2008) Introduction to Bioinformatics. Oxford Publication, 3rd International Student Edition
2. Rastogi S.C., Mendiratta N. and Rastogi P. (2007) Bioinformatics: methods and applications, genomics, proteomics and drug discovery, 2nd ed. Prentice Hall India Publication
3. Primrose and Twyman (2003) Principles of Genome Analysis & Genomics. Blackwell
4. Ghosh, Z. and Mallick, V. (2008) Bioinformatics- Principles and Applications. Oxford University Press.
5. Bionanotechnology: Lessons from Nature by David S. Goodsell
6. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology- Hari Singh Nalwa
7. Nanomaterials for Biosensors, Cs. Kumar, Wiley – VCH, 2007
8. Nanostructures and Nanomaterials: Synthesis, properties and applications. GhuzangG.Cao .Imperical College Press, 2004
9. Biosensors: A Practical Approach, J. Cooper & C. Tass, Oxford University Press, 2004
10. Nanotoxicology: Characterization, Dosing and Health Effects, Informa Healthcare. Nancy A. Monteiro – Riviere and C. Lang Tran, 2007.
11. Nanomedicine, Vol. IIA: Biocompatibilityby Robert A. Freitas

The student will be able to

PMB 303 CO1	Identify and classify nanoparticles, understand their synthesis methods, and describe characterization techniques for nanomaterials
PMB 403 CO2	Explain the concept of Biomimicry in nanotechnology and the use of nanotechnology in different sectors such as agriculture, healthcare, and environmental conservation
PMB 403 CO3	Describe computational tools used in biology and diagnostic studies, basic Unix/Linux commands, database concepts, and sequence analysis algorithms.

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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M.Sc. (Final) Microbiology IV Semester (CBCS)
MB 404 Project work : 5 Credits

Its mandate to have project work and the credits to be given are 5

Project Work Assessment: 5 credits (150 marks)

- ✓ **Internal Assessment: 2 credits= 50 marks***

* Internal Exam and assignment based on project work: (30 Marks)
* Project Design Presentation (20 Marks)

- ✓ **Semester end Assessment: 3 Credits= 100 Marks#**

Dissertation work and Final presentation (70 Marks)
Thesis writing and Viva voce (30 Marks)

Dr. SANDEEPTA BURGULA
Professor
Department of Microbiology
Osmania University, Hyd-07.

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