

DEPARTMENT OF MICROBIOLOGY
Kakatiya University
Warangal-506 009 (TS)

Vision:

To provide knowledge and skills in microbiology that will empower the learners through awareness of the significance of microorganisms in the plant, animal, human health, environment, industry, and general human welfare through a problem-based and skill-oriented curriculum.

Mission:

- It shall develop competently, committed, and compassionate leaders with the advanced knowledge, skills, and attitudes required to manage changes in the field.
- It shall endeavor to continuously acquire, upgrade, and disseminate knowledge, creating and developing skills of highly adaptable employees capable of working in both laboratory and managerial roles.
- It shall encourage students to go beyond the classroom and learn about basic research and applications.

Programme Outcomes (POs):

- PO1: Apply theoretical knowledge to develop critical thinking and practical understanding in the field of microbiology to find solutions to human welfare.
- PO2: Acquire, retain and apply technical concepts and knowledge relevant to different fields of microbiology.
- PO3: Obtain knowledge on the role of microbes in human disease, development of novel diagnostic methods, and immune response to microbial infection.
- PO4: Gain hands-on experience with laboratory equipment that could enrich them to perform high throughput research on microorganisms and execute the research methodology required in the food, dairy, and pharmaceutical industries.
- PO5: Communicate scientific concepts, experimental results, and analytical discussions clearly and concisely, both verbal and written.
- PO6: Opt for higher studies in national level institutes and overseas, jobs in various sectors, and entrepreneurship abilities in the field of microbiology (consultancy, training centres, and diagnostic centres).
- PO7: Acquire the ability to work efficiently with a team to accomplish a common goal.
- PO8: Understand the potential and impact of microbiological innovations in reducing environmental pollution, health sector, and agriculture.

Programme Specific Outcomes (PSOs):

PSO1: Get sufficient knowledge on principles and applications of microbiology, which will be applied in various sectors such as research and development, laboratories of microbial product-based industries (production of antibiotics, industrially important enzymes, and dairy products).

PSO2: Students can apply their knowledge in competitive exams such as CSIR-UGC NET, SET, GATE, ICMR-JRF, and other national levels exams, as well as in executing research projects.

Course outcomes (COs):

Semester I

General Microbiology

- CO1: Know the history and development of microbiology contributions of various scientists.
CO2: To gain knowledge on principles of microbial diversity, phylogeny, and taxonomy.
CO3: To learn the general characters and reproductive methods of algae, fungi, and protozoa.
CO4: To understand microbial growth and the environmental effect on microbial growth.
CO5: To learn a metagenomic approach to explore microbial diversity.

Virology

- CO1: Acquire knowledge about the structure and classification of viruses.
CO2: Understand the methods of cultivating plant viruses, animal viruses, and bacteriophages.
CO3: Understand the replication pattern of bacteriophages and plant and animal viruses.
CO4: Learn about viral vaccines, interferons, and antiviral drugs.
CO5: Acquire knowledge of different of viral organisms and their importance in agriculture, environment, and health.

Biological Chemistry

- CO1: Understand the structure of carbohydrates and physicochemical properties from monosaccharides to polysaccharides.
CO2: Understand the structure and classification of amino acids, the design of proteins and types of proteins, understanding of protein purification methods, etc.
CO3: Acquire knowledge about the classification, structures, importance, and functions of lipids.
CO4: Understand the difference between the properties and functions of nucleic acids and their chemical composition.
CO5: Understand the types of vitamins and their crucial role in metabolism. Learn about the structures and functions of porphyrins.

Cell Biology and Enzymology

- CO1: Understanding of energy sources and synthesis of energy, cell signaling, and communication systems.
CO2: Acquire knowledge about cell division, cancer-causing agents, and cancer biology.
CO3: To know the importance of enzymes and their role in different biological pathways.
CO4: Acquire knowledge about the industrial production and applications of enzymes.
CO5: Understanding the application of various enzymes as biosensors.

Semester II

Microbial Physiology and Metabolism

- CO1: Acquire the knowledge on nutritional diversity and nutrient uptake in microorganisms, their physiology, and economic importance
- CO2: Understand the mechanism of phototropism, diversity of phototrophs photochemistry, and modes of CO₂ fixation
- CO3: Understand the metabolism of carbohydrates and the interrelation between different metabolism pathways.
- CO4: To know the concepts of aerobic and anaerobic respiration and energy gaining, primary and secondary metabolisms, and biotransformations.
- CO5: Understand the synthesis and catabolism of various lipids and amino acids. Importance of and breakdown of purine and pyrimidine nucleotides

Molecular Biology

- CO1: Acquire knowledge about DNA replication, damage, and repair mechanisms in prokaryotes and eukaryotes.
- CO2: Understanding of transcription mechanism and role of different enzymes in transcription.
- CO3: To know the importance of translation, protein targeting, folding, and sorting.
- CO4: Acquire knowledge on the factors affecting the regulation of gene expression.
- CO5: Understanding the role of different molecules in various biological systems.

Immunology

- CO1: Learn about the structure and functions of lymphoid organs and the immune system.
- CO2: Understand the principles of antigen-antibody interactions *in vitro* and *in vivo*.
- CO3: Understand immunopathology (autoimmune diseases, hypersensitivity reactions)
- CO4: Acquire knowledge of tumor immunology and tissue and organ transplantation.
- CO5: To understand complement systems and pathways, and Hybridoma technology.

Biophysical Techniques and Instrumentation

- CO1: Understanding the preparation of buffers and gaining knowledge about different types of microscopes.
- CO2: Acquire knowledge about different analytical techniques like centrifugation and chromatographic techniques.
- CO3: To know the importance of different electrophoretic and radiation biology techniques and their applications.
- CO4: Acquire knowledge about spectroscopic techniques and their applications.
- CO5: Understanding the role of different biophysical techniques and their applications in various biological systems.

Semester III

Microbial genetics and Genetic engineering

- CO1: Gain knowledge about recombination and its models. The concept of gene mapping, the importance of plasmids, and transposable elements.
- CO2: Acquire knowledge about the mutation, mutagens, and their types. Importance of mutation screening methods.
- CO3: Gain knowledge of recombinant technology and gene libraries.
- CO4: Understand the mechanism of polymerase chain reaction and types of PCR and their importance.
- CO5: Understand the concept and strategies of gene therapy and its prospects.

Bioinformatics and Computational methods

- CO1: Acquire knowledge about the genomic tools and evolution of organisms.
- CO2: Understanding various biological data management and data access and processing.
- CO3: To know the importance of collecting, analyzing, and interpreting biological data using different statistical methods.
- CO4: Acquire knowledge about different statistical methods and their applications in biology.
- CO5: Understanding the different bioinformatic tools and biostatistical methods and their applications.

Bioprocess Technology

- CO1: Understanding of growth and preservation of industrially important microbes.
- CO2: Acquire knowledge about different fermentation techniques.
- CO3: Understanding the cost effect and recovery of industrially important microbial products.
- CO4: Acquire knowledge about the industrial production of various microbial metabolites.
- CO5: Understanding the role of different microbes and their uses in various industries.

Agricultural Microbiology

- CO1: Acquire knowledge about the soil structures and soil microbes and their interactions with plants in soil fertilization.
- CO2: Understanding the pathogenesis and interaction between pathogens and plants.
- CO3: Acquire knowledge about plant pathogens and their symptoms in various crop plants.
- CO4: Understanding different methods applied in disease control and post-harvest conditions and their control measures.
- CO5: To learn plant pathogens, their interaction, and control methods.

Semester IV

Environmental Microbiology

- CO1: Understand the study of diversity, structure, activities, and evolution of microbes. In short, it focuses on all the interactions of the microbes with the environment.
- CO2: Acquire the knowledge of biodiversity and various elements involved in this concept.
- CO3: Understand the concept and principles of soil microbiology, decomposition of organic matter, and concept of microbial leaching and biomining.
- CO4: Acquire knowledge of water purification methods and pollution control biotechnology.
- CO5: To gain knowledge on atmosphere and airborne microbes, the importance of air sampling methods, air quality, and air sanitation.

Medical Microbiology

- CO1: Application of various fields of medical microbiology.
- CO2: Understand the pathogenesis, epidemiology, and lab diagnostic procedure of bacterial infections.
- CO3: To know the pathogenesis of different types of viral infections.
- CO4: Acquire knowledge about the life cycle and pathogenesis of protozoan diseases.
- CO5: Knowledge of different diagnostic procedures (morphological, serological, and molecular levels).

Microbial Technology

- CO1: Understanding the involvement of different microbes in food spoilage.
- CO2: To know about different types of microbial foods.
- CO3: Acquire knowledge about the production of microbial foods and enzymes.
- CO4: To know about the industrial production of value-added products.
- CO5: Understanding the role of different microbes in spoilage and production of valuable foods and compounds.

Pharmaceutical Microbiology

- CO1: Understanding of growth and preservation of pharmaceutically essential microbes.
- CO2: Acquire knowledge about different types of antibiotics and cosmetics.
- CO3: To know about chemotherapy, mode of action of drugs, and screening methods.
- CO4: Acquire knowledge regarding the assays to identify multidrug-resistant microbes.
- CO5: Understanding pharmaceutically important microbes and their applications.

Ph.D. Programme in Microbiology:

Programme outcome:

The Research Scholars will be able to identify and recognize the root cause of societal problems and their importance in designing scientific experiments to mitigate and solve societal problems with ethical research and scientific temperament. The Research Scholar will become good academicians with sound scientific knowledge and rational thinking. In the end, Research Scholars will be awarded a Ph.D. degree, and they will be more suitable for higher education and industry needs.



KAKATIYA UNIVERSITY
M.Sc. Microbiology Syllabus
For the candidates admitted from the academic year 2021-2022
For University College and affiliated colleges

S. No	Paper Code	Title of Paper	Instruction Hours/week	No. of Credits	Marks		Total
					Internal Marks	External Marks	
Semester I							
1	MBT 101	General Microbiology	4	4	20	80	100
2	MBT 102	Virology	4	4	20	80	100
3	MBT 103	Biological Chemistry	4	4	20	80	100
4	MBT 104	Cell biology & Enzymology	4	4	20	80	100
5	MBP 105	General microbiology & Virology	6	4	-	100	100
6	MBP106	Biological chemistry & Cell Biology & Enzymology	6	4	-	100	100
7	MBS 107	Seminar	1	1		-	25
		Total		25			625
Semester II							
1	MBT 201	Microbial Physiology & Metabolism	4	4	20	80	100
2	MBT 202	Molecular Biology	4	4	20	80	100
3	MBT 203	Advanced Immunology	4	4	20	80	100
4	MBT 204	Biophysical Techniques & Instrumentation	4	4	20	80	100
5	MBP 205	Microbial Physiology & Molecular Biology	6	4	-	100	100
6	MBP 206	Adv. Immunol & Biophy. Tech. & Instrumentation	6	4	-	100	100
7	MBS 207	Seminar	1	1		-	25
		Total		25			625



FACULTY OF SCIENCE M.Sc. MICROBIOLOGY
Semester – I
Theory Paper –I
MBT-101: GENERAL MICROBIOLOGY

Unit – I

- a. Brief history of microbiology. Concepts of biodiversity, levels of biodiversity-importance and distribution of microbial diversity. Systematic position of microorganisms in universal tree of life.
- b. Exploration of microbial diversity: Culture dependant methods: Plate count method, community Level Physiological Profiles (CLLP), Culture independent methods: fatty acid methyl ester (FAME), phospholipid fatty acid (PLFA), Fluorescent antibody technique, FISH, whole cell *In situ* hybridization, reporter genes, thymidine incorporation.
- c. Nucleic acid based methods: G+C content, DNA reassociation, NA hybridization, Restriction fragment length polymorphisms (RFLP), Amplified fragment length polymorphisms (AFLP), Amplified ribosomal DNA (rDNA) restriction analysis (ARDRA), Rapid imaging spectrophotometric array (RISA)/Automated approach for ribosomal intergenic spacer analysis (ARISA), RAPD (Random amplified polymorphic DNA), Stable isotope proofing, Ribotyping, DNA microarrays.
- d. Metagenomic approach to explore microbial diversity, Concepts, principles, outlines of methodology.

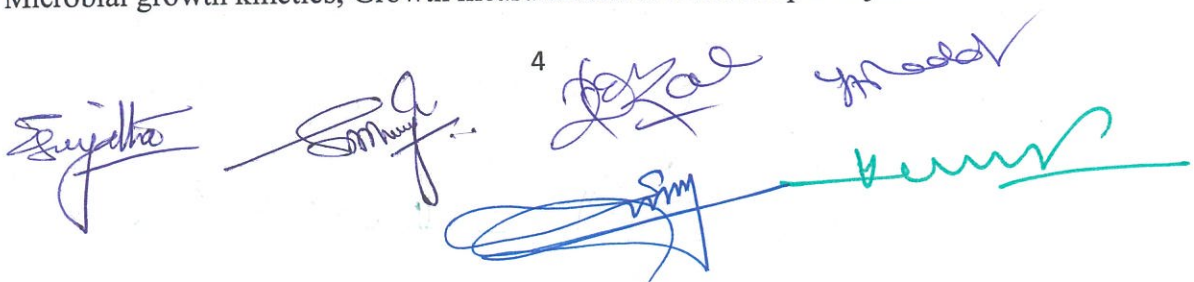
Unit – II

- a. Ultra structure and functions of prokaryotic cell. Detailed study of Archae, Eubacteria and Eukarya.
- b. Major characters used in identification: morphological, physiological, biochemical, ecological, genetical and molecular identification, Numerical taxonomy.
- c. A brief account of Bergey's Manual (Determinative and Systematic), Classification of bacteria according to 2nd edition of systematic bacteriology.
- d. General characters and importance of Rickettsiae, Mycoplasma, Chlamydae and Archaeobacteria.

Unit – III

- a. Growth of bacteria: Batch and continuous cultures. Factors influencing the growth, growth curve.
- b. Microbial growth kinetics, Growth measurement of microscopic objects.

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- c. Unculturable microbial diversity: Reasons for unculturability, improvements in culture cultivation methods. Distribution of unculturable microorganisms in different environments (marine, deep sea, hot springs, soil, biotic).
- d. Phylogeny and taxonomy of uncultured bacteria. Microbial dark matter.

Unit – IV

- a. Classification and general characters of algae- nutrition, thallus organization and reproduction. Characteristics of chlorophyceae, phaeophyceae, rhodophyceae and cyanophyceae.
- b. General characters and outline classification of fungi: Recent trends in classification of fungi according to Assembly of the Fungal Tree Of Life (AFToL). Importance of filamentous fungi.
- c. Structure, reproduction, molecular and biotechnological aspects of Yeasts.
- d. General characters, distribution and classification of protozoa with special reference to pathogenic protozoa. General account of plasmodium, Entamoeba, nematodes and flatworms.

Recommended Books

1. Sneath, P.H.A. and R.R. Sokal 1973 Numerical taxonomy. The Principles and Practice of Numerical Classification, San Francisco. W.H. Freeman
2. Sneath, P.H.A 1989 Analysis and Interpretation of sequence data for bacterial Systematic. The view of a Numerical taxonomist .Syst.Appl.Microbiol.12:15-31
3. Tom Parker, M. Lerline, H.Collier, 1990, Principles of Bacteriology, Virology and Immunity, VIII Ed.
4. Garrity, M. George. Winters, B.S. Denise 2001 Taxonomic outline of the prokaryotic genera Bergeys Manual of Systematic Bacteriology. II Ed.
5. Balows, A.A.G. Thuper, M. Dworker, W. Harder, K.Schleifer 1991 The Prokaryotes , Springer,
6. Verlog Gunsales and Stainer, The Bacteria I-V vol. Academic press
7. M.Madigan, M. T., J.M.Mrtinko and J.Parker 2000 Brock Biology of Microbiology IX Ed .Prentice Hall Inter, Inc.
8. Garrity George, M. Edieor-In Cheaf 2005 Bergey's Manual of Systematic Bacteriology II Ed. (Vol- I-V). J. Brenner, K.R. Krieg, J.T.Stanly. Editors. Springer-Verlog
9. Balows, A.A.G. Thuper, M. Dworker, W. Harder, K. Schleifer 1991 The Prokaryotes , Springer,
10. Prescott, L.M., J.P Harley and D.AKlein, 2007 Microbiology VII Ed. Mc Grow Hill,
11. Davis R.Y. E.A. Adeberg and J.L. Ingram,1991 General Microbiology
12. Stainer General Microbiology, V Ed., Printice Hall of India Pvt,Ltd. New Delhi
13. Schaechter.R. and Ledenberg.J 2004 The desk encyclopedia of microbiology. Elsevier Academic Press California.
14. Vandanme, D. B. Pot, M. Gillis, P. Devos, K. Kersters and J. Swings.1996 Polyphasic taxonomy, a consensus approach to Bacterial Systematic, Microbiological Reviews. 407-438.
15. Mehrotra RS and KR Aneja. An Introduction to Mycology, New Age Publishers.
16. Alexopoulos CJ et al, Introductory Mycology 4th Edition.
17. The Fungi: An Advanced treatise I-IV volumes (Ed) Ainsworth & Sussman; Academic Press.
18. Structure and Reproduction of algae FE Fritsch vol I & II.
19. Introductory Phycology – Trainor, F.R John Wiley, New York.
20. Protozoology – Grell, Karl G .1973 Springer – Verlag, Heidelberg.
21. The biology of Protozoa-Sleigh, MA American Elsevier, New York.

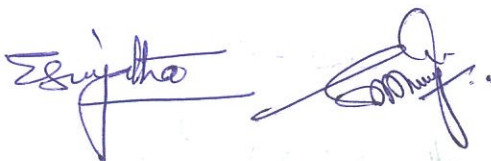
FACULTY OF SCIENCE M.Sc. MICROBIOLOGY
Semester-I
Practical Syllabus Paper-I
MBP- 105: GENERAL MICROBIOLOGY

Experiments

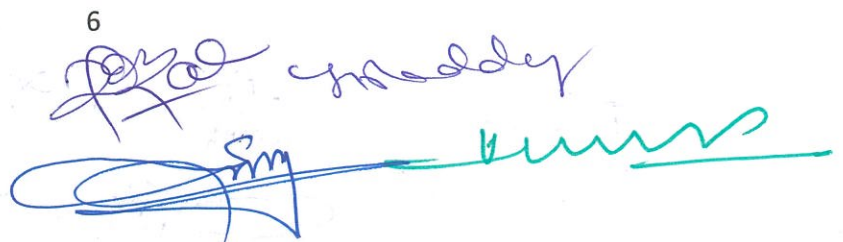
1. Preparation of culture media.
2. Micrometry-Calibration and measurement of microorganisms using ocular and stage micrometers and calculation of the mean and standard deviation.
3. Demonstration of bacterial motility by hanging drop technique
4. Gram staining
5. Endospore staining
6. Flagella staining
7. Capsule staining
8. Staining of PHB granules
9. Demonstration of mycorrhizal association.
10. Measurement of bacteria growth by turbidometric methods.
11. Cultivation of anaerobic bacteria:
 - i) Shake culture technique ii) Pyrogallic acid iii) Candle method iv) Liquid paraffin method v) Gaspak jar method
12. Identification of bacterial cultures by performing biochemical tests
 - a. Indole test
 - b. Methyl red test
 - c. VogesProskauer test
 - d. Citrate test
 - e. Oxidase test
 - f. Carbohydrate fermentation and Gas production
 - g. Catalase test
 - h. Gelatinase test
 - i. Caseinase test
 - j. Amylase test
 - k. H₂S production test
 - l. Nitrate reduction test
 - m. Urease test

Spotters

1. Fungi: *Rhizopus, Mucor, Penicillium, Aspergillus, Alternaria, Curvularia,*
2. Algae: *Nostoc, Scytonema, Oscillatoria, Anabaena, Spirulina,*
3. Protozoa: *Trypanosoma, Giardia, Leishmania, Entamoeba histolytica, Plasmodium,*
(permanent slides),
4. Helminthes: *Ascaris* (round worm), Tape worm (*Teneo solinum*).



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FACULTY OF SCIENCE M.Sc. MICROBIOLOGY

Semester – I

Theory Paper –II

MBT 102: VIROLOGY

Unit – I

- Brief account on discovery of viruses, Chemical composition, morphology and symmetry with reference to T4, TMV, Adeno, Influenza, Rhabdo and HIV. Genome diversity in viruses.
- Subviral particles: Satellite viruses, Viroids, DI particles and Prions
- Taxonomy of viruses: Classification and nomenclature of viruses as per latest version of ICTV.
- Isolation, purification, cultivation, assay and characterization of plant, animal and bacterial viruses.

Unit – II

- Life cycles of bacterial viruses: One step growth curve, Lytic and Lysogenic cycles with reference to T4, λ Phage and ϕ X174.
- Replication patterns of specific plant viruses TMV and CaMV.
- Replication strategies employed by animal viruses: Herpes, Hepatitis, Adeno, Retroviruses and Corona virus (SARS CoV).

Unit – III

- General account of oncogenic viruses (RNA and DNA).
- Viral interferons: nature and source of interferons, types of interferons, mode of action of interferons and therapeutic applications.
- Antiviral drugs: Mode of action of antivirus drugs, Inhibitors of viral attachment, entry of viral agents and uncoating, polymerase inhibitors, protease inhibitors, inhibitors of nucleoside and nucleotide reverse transcriptase and inhibitors of integrase.
- Viral vaccines: Conventional vaccines (live attenuated vaccines and killed vaccines), advanced vaccines (synthetic vaccines, recombinant subunit vaccines, vector vaccines, mRNA and DNA vaccines).

Unit – IV

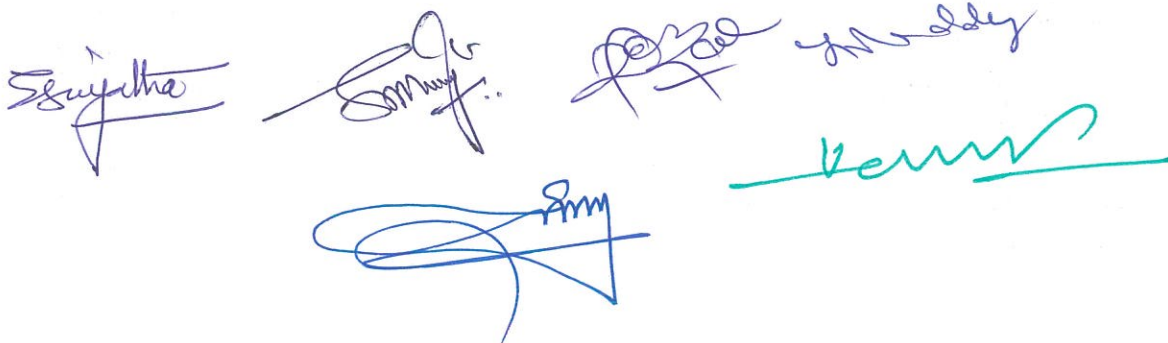
- Importance of applications of viruses in biotechnology, viruses as cloning vectors, CaMV promoter, Phage display.
- Viruses as therapeutic agents (Phage-based therapy). biocontrol agents (Agriculture and aquaculture), waste water treatment, environmental sanitizers.
- Importance and applications of bacteriophages, viruses for gene delivery.
- Emerging and reemerging viral diseases: Causes national and global impact strategies



for tackling emerging diseases, SARS COVID-19, Zika, Hanta, SARS, KFD, H1N1 (Influenza virus subtype), Chandipura viral encephalitis, Nipah viral encephalitis.

Recommended Books

1. Alan J. Cann, 1997 Principles of Molecular Virology.(2nd edition).Academic Press, California.
2. Conrat HF, Kimball PC and Levy J.A. 1988 Virology. II edition. Prentice Hall, Englewood Cliff, New Jersey
3. Dimmock,N.J, Primrose,S. B.1994 Introduction to Modern Virology IV edition. Blackwell Scientific Pub, Oxford
4. Flint, S.J., Enquist, L.W., Krung, R. Racaniello, VR. andSkalka, A.M. (2004). Principles of Virology,ASM Press
5. Molecular Biology, Pathogenesis and Control, ASM Press, Washington D.C.-
6. Roger Hull, 2002 Mathews' Plant Virology. (4th Edition). Academic press-A
7. Ram Reddy S and Reddy S M. 2007 Essentials of Virology Scientific Publishers (India) Jodhpur
8. Knipe, DM et al (eds) 2001 Fields Virology Vol I , Lippincott Williams and Wilkins
9. Granoff,A and Webster R.G. 1999 Encyclopedia of Virology Vol I, II and III San Diego Acad. Press
10. Medical Virology 10th Edition by Morag C and Tim bury M C 1994. Churchil Livingstone, London.
11. Blackwell Scientific Publications. Oxford.
12. Virology 3 rd Edition by Conrat H.F., Kimball P.C. and Levy J.A. 1994. Prentice Hall,
13. Englewood Cliff, New Jersey.
14. Molecular Biology, Pathogenesis and Control by S.J. Flint and others. ASM Press,
15. Washington, D.C. Applied Virology. 1984. Edited by Edonard Kurstak. Academic Press Inc.
16. Introduction to Modern Virology by Dimmock.
17. Prion diseases by Gaschup, M.H.
18. Clinical virology Manual by Stevens, S., Adinka, R I., Young, S.A.



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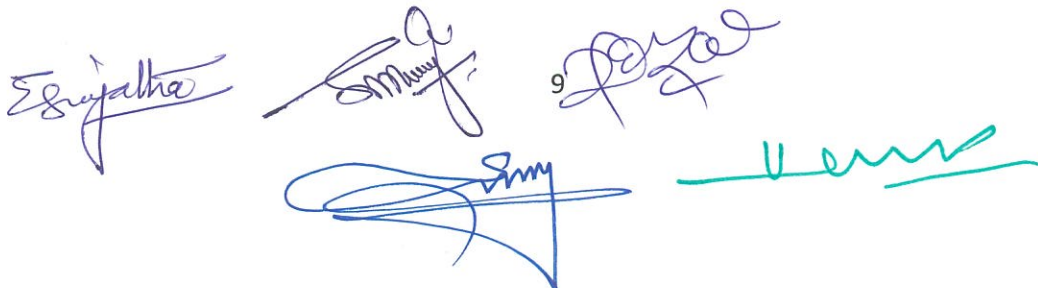
FACULTY OF SCIENCE M.Sc. MICROBIOLOGY
Semester-I
Practical Syllabus Paper-II
MBP 105: VIROLOGY

Experiments

- 1) Isolation of phages from soil/sewage.
- 2) Cultivation and preservation of phages.
- 3) One step growth curve for determination of virus titer.
- 4) Cultivation of animal viruses in developing chick embryo (Amniotic, allontic, CAM).
- 5) Lysogeny-transduction.
- 6) Demonstration of cytopathological changes (slides/pictures).
- 7) Symptomatic observations of plant viral infections.
- 8) Estimation of chlorophyll content in healthy and viral infected leaves.
- 9) Estimation of protein content in healthy and viral infected leaves.
- 10) Haemagglutination inhibition.

Spotters

1. Beijerinck.
2. W.M Stanelly.
3. Tobacco mosaic virus (TMV).
4. Adenovirus.
5. T4 phage.
6. HIV.
7. SARS CoV.
8. Symptoms of plant viral diseases.
9. Symptoms of animal viral diseases.
10. Prions.
11. Density-gradient centrifugation.
12. Genome of Øx174.
13. Plates showing plaques.
14. Latex droplet method.
15. ELISA.
16. *E.coli* infected with T4 phage.



FACULTY OF SCIENCE M.Sc. MICROBIOLOGY
Semester – I
Theory Paper –III
MBT 103: BIOLOGICAL CHEMISTRY

Unit - I


- a. Carbohydrates: Structure, characters and classification. Physico-chemical properties. Monosaccharide-functional isomers, ring structure, glycosides, derivatives of monosaccharide - amino sugars, sugar acids and phosphorylated sugars.
- b. Oligosaccharide-Disaccharides- sucrose, lactose and maltose. Trisaccharides-Raffinose, tetrasaccharide, stachyrose.
- c. Polysaccharides-Structure and occurrence (starch, cellulose, chitin, glycogen and peptidoglycan). Homoglycons, heteroglycons and conjugated glycons. Biological significance of polysaccharides.
- d. Functions of carbohydrates-Energy storage, structural elements, and metabolic intermediates. Carbohydrates as informational molecules.

Unit - II

- a. Amino acids – Structure, chemical properties and types of amino acids, standard amino acids, nonstandard amino acids, peptide bond. D-amino acids, beta- and gamma-amino acids.
- b. Classification of amino acids. Essential and non-essential amino acids. Analysis of mixtures of amino acids. Derivatives of amino acids.
- c. Proteins classification, Physico-chemical properties and biological functions of proteins. Structure organization-Primary, secondary, tertiary and quaternary structures and specificity of proteins, supramolecular assemblies of proteins, glycoprotein and proteoglycans..
- d. Structure and purification methods-Protein isolation, solubilities of proteins, chromatographic separation of proteins and electrophoresis. Characterization of proteins.

Unit - III

- a. Lipids - physico - chemical properties, separation, distribution in nature, characterization and saponification and iodine number.
- b. Classification of lipids, nomenclature, outline structure, properties and functions of glycerides, neutral lipids (waxes, fats and oils).
- c. Phospholipids, spingophospholipids and glycolipids. Steroids- steroid hormones, hormone precursors, plant sterols, ergosterol, stigmasterol and cholesterol.
- d. Properties of lipid aggregates-Micelles and bilayers, liposomes, bilayer dynamics. Biological membranes, fluid mosaic model of membrane structure. Important features of bacterial lipids.

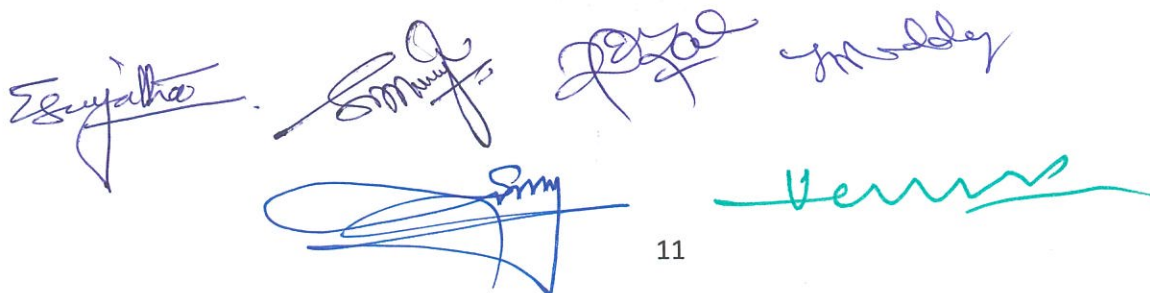


Unit – IV

- a. Types and composition of purine and pyrimidine bases and their nomenclature, nucleosides, nucleotides and polynucleotides. Nucleic acids: Types of RNA and DNA their structure, properties and functions.
- b. Vitamins: Classification, definition and general characteristics, classification of water soluble vitamins, structure and their biochemical properties.
- c. Vitamins: Classification of fat soluble vitamins, structure and their biochemical properties. Deficiency and human requirement of different vitamins.
- d. Porphyrins: Porphyrin nucleus and classification. Importance of metalloporphyrins occurring in nature-hemoglobin, chlorophyll. Bile pigments-chemical nature and their physiological significance.

Recommended Books

1. Voet Donald and Voet J.G .3rd Edition , Biochemistry John Wiley and sons INC
2. Zubay .G. Biochemistry- Wm.C.brown Publishers
3. White .D. 2000 The Physiology and Biochemistry of prokaryotes-Oxford Univ.press
4. Lehninger A.L.Cox and Nelson -2006,4th Edition, Principles of Biochemistry –CBS Publishers and Distribution Pvt.Ltd
5. Stryer .L.5th Edition –Biochemistry .W.H. Freeman and Co
6. Wilson. K. and Walker.J.2000 Principle and Techniques –Practical Biochemistry-Cambridge University press
7. Murray, Harpers Biochemistry Mc Graw Hill
8. White , Handler and Smith-Biochemistry
9. West and Todd –Biochemistry Mac Millan Publishers
10. Corn and Stumpf, 5th Edition-Outlines of Biochemistry-Wiley Eastern Publications.
11. Morrison –Physical Biochemistry (Oxford)
12. Satyanarayana and Chakrapani 3rd Edition-Biochemistry Books and Allied Publishers
13. Trevor Palmer 2004 Enzymes, Affiliated East-West Press Pvt .Ltd
14. Dixon and Webb –Enzymes
15. Rawn, J.D.2004 Biochemistry Panima Pub. Corporation.
16. Voet Donald, J.W.Voet and Ch.W. Pratt, 2006 Fundamentals of Biochemistry 2ndED.Jhon Willey & Sons Inc.
17. David,E. Metzler,2006 Biochemistry 2nd Ed Academic Press
18. Willium, H. Elliott and Daphne ,C. Elliot, 2004 Biochemisry and Molecular Biology 2nd ED Oxford University Press



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FACULTY OF SCIENCE M.Sc. MICROBIOLOGY
Semester - I
Practical Syllabus Paper - II
MBP 106: BIOLOGICAL CHEMISTRY

Experiments

1. Quantitative estimation of glucose by Anthrone method
2. Quantitative estimation of reducing sugars by 3, 5, DNS method
3. Quantitative estimation of fructose
4. Quantitative estimation of proteins by Lowry's method
5. Quantitative estimation of Indole Acetic Acid
6. Quantitative estimation of Ascorbic acid
7. Quantitative estimation of Amino acid
8. Qualitative test of carbohydrates: Glucose, Xylose, Starch, Lactose, Maltose, Sucrose
9. Qualitative test of amino acids: Tryptophan, Tyrosine, Methionine, Arginine, Proline,
10. Qualitative test of proteins: Gelatin, Globulin, Albumin, Peptone, Casein
11. Determination of iodine number of fat
12. Qualitative test of lipids: Cholesterol

Spotters

1. Structure of monosaccharides
2. Structure of Oligosaccharides
3. Structure of Polysaccharides
4. Structure of Amino acids
5. Structure of Proteins
6. Structure of Phospholipids
7. Structure of Cholesterol
8. Structure of nucleotides
9. Structure of DNA
10. Structure of t-RNA
11. Structure of Cyanocobalamin (Vit B12)
12. Structure of Porphyrin



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FACULTY OF SCIENCE M.Sc. MICROBIOLOGY
Semester - I
Theory Paper- IV
MBT 104: CELL BIOLOGY AND ENZYMOLOGY

Unit - I

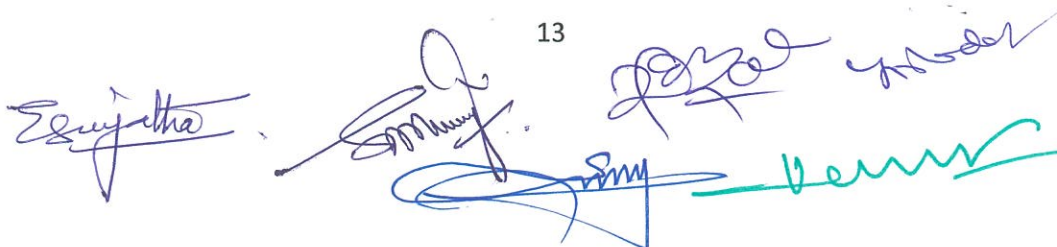
- a. Principles of bioenergetics – Laws of thermodynamics, enthalpy, entropy, concept of free energy: chemical equilibriums; structure and energetics of ATP molecule and other high energy compounds, types of phosphorylation. Oxidation and reduction reactions.
- b. Chemiosmotic hypothesis and proton motive force and energy transformations. Electron transport, oxidative phosphorylation, structure of ATP synthase; mechanism of ATP synthesis. Inhibitors and uncouplers
- c. Membrane structure and dynamics; diversity structure and physiology of membrane pumps, carriers and channels.
- d. Cell signaling pathways: Basic elements of signaling system; extracellular signal molecules, receptors-ion linked, G-protein linked and enzyme linked receptors; calcium and NO as intracellular messengers. Convergence, divergence and crosstalk among different signaling pathways.

Unit - II

- a. Cell cycle: Over view, phases of the cell cycle, cell growth and extra cellular signals, Regulations of cell cycle progression (cyclins and cyclin dependent kinases), cell differentiation and cell cycle check points.
- b. Cancer biology: Types of cancers-benign and malignant, carcinogens - physical, chemical and biological, carcinogenesis, metastasis and invasion, tumorigenesis.
- c. Cancer critical genes: Proto-oncogenes, oncogenes, tumor-suppressor genes (antioncogenes), *p53* gene, telomeres and cancers.
- d. Apoptosis (Programmed cell death): Apoptosis pathways and molecular mechanism of apoptosis.

Unit - III

- a. Introduction and historical perspective of enzymes; properties, classification and nomenclature; structures and biological functions; theory of enzymatic catalysis.
- b. Specificity of enzymes; Models of enzymes action-Fisher's lock and key hypothesis, Koshland's induced fit hypothesis, Haldane and Pauling concept.
- c. Enzyme kinetics: Effect of substrate concentration, derivation of Michaelis-Menten equation, K_s , K_m , V_{max} and K_{cat} and their significance, methods to determine K_m and V_{max} ; Lineweaver-Burk plots, Eadie-Hofstee and Hanes plots.
- d. Enzyme inhibition – competitive, un-competitive, non-competitive, partial, substrate, allosteric inhibitions. Allosteric enzymes, Isozymes, Abzymes.



Unit - IV

- a. Enzyme regulation: Product inhibition and feedback control, allosteric regulation, regulation, enzyme induction and repression, chemical modifications, covalent modifications, calmodulin mediated regulation.
- b. Immobilization of enzymes: Methods of immobilization, ionic binding, adsorption, covalent bonding, micro-encapsulation and gel entrapment, membrane confinement; Practical and economic advantages of enzymes for industrial use.
- c. Enzyme purification: Techniques of enzyme purification, assessment of purity, units of enzyme activity, recovery and yield of enzymes, characterization of enzymes.
- d. Enzyme stabilization by selection and genetic engineering, molecular graphics in protein engineering – Biosensors (glucose oxidase, cholesterol oxidase, urease and antibodies as biosensors).

Recommended Books

1. Getzen berg, R.H. and E.E. Bittar, Cell Structure and Signaling, Elsevier Science.
2. Cossart et al. 2000 Cellular Microbiology
3. Phillip Sheeler and Donald E. Blanch Cell & Molecular Biology 3rd ED John Wiley Pub.
4. Ernet, J.M. Helmreich, The Biochemistry of Cell Signaling, Oxford Press.
5. Cooper, The Cell.
6. De Roberts and De Roberts, 1998 Cell and Molecular Biology. Wavelly Pvt. Ltd.
7. Voet and Voet J.G. 3rd Edition, Biochemistry John Wiley and sons INC
8. Zubay .G. Biochemistry- Wm.C. Brown Publishers.
9. White .D. 2000 The Physiology and Biochemistry of prokaryotes-Oxford Univ. Press.
10. Lehninger A.L. Cox and Nelson -2006, 4th Edition, Principles of Biochemistry –CBS Pub.
11. Gottschalk .G. 1985 Bacterial metabolism –Springer Verlag
12. Stryer .L. 5th Edition –Biochemistry. W. H. Freeman and Co
13. Wilson. K. and Walker.J. 2000 Principle and Techniques –Practical Biochemistry-Cambridge University Press.
14. Murray, Harpers Biochemistry Mc Graw Hill.
15. Morrison –Physical Biochemistry (Oxford).
16. Satyanarayana and Chakrapani 3rd Edition-Biochemistry Books and Allied Publishers.
17. Trevor Palmer – Enzymes, 2004 Affiliated East-West Press Pvt .Ltd.
18. Dixon and Webb –Enzymes.
19. Pollard T D and Earnshaw W. C .2008 Cell Physiology 2nded Saunders, Elsevier.
20. Albert *et al.*, Molecular Biology of cell. 4th Edition Garland Publishing Inc.
21. Karp Gerald 2008 Cell and Molecular Biology John Wiley & Sons, Inc. Lewin, B. 2004 Genes VIII. Oxford University Press, Oxford.
22. Principles of Biochemistry, 3rd Edition by Lehninger, Nelson & Cox.
23. White, D. 1995 The Physiology and Biochemistry of Prokaryotes, Oxford University Press,



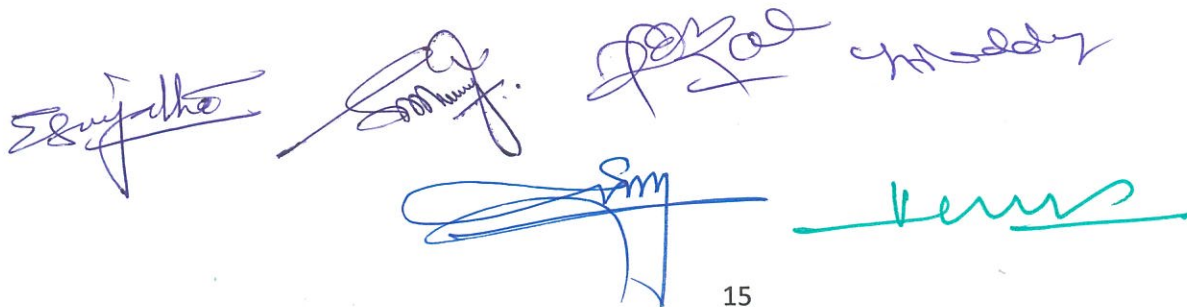
FACULTY OF SCIENCE M.Sc. MICROBIOLOGY
Semester – I
Practical Syllabus Paper- IV
MBP 106: CELL BIOLOGY AND ENZYMOLOGY

Experiments

1. Demonstration of mitotic cell division stages
2. Demonstration of meiotic cell division stages
3. Evaluation of kinetic constant of the purified enzyme.
4. Effect of PH on enzyme activity
5. Effect of temperature on enzyme activity
6. Effect of time on enzyme activity
7. Effect of enzyme concentration on enzyme activity
8. Effect of enzyme inhibitors on enzyme activity.
9. Immobilization of Enzymes
10. Enzyme purification
11. Estimation of arginase activity
12. Estimation of catalase activity.

Spotters

1. Giant chromosomes
2. Polytene chromosome
3. Lampbrush chromosome
4. Cell cycle
5. Metaphase
6. Anaphase
7. Lock and key model
8. Allosteric inhibitors
9. Un- Competitive enzyme activity
10. Non-Competitive enzyme activity
11. Competitive enzyme activity
12. Lineweaver-Burk plots.

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FACULTY OF SCIENCE M.Sc. MICROBIOLOGY
Semester – II
Theory Paper – I
MBT 201: MICROBIAL PHYSIOLOGY AND METABOLISM

Unit – I

- a. Nutritional diversity in microorganisms, nutritional types - autotrophy, heterotrophy, chemotrophy, phototrophy, lithotrophy and organotrophy. Nutrition –essentiality of major and minor elements, growth factors.
- b. Uptake of nutrients: passive diffusion, facilitated diffusion, active transport, group translocation, iron transport–siderophores.
- c. Chemotrophism: (sulphur, ammonia, nitrite, iron, hydrogen, carbon monoxide oxidizers) and their importance, reverse electron transport, CO₂ assimilation, reductive acetyl COA pathway.
- d. Chemoheterotrophism: Acetogens, Methanogens, physiology of methanogenesis and its importance. Physiology and economic importance of methylotrophs.

Unit – II

- a. Phototropism: Oxygenic and anoxygenic phototrophs and their diversity, photosynthetic pigments and their light absorption, basic photochemistry of PSI, PSII and light driven electron transport.
- b. Modes of CO₂ fixation (Calvin cycle, reverse TCA cycle, HP pathway), Halobacterial photosynthesis. Anaplerotic reactions.
- c. Carbohydrate metabolism – various pathways underlying the utilization of different sugars (EMP, ED, HMP, phosphoketolase pathway) in microorganisms. Gluconeogenesis and its significance.
- d. Outlines of inter relationship between carbohydrate, protein and lipid metabolisms.

Unit – III

- a. Aerobic respiration: TCA cycle- intracellular location and reactions, amphibolic reactions. Glyoxalate cycle. Mechanisms of substrate–level phosphorylation. Respiratory electron transport in mitochondria and bacteria. Mechanism of oxidative phosphorylation.
- b. Anaerobic respirations: sulphate, nitrate, carbonate respirations and their ecological significance.
- c. Fermentations: Types of fermentations, alcoholic, lactate, propionate, mixed acid, butyrate and butanol fermentations and their industrial importance.
- d. Concepts of primary and secondary metabolisms. Biosynthesis of secondary metabolites with special reference to penicillin and polyketides, biotransformation, Bioluminescence, quorum sensing.

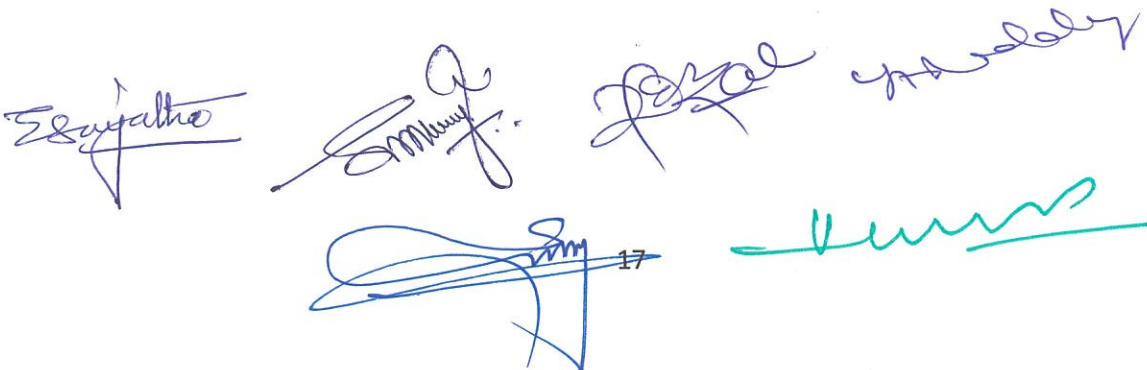


Unit – IV

- a. Lipid metabolism: Biosynthesis of glycerols, phospholipids, glycolipids and fatty acids. Cholesterol biosynthesis. Oxidation of saturated and unsaturated fatty acids.
- b. Amino acid metabolism: Assimilation of inorganic nitrogen and sulphur. Biosynthetic pathways of amino acids and their regulation with emphasis on tryptophane and histidine. Porphyrin biosynthesis.
- c. Catabolism of amino acids: Transamination, decarboxylation and deamination. Degradation of proteins-proteases, exo-endo peptidases.
- d. Nucleotide metabolism: Biosynthesis of purine and pyrimidine nucleotides-salvage and *de novo* pathways. Biosynthesis of deoxyribonucleotides and regulation. Catabolism of nucleotides.

Recommended Books

1. Caldwell, D.R. 1995 Microbial Physiology and Metabolism, Wm. C. Brown Publishers, USA
2. Lansing M. Prescott, John P. Harley and Donald A. Klein. 2019 Microbiology (9th edition). McGraw-Hill Company, New York.
3. Larry McKane and Judy Kandel. 1996 Microbiology-Essentials and applications. (2nd edition). Mc Graw Hill, Inc., New York.
4. Moat, A.G. and Foster, J.W. 1988 Microbial Physiology (Second Edition). John Wiley & Sons.
5. Pelczar Jr, M.J. Chan, E.C.S., Kreig, N.R. 1993 Microbiology, Mc. Graw Hill. Inc, New York.
6. Salle, A.J. 1996 Fundamental principles of Bacteriology (7th edition). Tata McGraw-Hill publishing company limited, New Delhi.
7. White, D. 1995 The Physiology and Biochemistry of Prokaryotes, Oxford University Press,
8. Ram Reddy, S and S.M. Reddy, 2006 Microbial Physiology, Scientific Pub, Jodhpur.
9. Donald Voet and Judith G. Voet, 1995. Biochemistry – Second Edition. John Willey and Sons,
10. Lubert Stryer. 1995. Biochemistry.(4th edition). W.H. Freeman and company, New York.
11. Zubay, G. 1998 Biochemistry WCB. Mc Graw – Hill, Iowa.
12. Principles of Biochemistry, 3rd Edition by Lehninger, Nelson & Cox.
13. Harper's Review of Biochemistry by Martin, Mayer & Rodwell.
14. Smith, Hill, Lehman, Lefkowitz, Handler & White. Principles of Biochemistry: General aspects
15. Outlines of Biochemistry (5th edition) Conn, Stumpf, Bruening & Doi.
16. Gottschalk G. 1986 Bacterial Metabolism 2nd ed. New York: Springer –Verlag.
17. Dawes, I.W., Sutherland ,IW 1992 Microbial Physiology 2nd edition London: Blackwell scientific Publishers



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FACULTY OF SCIENCE M.Sc. MICROBIOLOGY

Semester – II

Practical Syllabus Paper – I

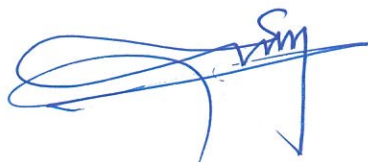
MBP 205: MICROBIAL PHYSIOLOGY & METABOLISM

Experiments

1. Growth of the bacteria at different P^H.
2. Effect of different temperatures on bacterial growth.
3. Effect of osmotic pressure.
4. Isolation of photosynthetic bacteria from sewage water.
5. Estimation & characterization of bacterial chlorophylls.
6. Enrichment cultivation of photosynthetic bacteria – Winogradsky column.
7. Determination of Thermal death time.
8. Carbohydrate catabolism by microorganisms through oxidation and fermentation of glucose.
9. Estimation of ethanol in fermentation broth.
10. Estimation of lactic acid in fermentation broth.

Spotters

1. Passive diffusion.
2. Facilitated diffusion.
3. PSI.
4. PSII.
5. Halobacterial photosynthesis.
6. Electron transport.
7. Biotransformation.
8. Bioluminescence.
9. Quorum sensing.
10. Phospholipids.
11. Steroids.
12. Ribonucleotide reductase.



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FACULTY OF SCIENCE M.Sc. MICROBIOLOGY
Semester – II
Theory Paper – II
MBT 202: MOLECULAR BIOLOGY

Unit – I

- a. Chromosome organization in prokaryotes and eukaryotes.
- b. DNA replication: General principles, enzymes involved in DNA replication, various models of replication (semi conservative, rolling circle, unidirectional and bidirectional). DNA synthesis by reverse transcription, inhibitors of DNA replication.
- c. DNA damage: Types of damage (deamination, oxidative damage, alkylation, and pyrimidine dimers).
- d. DNA Repair pathways: Methyl-directed mismatch repair, very short patch repair, nucleotide excision repair, base excision repair, recombination repair and SOS system.

Unit – II

- a. Structural features of rRNA, tRNA and mRNA and their functions.
- b. Transcription: General principles, basic apparatus, RNA polymerases, promoters, enhancers and other regulatory sequences.
- c. Mechanism of transcription and inhibitors of transcription in prokaryotes and eukaryotes.
- d. Post-transcriptional modifications: Transcriptional attenuation, cutting and trimming of rRNA, mRNA modifications (capping, polyadenylation and splicing), cutting and modification of tRNA, catalytic RNA (Ribozymes), group I and group II intron splicing and RNase P.

Unit – III

- a. Translation: Basic features of genetic code, Wobble concept, prokaryotic and eukaryotic ribosomes.
- b. Details of translation: Initiation, elongation and termination, factors that control the translation, inhibitors of protein synthesis.
- c. Post-translational modifications: Chemical modifications of proteins, proteolytic degradation, Inter splicing and protein folding.
- d. Protein sorting and targeting: Signal hypothesis-signal sequences, signal recognition particle and role of molecular chaperones in protein folding and targeting.

Unit – IV

- a. Regulation of gene expression: Operon concept, regulatory elements of operon - inducers, apo-repressors and co-repressors, positive and negative regulations, catabolite repression and regulation attenuation.

- b. Detailed account of structure, function and regulation of *lac* operon, *trp* operon and *ara* operon.
- c. Global regulatory responses: Heat shock response, stringent response, SOS response and Regulation by small molecules such as ppGPP, pppGPP and cAMP.
- d. Hormone and Environmental factors affecting gene expression coordinate regulation of unlinked genes. Regulatory RNA.

Recommended Books

1. Brown, T.A. 1999 Gene Cloning. 3rd edition. Chapman and Hall Publications, USA.
2. Chirikjian, J.G. 1995 Biotechnology – Theory and Techniques, Vol. II, Jones and Bartlett Publishers.
3. Gerhardt, P. Murray, R.G., Wood, W.A., and Kreig, N.R. 1994 Methods for General and Molecular Bacteriology, ASM Press, Washington D.C.
4. Glick, B.R. and Pasternak, J.J. 1998 Molecular Biotechnology – Principles and Applications of Recombinant DNA, ASM Press, Washington D.C.
5. Lewin, B. 2008 Genes IX. Oxford University Press, Oxford.
6. Murray Moo 1992 Plant Biotechnology. Young, Pergamon Press.
7. Antony, J.F., Griffiths, Gilbert, W.M., Lewontin, R.C. and Miller, J.H. 2002 Modern genetic analysis, Integrating Genes and Genomes, 2nd edition, WH Freeman and Company, New York.
8. Blackburn, G.M. and Gait, M.J. 1996 Nucleic acids in chemistry and biology. Oxford University Press.
9. Molecular Biology of cell. Albert *et al.*, 4th Edition Garland Publishing Inc.
10. Maloy, S.R., Cronan, J.R. Freifelder, D. 1994 Microbial Genetics, Jones and Bartlett Publishers.
11. Macinski, G.M. and Freifelder, D. 1998 Essentials of Molecular Biology, 3rd Ed, John and Bartlett Publishers.
12. Sir John Kendrew 1994 The Encyclopedia of Molecular Biology. Blackwell Science Ltd
13. Watson, J.D., Hopkins, N.H., Roberts, J.W., Steitz, J.A. and Weiner, A.M. 1998 Molecular Biology of the Gene, 4th edition, Benjamin/Cummings publishing company.
14. Freifelder, D. 1997 Essentials of Molecular Biology. Narosa Publishing House, New Delhi.
15. Freifelder, D. 1990 Microbial Genetics. Narosa Publishing House, New Delhi.
16. Snyder, L. and Champness, W. 1997 Molecular Genetics of Bacteria. ASM press, USA.
17. Maloy, S.R., Cronan, J.E. and Freifelder, D. 1994 Microbial Genetics, Jones and Bartlett Publishers, London.
18. Turner, P.C., McLennan, A.G., Bates, A.D. and White, M.R.H. 1998 Instant Notes in Molecular Biology, Viva Books Pvt., Ltd., New Delhi.
19. Twynan, R.M. 2003 Advanced Molecular Biology. Viva books Pvt. Ltd. New Delhi.
20. Ram Reddy S, Venkateswarlu K and Krishna Reddy V 2007 A Text Book of Molecular Biotechnology Himalaya Publishers Hyderabad.
21. Ram Reddy S. 2021. Plant Molecular Biology, Telugu Akademi (English version) Hyderabad.

Sevatho

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FACULTY OF SCIENCE M.Sc. MICROBIOLOGY

Semester – II

Practical Syllabus Paper – II
MBP 205: MOLECULAR BIOLOGY

Experiments

1. Estimation of DNA by DPA method.
2. Estimation of RNA by orcinol method
3. Isolation of DNA from sheep Liver / yeast/ *E.coli*
4. Determination of purity of DNA
5. Isolation of RNA from plant sample
6. Isolation of RNA from viral infected plant sample
7. Problems on DNA characteristics
8. Problems related to Transcription, Genetic code,
9. Problems related to Translation and Gene regulation.

Spotters

1. ATPase
2. Semiconservative model of DNA replication
3. Rolling circle replication
4. Replication fork
5. Nucleosomes
6. DNA damages
7. Action of topoisomerase
8. Okazaki fragments
9. RNA splicing & spliceosome
10. Structure of *lac* operon
11. Structure of *Trp* operon
12. Structure of *Ara* operon
13. Structure of CAMP.
14. Structure of P₄PPGTP.
15. Molecular Chaperons
16. Ribosomes.

Srijalho

Smita

Jaya Prasad

Smita

Sumit

FACULTY OF SCIENCE M.Sc. MICROBIOLOGY

Semester-II

Theory Paper – III

MBT 203: ADVANCED IMMUNOLOGY

Unit – I

- History and scope of immunology, haematopoiesis, structure and function of cells and organs of immune system.
- Types of immunity (innate and acquired, active and passive) immune response (cell mediated and humoral response).
- Immunohaematology: Blood groups, blood transfusion, Rh-incompatibility.
- Antigens: Antigen types, haptens, epitopes, adjuvants, Antigen specificity. Antibodies: Immunoglobulins structure, distribution and function. Theories of antibody production.

Unit – II

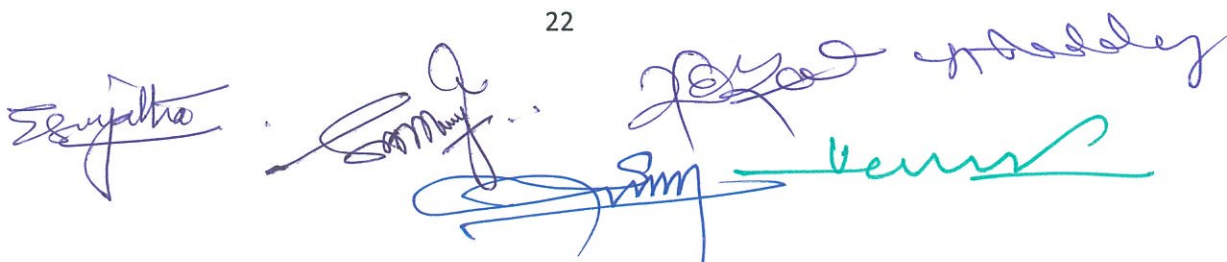
- Immunological reactions: *In vitro* methods: Agglutination, Precipitation, Complement fixation, Immunofluorescence, ELISA and RIA, cell-sorting-flow cytometry.
- In vivo* methods: Phagocytosis, Opsonization and Neutralization.
- Complement components, complement activation pathways (Classical, Alternative and Lectin pathways).
- Regulation of complement system, biological consequences of complement, and complement deficiencies.

Unit – III

- Transplantation immunology: Structure and functions of MHC (Major histocompatibility complex).
- HLA tissue typing and Organ transplantation (graft versus host reaction and rejection).
- Tumor Immunology: Tumor antigens, Host immune response to tumors.
- Tumors escape mechanisms, immunodiagnosis of tumors and immuno-therapy of tumors.

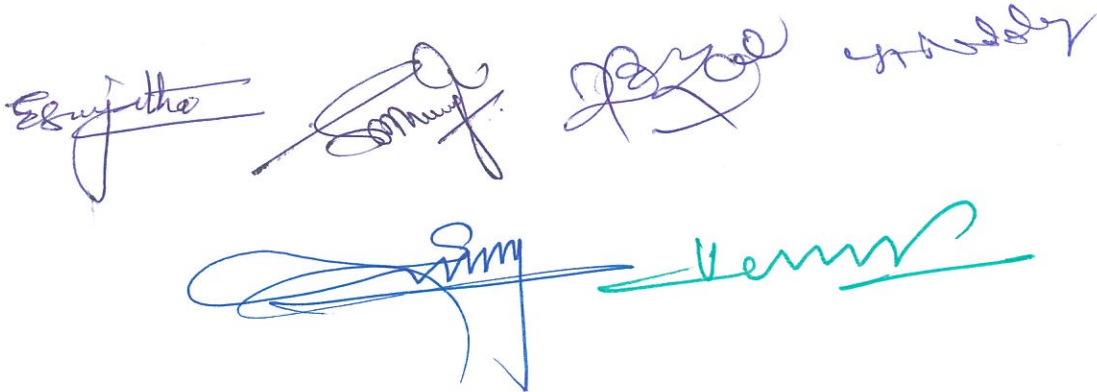
Unit – IV

- General account of immuno deficiency disorders: Primary and Secondary Immunodeficiency. Phagocytic cell disorder, Autoimmunity and autoimmune disorders.
- Hypersensitivity reactions: Type-I, II, III and IV and their respective diseases, immunodiagnostic methods of hypersensitivity.
- Hybridoma technology for synthesis of monoclonal antibodies and their applications. Recombinant antibodies.
- Types of Vaccines: whole organism vaccines, Recombinant vaccines, DNA vaccines, synthetic peptide vaccines, Subunit vaccines, Immunization procedures.



Recommended Books

1. Bellanti. J.A.1985 Immunology III Ed.
2. Coleman, R.M. Lambard, M. F. and Siccard , 1992 Fundamental of Immunology II Ed.
3. Kuby, J. 2004 Immunology VI Ed. W.H. Freeman and Company New York.
4. Poul, W.E. 1990 Fundamental of Immunology II Ed. Ravar Press, New York.
5. Riot. M.Ivan 1998 Essential Immunology VII Ed. ELBS and Black well Scientific Pub. .
6. Tizarrd. I.R. 2004 Immunology an Introduction II Ed. Thomson Asia Pvt. Ltd
7. Ross. G.D. Immunology of the complement System
8. Riott, J.M. Brostoff, J.J and Male D.K. 1996 Immunology IV Ed. CV Mos by Pub. St. Loius.
9. Johnstone, A. and R. ThropeImmuno Chemistry.
10. Weir, Hand Book of experimental Immunology Voll, II
11. Stiter, Terr and Parlow Basic and Clinical Immunology
12. Tom Parker, M. Lesline, H. Collier, 1990 Principles of Bacteriology, Virology and Immunity.VII Ed.
13. Chapel, H. and Halbey, 1986 Essentials of clinical Immunology ELBS London.
14. Donald M. Weir, John Steward, 1993 Immunology VII Ed. ELBS, London.
15. Hue Davis, 1997 Introductory Immunology Champman and Hall Publisher.
16. Peter, J Delves, Ivan M. Roit Ed 1998 Encyclopedia of Immunology II Ed.Acad, Press.
17. Ridklad, M. Aydl, 1995 Immunology II Ed. Baltimore, Hangkang, NMS Pub.
18. Janeway, C. 2004 Immunology VI ED, Garland Science. New York.



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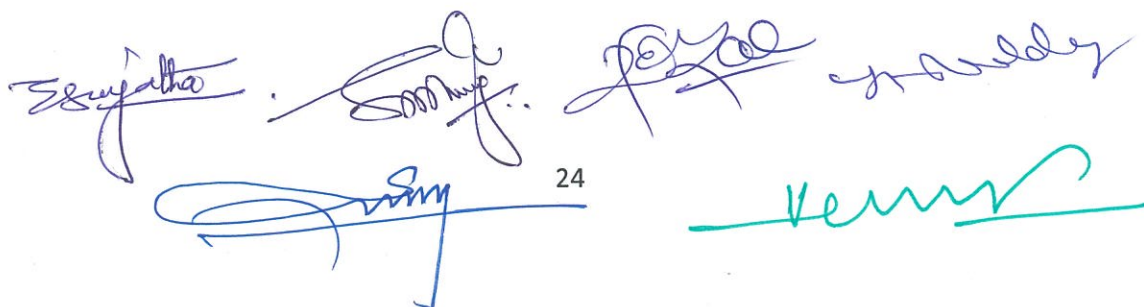
FACULTY OF SCIENCE M.Sc. MICROBIOLOGY
Semester – II
Practical Syllabus Paper- III
MBP 206: ADVANCED IMMUNOLOGY

Experiments

1. Typing of human blood groups. (Haemagglutination).
2. Differential staining of WBC by Leishman's stain.
3. Enumeration of RBC and WBC.
4. Estimation of hemoglobin count in blood.
5. Widal tests: i) Slide agglutination ii) Tube agglutination methods.
6. VDRL test (Venereal disease research laboratory).
7. Hepatitis-B Surface antigen test.
8. HCG test (Agglutination inhibition test).
9. ELISA test.
10. Detection of rheumatoid factor (RF factor).
11. ASO Test- Anti streptolysin 'O' test.
12. Immuno diffusion test: i) Single radial immuno diffusion ii) Double immuno diffusion.
13. Immunoblotting for detection of proteins by staining.
14. Immuno electrophoresis.
15. Isolation of lymphocytes.

Spotters

1. Lymph node.
2. Spleen.
3. Thymus gland.
4. Structure of IgG, IgM, IgA, IgE.
5. Monoclonal antibodies.
6. ELISA plate.
7. Immuno precipitation.
8. Flow cytometry.
9. Immunofluorescence.
10. RIA.
11. Hypersensitive reactions Type-I,II,III,IV
12. Systemic lupus erythematosus (SLE).
13. Myasthenia gravis disease.


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FACULTY OF SCIENCE M.Sc. MICROBIOLOGY
SEMESTER- II
Theory Paper- IV
MBT 204: BIOPHYSICAL TECHNIQUES & INSTRUMENTATION

Unit – I

- a. Buffers: Henderson and Hesselbach equation, P_{ka} and P_{kb} . Preparation of buffers, measurement of pH, types of electrodes.
- b. Viscosity: specific, intrinsic and reduced viscosities, viscometers, determination of molecular size and shape through viscosity.
- c. Osmosis: Osmosis in relation to molecular size and molecular weight, osmometer; Dialysis, Membrane filtration and application.
- d. Microscopy: Phase contrast, Fluorescence microscopy, Electron microscopy- Transmission and Scanning electron microscopes (TEM & SEM).

Unit – II

- a. Centrifugation techniques: Basic principles of centrifugation, standard sedimentation coefficient and measurement of sedimentation coefficient.
- b. Analytical and preparative centrifugation, differential, rate zonal and equilibrium density gradient centrifugation. Applications in determination of molecular weight.
- c. Chromatography: General principles. Types - partition, adsorption; paper and thin layer chromatography.
- d. Column chromatography, HPLC, GLC, Gel filtration, Ion exchange chromatography and Affinity chromatography.

Unit – III

- a. Electrophoresis: General principles, Types - moving boundary electrophoresis, paper electrophoresis, cellulose acetate, starch gel electrophoresis, polyacrylamide electrophoresis and agarose gel electrophoresis.
- b. Pulse-field gel electrophoresis, horizontal and vertical electrophoresis, two-dimensional electrophoresis, immune-electrophoresis, iso-electric focusing electrophoresis, capillary electrophoresis. Blotting techniques -Southern, northern and western blotting.
- c. Radioisotopic techniques: Principle and applications of tracer techniques in biology. Radioactive isotopes, Radioactive decay and commonly used isotopes in biology.
- d. Detection and measurement of radioactivity, Geiger-Muller counter, scintillation counter, Autoradiography, labeling procedures and safety aspects.

Unit – IV

- a. Spectroscopic techniques: Principle, simple theory of absorption of light by molecules, electromagnetic spectrum.



- b. Spectroscopy: The two most important tools used in nanotechnology research – Infrared spectroscopy and Raman spectroscopy.
- c. Instrumentation: Measuring the absorption and application of UV-visible spectrophotometer, Fluorescence spectroscopy.
- d. Instrumentation: Measuring the absorption and application of NMR, ESR and Mossbauer spectroscopic method.

Recommended Books

1. Hames, B.D. and Rickwood, D. 1990 Gel Electrophoresis A Practical Approach, Oxford University Press, New York.
2. Westermeier, R. 1993 Electrophoresis in practice VCH, Federal Republic of Germany.
3. Cotterill, R.M J. 2002 Biophysics An Introduction, John Wiley and Sons England.
4. Harrett, R.H. and Grisham C...M, 2004 Biochemistry III Ed. Cole publishing co. California.
5. Nolting, B. 2006 Methods in Modern Biophysics II Ed. Springer, Germany.
6. Pattabhi, V. and Goutham .N.2002 Biophysica Kluwer Academic Pub. New York
7. Wilson Keith and Walker John 2005 Principles and Techniques and Biochemistry and Molecular Biology VI Ed. Cambridge University press, New York.
8. Narayana .P. 2000 Essentials of Biophysics New Age International Pub. New Delhi.
9. Stephenson, F.H. 2003 Calculation in molecular biology and biotechnology Academic Press, Elsevier Science .London.
10. Keeler, J.2002 Understanding NMR spectroscopy. John Wiley and Sons England.
11. Cavangh John et al 1995 Proton NMR, Spectroscopy principles and practice, Academic Press.
12. Holme. D.J. and H. Peck. Analytical Biochemistry.
13. A. Upadhyay, K.Upadhyay and N. Nath 2006 Biophysical Chemistry, Principles and Techniques Himalaya Pub. House.
14. Slater, R.J. 1991 Radioisotopes in Biology. A practical Approach, IRL Press, Oxford.
15. Holler, F.J., D.A. Skoog and S.R. Crouch, 2007 Principles of Instrumental Analysis IV ED. Thomson, Brooks/Cole Pub. US
16. Richard Brooker and Earl Boysen (2006). Nanotechnology. Wiley Publishing Inc., India. Pp 361.
17. Reddy, SM and Ramchander M. 2020. Instrumentation in Biosciences. Scientific Publishers (India), Jodhpur.

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FACULTY OF SCIENCE M.Sc. MICROBIOLOGY
Semester –II
Practical Syllabus Paper- IV
MBP 206: BIOPHYSICAL TECHNIQUES & INSTRUMENTATION

Experiments

1. Determination of Pka value of amino acid
2. Determination of y max of a given solution
3. Separation of Carbohydrates by Paper Chromatography
4. Separation of Amino Acids by Paper Chromatography
5. Separation of Lipids by Thin Layer Chromatography
6. Demonstration of Column Chromatography
7. Verification of Lambert-Beers Law By UV-VIS Spectrophotometer
8. Separation of Proteins by Electrophoresis
9. Separation of DNA by Electrophoresis
10. Ultraviolet Spectroscopy of Proteins
11. Membrane separation-Dialysis.

Spotters

1. Gas Liquid Chromatography
2. Gel filtration Chromatography
3. Column Chromatography
4. HPLC
5. Ion Exchange Chromatography
6. Affinity Chromatography
7. Electrophoretic Unit
8. Banding pattern of Proteins (Gel image)
9. Banding patterns of DNA (Gel image)
10. Southern blotting
11. Northern blotting
12. Western bolting.
13. Centrifuge.
14. U.V spectrophotometer.
15. Fluorescence spectrophotometer.
16. Raman spectroscopy.

Sugantha

Smruti

Smruti 27

Pradeep Choudhary

Venur

M. Sc. Microbiology
Syllabus (Semester-wise)
w. e. f. the academic Year 2021-2022
for University College and Affiliated Colleges



Department of Microbiology
KAKATIYA UNIVERSITY
WARANGAL- 506 009 (TS)



KAKATIYA UNIVERSITY
M.Sc. Microbiology Syllabus
For the candidates admitted from the academic year 2021-2022
For University College and affiliated colleges

S. No	Paper Code	Title of Paper	Instruction Hours/week	No. of Credits	Marks		Total
					Internal Marks	External Marks	
Semester III							
1	MBT 301	Microbial Genetics & Genetic Engineering	4	4	20	80	100
2	MBT 302	Bioinformatics & Computational Methods	4	4	20	80	100
3	MBT 303	Bioprocess Technology	4	4	20	80	100
4	MBT 304	Agricultural Microbiology	4	4	20	80	100
5	MBP 305	Micro. and Gen. Engi. & Bioin. and Comp. Meth.	6	4	-	100	100
6	MBP 306	Bioprocess Technology & Agri. Microbiology	6	4	-	100	100
7	MBS 307	Seminar/Tutorials	1	1		-	25
		Total		25			625
Semester IV							
1	MBT 401	Environmental Microbiology	4	4	20	80	100
2	MBT 402	Medical Microbiology	4	4	20	80	100
3	MBT 403	Microbial Technology	4	4	20	80	100
4	MBT 404	Pharmaceutical Microbiology	4	4	20	80	100
5	MBP 405	Environmental Microbiol. & Medical Microbiol.	6	4	-	100	100
6	MBP 406	Microbial Technology & Pharmaceutical Micbio.	6	4	-	100	100
7	MBS 407	Seminar/Tutorials	1	1		-	25
		Total		25			625

Semester-III
Paper-I
MBT 301: MICROBIAL GENETICS & GENETIC ENGINEERING

Unit - I

- a. Genetic recombination in bacteria: Conjugation (including sexduction), Transformation and transduction; Models of homologous recombination - The Holliday model and Double strand break repair model. Site-specific recombination.
- b. Gene mapping in prokaryotes: Deletion mapping, complementation, intragenic complementation, heteroduplex mapping, DNA footprinting, Chromosome walking, and jumping.
- c. Plasmids: Types and Characteristics of plasmids, F plasmids, R-plasmids, Colicinogenic plasmids, Ti-plasmid and other plasmids, broad host range plasmids.
- d. Transposable elements: Types of Bacterial transposons, mechanism, and types of transposition. Genetic phenomena mediated by transposons, transposons as genetic tools.

Unit - II

- a. Mutations: Types of mutagens (physical, chemical, and environmental), mutagenesis, types of mutations; Molecular basis of mutations-frameshift mutations, transitions, transversions.
- b. Site-directed mutagenesis and its significance.
- c. Mutation screening in microorganisms: Evaluation of mutagens using microbial systems, Ames test, Replica Plating method, Antibiotic enrichment test, and Chromogenic substrate test.
- d. Molecular methods for detection of mutations: Genotyping of Bacteria and Viruses, DNA sequencing, AFLP, RFLP, and RAPD methods.

Unit - III

- a. Recombinant DNA technology: DNA manipulating enzymes, Restriction endonucleases - specificity, sticky ends and blunt ends.
- b. Cloning vectors: Plasmids, phasmids, phagemids, cosmids, YAC, and BAC vectors and their advantages and disadvantages. Ligation, optimizing ligation conditions- linkers, adapters, homopolymer tailing.
- c. Selection of transformants: Insertional inactivation, Blue and white selection. Identification of cloned genes-colony hybridization.
- d. DNA libraries: Construction and screening of genomic libraries, isolation of mRNA, cDNA synthesis, and cDNA libraries.

Unit - IV

- a. Polymerase chain reaction (PCR) technology: Theoretical aspects of PCR- PCR cycle, thermostable DNA polymerases, primers, and their importance, optimizing the conditions for PCR, factors limiting PCR efficiency.
- b. Different versions of PCR: AP-PCR, Multiplex PCR, Broad range PCR, Inverse PCR, Nested PCR, Real time PCR and their applications; Applications of PCR technology- Forensic, clinical diagnosis, detection of pathogens in food, water; PCR in molecular evolution.
- c. Applications of rDNA technology in agriculture, medicine, and industry: Production of heterologous protein products, role of expression vectors, production of insulin, human growth hormone, and hepatitis vaccine.
- d. Gene therapy: Inherited disorders, detection of gene defects, strategies for gene therapy- *in vivo* and *ex vivo*. Gene delivery strategies: viral vectors and liposomes and their advantages and disadvantages. Future prospects of gene therapy.

Recommended Books

1. Brown, T.A. 1999 Gene Cloning. 3rd edition. Chapman and Hall Publications, USA.
2. Burrell, M.M. 1993. Enzymes of Molecular Biology, Humana Press.
3. Glick, B.R. and Pasternak, J.J. 1998 Molecular Biotechnology – Principles and Applications of Recombinant DNA, ASM Press, Washington D.C.
4. Lewin, B. 2008 Genes IX. Oxford University Press, Oxford.
5. Winnacker, E.L. 1987 From genes to Clones. VCH Publications, Germany.
6. Antony JF, Griffiths, Gilbert, W.M., Lewontin, R.C. and Miller, J.H. 2002 Modern Genetic Analysis,
7. Integrating Genes and Genomes, 2nd edition, WH Freeman and Company, New York.
8. Molecular Biology of cell. Albert *et al.*, 4th Edition Garland Publishing Inc.
9. Maloy, S.R., Cronan, J.R. Freifelder, D. 1994 Microbial Genetics, Jones and Bartlett Publishers.
10. Gene, 4th edition, Benjamin/Cummings publishing company.
11. Freifelder, D. 1997 Essentials of Molecular Biology. Narosa Publishing House, New Delhi.
12. Twynan, R.M. 2003 Advanced Molecular Biology. Viva books Pvt. Ltd. New Delhi.

Semester- III Practical Paper – I

MBP 305: MICROBIAL GENETICS & GENETIC ENGINEERING

1. Isolation of auxotrophic mutants by Replica plate technique
2. Mutagenesis and UV survival curve
3. Isolation of petite mutants
4. Restriction analysis of DNA and agarose gel electrophoresis
5. Diauxic growth experiment
6. Preparation of competent cells
7. Transformation- selection of recombinants-Blue and white selection(X-gal method)
8. Amplification of DNA by PCR
9. Problems related to
 - (a) Mutation (b) Recombination(Conjugation, transformation, transduction), (c) Gene mapping (d) Restriction mapping (e) Primer design and PCR amplifications (f) DNA libraries.

Spotters:

1. Bacterial conjugation
2. Holiday model
3. Thymine dimers
4. Ames Test
5. Cassette mutagenesis
6. Sticky ends
7. pBR322
8. X-gal plate
9. Replica plating technique
10. PCR
11. rDNA production of human growth hormone
12. Viral vectors
13. Real-Time PCR
14. Liposomes
15. Restriction endonucleases
16. In vivo gene therapy

**Semester - III
Paper-II**

MBT 302: BIOINFORMATICS & COMPUTATIONAL METHODS

Unit – I

- a. Bioinformatics: definition, concept, scope, relevance of bioinformatics, development of bioinformatics, applications of bioinformatics. Operating systems (Linux) and programming languages (Perl, CORBA) in bioinformatics.
- b. Databases: Gene banks, objectives, types of databases- flat files, relational databases, objective-oriented databases, hypertext databases, web interfaces; Resource databases- Generalized (DNA, protein) and specialized databases.
- c. Search tools: Data mining, BLAST, and FASTA.
- d. Sequence analysis of biological data: terminology, methods for alignment- pairwise & multiple sequence alignments, algorithm for alignment of sequencing fragments

Unit – II

- a. Phylogenetic analysis: Concept of phylogenetic trees, phylogenetic trees, and multiple alignment methods - distance matrix, character-based evaluation of methods, evaluation of phylogenies, steps in constructing alignments and phylogenies, working with phylogeny trees- with suitable software-EMBOSS
- b. Gene prediction: Approaches and methods, tools- GRAIL, GenLang, BCM GeneFinder, Procrutes, GeneParser. Prediction of protein structure- Methods for structure prediction for known and unknown folds, prediction of protein function.
- c. Genomics: Gene mapping, sequence assembly and gene expression, DNA microarrays, microarray design, and data analysis.
- d. Proteomics: Definition, proteome analysis; tools for proteome analysis, protein-protein interactions; metabolic and genetic networks, concept of E- cell.

Unit – III

- a. Biostatistics: Definition, scope, applications in biology, terminology; sampling techniques- random and non-random methods.
- b. Measures of central tendencies: Mean, mode, median, standard error, and standard deviation.
- c. Probability: Concepts, terminology, kinds of probabilities, theorems of probability, normal, binomial, and Poisson distribution.
- d. Chi-Square test: Characteristics of chi-square test, degrees of freedom, test of goodness of fit, null hypothesis.

Unit – IV

- a. Analysis of variance (ANOVA): Methods of ANOVA, one-way and two-way classifications, F-test, steps involved in ANOVA, and the importance of ANOVA.
- b. Correlation: Definition, methods of studying the correlation, types of correlations-scatter diagram, Karl Pearson's efficient of correlation and rank correlation method.
- c. Regression: Definition, Types of regression analysis, regression equation, methods of studying regression, graphic and algebraic methods, and the importance of regression.
- d. Importance of statistical software in data analysis.

Recommended Books

1. Andreas D. Baxevanis, B.F. Francis Ouellete. 2004 Bioinformatics A practical guide to the analysis of genes and proteins,
2. Attwood, T.K. and D.J Parry-Smith. Introduction to Bioinformatics
3. Bishop, M. J. and C.J. Rawlings Nucleic acid and protein sequence analysis-A practical approach
4. Chritine Orenge, David Jones, Janet Thornton. Bioinformatics: genes, proteins and computers
5. Cynthia and Perk Jambeck Bioinformatics computer skills, Wiley
6. Dan E. Krane, Michael Raymer. 2003 Fundamental Concepts of bioinformatics,
7. David Mount. 2003 Bioinformatics sequence and genome analysis
8. Higgins, W. Taylor. Bioinformatics: Sequences, structure and databanks- A practical approach,

9. Jean-Michel claverie, Cedric Notredme Bioinformatics A Beginner's Guide, Wliiey Publication
10. Jonathan Pevsner. 2004 Bioinformatics and Functional Genomics
11. Stephen Misener and Stephen A. Krawetz. Bioinformatics methods and protocols
12. Wardlaw, AC 1985 Practical statistics for experimental Biologists.
13. Rastogi VB. Fundamentals of Biostatistics, Ane Books, New Delhi
14. Khan and Khanum Fundamentals of Biostatistics, Ukaaz Publications, Hyderabad

Semester- III
Practical Paper – I

MBP 305 BIOINFORMATICS & COMPUTATIONAL METHODS

1. Aligning sequences using Clustal-X
2. Sequence data retrieval in FASTA format from NCBI database.
3. Similarity search in BLAST for protein or nucleotide sequence.
4. Prediction of secondary structure of protein
5. Viewing the Protein Data Box (PDB) files using Rasmol software.
6. Conversion of raw sequences into different sequence format by using Read Seq Tool.
7. Problems on mean, median, mode, standard deviation and standard error
8. Problems on probability distributions
9. Problems on Chi-square test
10. Problems on one way and two-way ANOVA and F-test analysis
11. Problems on Karl Pearson's Correlation coefficient and Rank Correlation coefficient
12. Problems on Regression analysis

Spotters:

1. Gene banks
2. Phylogenetic tree
3. DNA microarrays
4. Protein structure
5. Proteome analysis
6. K-mer frequency diagram
7. Clustal-x alignment map
8. Graphical presentation of Data
9. Histogram
10. Frequency polygon
11. Frequency curve
12. Pie chart
13. Cartogram
14. Scatter Diagram of correlation
15. Regression analysis

Semester - III
Paper - III
MBT 303: BIOPROCESS TECHNOLOGY

Unit – I

- a. An overview of fermentation technology, range of fermentation processes, components of fermentation process, primary and secondary metabolites.
- b. Industrial microorganisms: isolation, preservation, screening and strain improvement and maintenance.
- c. Formulation of industrial media: Media compositions for fermentation processes, carbon, nitrogen, mineral sources, buffers, antifoam agents, medium optimization.
- d. Stoichiometry of cell growth and product formation, sterilization of media and fermenters, scale – up process and starter culture technology

Unit – II

- a. Basic design of a microbial fermentor, types of fermentation vessels, aseptic operation, containment,
- b. Construction of fermenter (stirrer glands, bearing, valves, steam traps) baffles, spargers and impellers.
- c. Types of fermentations: batch, continuous, fed-batch, solid state, sub-merged.
- d. Aerobic and anaerobic, dual and multiple fermentations, their advantages and disadvantages.

Unit – III

- a. Importance of downstream processing in industrial fermentation processes. Problems and requirements of bioproduct recovery and purification.
- b. Physicochemical basis of bioseparation processes.
- c. Fermentation economics - Market potential, effects of maintenance legislation on production of antibiotics and recombinant proteins..
- d. Continuous fermentation, product recovery costs, water usage and recycling, and effluent treatment.

Unit – IV

A brief outline of processes for the production of the following commercially important products:

- a) Primary metabolites
 - i) Organic acids : Citric acid, Lactic acid,
 - ii) Amino acids : Glutamic acid, L-lysine,
 - iii) Solvents : Acetone, Ethyl alcohol
 - iv)
- b) Secondary metabolites
 - i) Antibiotics : Streptomycin, Penicillin
 - ii) Vitamins : B₁₂, Riboflavin,
 - iii) Biofuels : Hydrogen, Methane

Recommended Books

1. Berry, D.R. (Ed) 1998 Physiology of Industrial fungi BSP, Oxford University.
2. Crueger & Crueger Biotechnology: A Text Book of Industrial microbiology 2nd edition
3. Dellweg .Biotechnology Vol III.
4. Demain, A.L Biology of Industrial Microorganisms
5. Diliello Methods in Food and Dairy Microbiology
6. Henry, C. Vogel and L. Celeste Todaro 2005 Fermented and Biochemical Engineering Hand Book 2ed Standard Publishers Distribution New Delhi
7. Coeplor, S.H. and D.Perhman Encyclopedia of Industrial microbiology Vol. I & II
8. Patel, A.H. Industrial microbiology
9. Pepler & Pearlman - Microbial Technology Vol I & Vol II .

10. Prescott & Dunn, Industrial microbiology,
11. Prescott & Dunn's Fundamentals of Applied Microbiology (2nd edition)
12. Rao. D.J. 2005 Intriducion to Biochemical Engineering McGraw-Hill
13. Reed, G. Industrial Microbiology, CBS Publishers

Semester- III
Practical Paper- II
MBP 306: BIOPROCESS TECHNOLOGY

1. The use of Logarithms in microbial growth study and fermentation process.
2. Determination of the midpoint of the Logarithmic phase of microbial growth in fermentation process.
3. Harvesting the microbial cells and determination of the yield of fermentation products.
4. Manometric study in fermentation process.
5. Isolation and identification of secondary metabolites in the fermentation process.
6. Design and construction of microbial fermentor.
7. Screening of microorganisms through war cup method in strain improvement.
8. Production and estimation of Streptomycin.
9. Production and estimation of Lactic acid.
10. Production and estimation of Ethyl alcohol.
11. Production and estimation of Penicillin.
12. Production and estimation of Indole Acetic Acid (IAA).
13. Estimation of Cynacobalamine (Vitamin B12).

Spotters:

1. Design of fermenter
2. Seed Flask
3. Seed fermenter
4. Production fermenter
5. Air sparger
6. Foam breaker
7. Stirrer gland
8. Baffles
9. Impellers
10. Bread
11. Monometric fermenter
12. Strain improvement
13. Immobilized beads

Semester - III
Paper- IV
MBT 304: AGRICULTURAL MICROBIOLOGY

Unit - I

- a. Natural and engineered ecosystems - suitability of soil for agriculture, soil chemistry, humus formation, soil fertility, micro/macro nutrients, frequency/density and abundance of soil microbes, biological significance of soil enzymes.
- b. Global nitrogen cycle – microbiology and ecological importance of ammonification, nitrification and denitrification – diversity of nitrogen fixers (free living, aerobic, symbiotic, endophytic bacteria).
- c. Biology of nitrogen fixation – establishment of symbiosis-Physiology of legume root nodule, leghaemoglobin synthesis, biochemistry and genetics of symbiotic and asymbiotic nitrogen fixation, action of nitrogenase and hydrogenase.
- d. Rhizosphere – Nature, extent, influence of root exudates on microflora, plant growth promoting rhizobacteria (PGPR) and siderophore production, nature and ecological significance of ectotrophic and endotrophic mycorrhizal associations, role of microbes in solubilization of phosphorus, sulphur and iron.

Unit - II

- a. Principles of plant disease resistance, entry and establishment of pathogens in plants, host-parasite interaction, role of enzymes and toxins in pathogenesis.
- b. Protection and defense, mechanism of disease resistance (performed and induced defense, local signals), programmed cell death, induced structural barriers, phytoalexins.
- c. Biochemical basis of disease resistance – Systemic acquired resistance (SAR), Local acquired resistance (LAR) and Pathogenesis related proteins (PR-proteins) - chitinases and glucanases.
- d. Transgenic Resistance - horizontal and vertical resistance, classification and functions of resistance genes, transformation for disease resistance, Bt genes and resistance to insects.

Unit - III

- a. Plant disease triangle, disease forecasting, reproduction, inoculum, virulence, dissemination.
- b. Symptoms, disease cycle and management of the following plant diseases: Fungal diseases – late blight of potato, downy mildew of grapes, loose smut of wheat, smut of bajra, covered smut of barley, blast disease of paddy, red rot of sugarcane.
- c. Bacterial diseases – bacterial blight of paddy, angular leaf spot of cotton, common scab of potato.
- d. Viral diseases – tobacco mosaic, leaf curl of tomato, yellow vein mosaic of bhindi.

Unit - IV

- a. Cultural methods, agronomic practices (crop rotation, field and crop sanitation), chemical control (fungicides, fumigants, inorganic copper/sulphur compounds, dithiocarbamates)
- b. Organic agriculture and disease control – Biofertilizers – development and the concept, *Rhizobium*, *Bradyrhizobium*, *Azotobacter*, *Azospirillum*, *Acetobacter*, *Frankia*, algal fertilizers, mass cultivation techniques, quality control of biofertilizers, field performance of biofertilizers, problems and prospects.
- c. Microbial pesticides – development and significance, source organisms, Bacteria – *Bacillus thuringiensis*, Bt based commercial products, other bacilli producing pesticides, Fungi – *Beauveria bassiana*, *Metarhizium anisopliae*, *Trichoderma viride*, Viruses - Baculo virus for insect pest control (NPV – Nuclear Polyhedrosis Virus).
- d. Postharvest diseases and their control – microbial spoilage of fruits and vegetables, stored grains/seeds, mode of infection and factors influencing post-harvest diseases, strategies for post-harvest disease control through fungicides, irradiation, fumigation and vapor heat treatment.

Recommended Books

1. Agrio, G.N. Plant pathology
2. Alexander, M Soil Microbiology
3. Bilgrami, K.S. and H.C. Dube Modern Plant pathology
4. Biofertilizers by N.S. Subba Rao
5. Mehrotra, R.S. Plant Pathology
6. Microbial ecology: Principles, methods & applications & Biological nitrogen fixation.
7. R.S. Singh An introduction to principles of plant pathology
8. Rangaswami, G. and A. Mahadevan Diseases of crop plants
9. Rangaswamy, G and. Bhagyaraj D.J .Agricultural Microbiology
10. Singh, R.S. Plant diseases resistance
11. Rander Plank Plant disease resistance
12. Vidyasekaran Molecular plant pathology

Semester- III

Practical Paper- II

MBP 306: AGRICULTURAL MICROBIOLOGY

1. Isolation of phosphate solubilizing microorganisms
2. Estimation of organic matter in agricultural soils to assess the soil-fertility
3. Estimation of cell wall degrading enzymes: cellulases (exo-and endo-glucanases), polymethyl esterases, poly galacturonase, pectic lyase in host-pathogen interactions
4. Estimation of accumulated soil enzymes : catalase/peroxidase, phosphatase, urease,
5. Isolation and identification of cyanobacteria used as biofertilizers-*Nostoc*, *Anabaena*, *Scytonema*
6. Isolation of *Rhizobium* from root nodules
7. Classification and symptomology of plant diseases covered in theory (unit III)
8. Determination of Disease Tolerance Index (DTI) in crop plants
9. Enumeration of Rhizosphere microflora and comparison with normal soil microflora (Rhizosphere effect)
10. Enumeration of ammonifiers, nitrifiers and denitrifiers in soil samples
11. Assay of fungicides by humid chamber technique and calculation of LD50 value
12. Section cutting of infected plant parts.

Spotters:

1. Downy mildew of peas
2. Downy mildew of bajra
3. White rust of crucifers
4. Powdery mildew of cucurbits
5. Whip smut of sugarcane
6. Wilt of pigeon pea
7. Wilt of cotton
8. Root rot of cotton
9. Stem rot of rice
10. Brown spot diseases of rice
11. Blast diseases of rice
12. Bacterial blight of paddy
13. Angular leaf spot of cotton
14. Stalk rot of maize
15. Sesamum phylloidy
16. Yellow vein mosaic of bhendi

Semester-IV
Paper- I
MBT 401: ENVIRONMENTAL MICROBIOLOGY

Unit - I

- a. Introduction to Microbial Diversity, types of micro-organisms - bacteria, archebacteria, eucarya, interaction between microorganisms, microbial succession.
- b. Extremophiles – Habitat, effect of extreme conditions on cellular components, membrane structure, nucleic acids and proteins, adaptation mechanisms in micro-organisms in diverse environments.
- c. Study of thermophiles, psychrophiles, halophiles, piezophiles, acidophiles, alkalophiles, xerophiles, radiation resistant organisms, methanogens.
- d. Biotechnological applications of extreme proteins from above groups, Geomicrobiology – biofouling, biocorrosion.

Unit - II

- a. Principles and concepts of soil microbiology: soil principles and properties – soil formation, texture, composition, characteristics, density and biomass of microbes in soil, terrestrial carbon cycles, soil fertility.
- b. Decomposition of organic matter – litter chemistry, carbon assimilation and immobilization, dynamics of organic matter, accumulated soil enzymes and their role in soil development.
- c. Bioremediation of polluted soils – Microbes in polluted soils, strategies of their survival, mechanisms of the degradation of pesticides, biohydrometallurgy using recombinant microbes for recovery of precious metals.
- d. Microbial leaching and biomining (copper and uranium) – dump, heap and agitated leaching, chemistry and microbiology of bioleaching, biomining (*ex situ and in situ* – hole to hole leaching), plasmids and genes in biomining.

Unit - III

- a. Principles and concepts of Water Microbiology: Global water reserves, physical/chemical/biological/microbiological characteristics of water, water consumption cycle, biomonitoring of the aquatic environment, pollution indices, eutrophication.
- b. Wastewater treatment through aerobic microorganisms – Biological filters, aeration tanks, activated sludge, biological ponds, irrigation fields.
- c. Wastewater treatment through anaerobic microorganisms – septic tanks, Imhoff's tank, up-flow anaerobic sludge blanket (UASB), anaerobic filters, anaerobic attachment film expanded bed (AAFEB), anaerobic rotating biological contractor.
- d. Pollution control biotechnology – commercial blends of microorganisms and enzymes, immobilized cells and enzymes, biotechnological approaches for recovery of useful products from sewage and industrial wastes (methane).

Unit - IV

- a. Historical introduction – Nomenclature of atmospheric layers, microbes as source and sink of atmospheric pollutants, pollutant transformation by microbes, airborne microbes and their reservoirs, bioaerosols.
- b. Air sampling techniques – slit samples, cascade impactor, Hirst trap, Anderson's air sampler, vertical cylinder trap, Burkard trap. The impingers – proton impinger and pre-impinger.
- c. Air quality in Indian cities – mapping of the hot spots, air quality monitoring and measurement, impact of air-borne microorganisms on living beings, fungal allergy, immediate/delayed type of hypersensitivity, atopic allergy.
- d. Air sanitation – control of air-borne pathogens, irradiation, chemical disinfection, dust control. Biotechnological methods for the abatement of environmental bio-pollution.

Recommended Books

- | | |
|-------------------------------|--|
| 1. Alexander M. | Soil Microbiology |
| 2. Atlas & Batra | Microbial Ecology |
| 3. Burns R.G & J.H.Slater | Experimental Microbial Ecology |
| 4. Gabriel Bitton | Wastewater Microbiology |
| 5. Gilbert S. Omen | Environmental Biotechnology |
| 6. Gray T.R.G.&S.T.Williams | Soil Microorganisms |
| 7. Gregory P.H. | The Microbiology of Atmosphere |
| 8. Lautit M.W&C.M.Eds.Keuin | Microbial Ecology Proc. |
| 9. Lynch J.M and N.J. Poole | Microbial Ecology: A conceptual approach |
| 10. Michael S.Swizenbaury(Ed) | Anaerobic Treatment of Sewage |
| 11. Mishra R.R | Soil Microbiology |
| 12. Ralph Mitchell | Environmental Microbiology |
| 13. Ratledge C. | Biochemistry of Microbial degradation |
| 14. Subba Rao N.S. | Soil Microbiology |

Semester - IV Practical Paper- I

MBP 405: ENVIRONMENTAL MICROBIOLOGY

1. Determination of Biochemical Oxygen Demand (BOD) of sewage water
2. Determination of Chemical Oxygen Demand (COD) of industrial wastewater
3. Bacteriological examination of water using multiple tube fermentation test: presumptive test, confirmed test and completed coli form test.
4. Estimation of Gross primary productivity (GPP), Net Primary Productivity (NPP), and Respiratory Consumption (RC) to determine the autotrophic/heterotrophic status of aquatic bodies
5. Estimation of phosphates, sulphates and nitrates (eutrophication factors) in polluted and unpolluted water bodies
6. Disinfection of potable water by chlorine (bleaching power method) – determination of chlorine demand and residual chlorine
7. Biomonitoring of water quality by algal indices: Nygaard's index, Palmer's index, Kothe's index, Margalef's index.
8. Bioremediation of heavy metals : chromium/cadmium/lead
9. Phytoremediation of toxic metals by cyanobacterial species
10. Assay of lignolytic enzymes (lignin peroxidase and laccase) by white rot fungi
11. Decolourization of dye effluents by immobilized bacteria and fungi
12. Biodesulphurization of coal by *Thiobacillus ferrooxidans*
13. Air sampling by Petri plate method/gravity slide method/tilak air sampler
14. Estimation of xylanase enzyme: Role in biopulping

Spotters:

1. Multiple tube fermenter
2. Winogradsky column
3. Aeroflora agar plate
4. Dye effluent treatment
5. Decomposed litter Humus
6. Bioleaching rayon pulp
7. Desulphurised coal (Clean coal)
8. Drug sensitivity
9. Anderson air samplers
10. Water cycle
11. Burkard trap
12. Air quality index (AQI)
13. AAFEB
14. Impingers
15. HEPA filter

Semester - IV
Paper - II
MBT 402: MEDICAL MICROBIOLOGY

Unit – I

- a. History of medical microbiology. General attributes and virulence factors of bacterial and viral infections.
- b. Diagnosis of infectious diseases: Types of specimens, specimen collection, transport and processing of material, culture isolation and identification for microbiological diagnosis.
- c. Immunodiagnosis: Immunological assays, Serological tests and Immunoblotting.
- d. Molecular diagnosis: Nucleic acid hybridization techniques, PCR, Transcription Mediated Amplification (TMA), Nucleic acid Sequence Based Amplification (NASBA), Ligase chain reaction.

Unit – II

Detailed study of morphology, cultural characteristics, antigenic structure, pathogenicity, clinical symptoms, laboratory diagnosis, prevention-control and treatment of diseases caused by the following bacterial pathogens

- a. Air-borne infections: β -Hemolytic Streptococci, Pneumococci, *Corynebacterium diphtheria*, *M. tuberculosis* and *N. meningitis*
- b. Water-born infections: *E. coli*, *Salmonella typhi* and *Shigella dysenteriae*.
- c. Wound infections: *Clostridium tetani*, *Staphylococcus aureus* and *Pseudomonas*.
- d. Sexually transmitted diseases: *Treponema pallidum* and *Neisseria gonorrhoea*.

Unit – III

Detailed study of etiology, cultivation, antigenic structure, pathogenesis, laboratory diagnosis, prevention and treatment of following viral disease

- a. Airborne infections: Influenza virus, Adenovirus, Mumps, Measles and Corona Virus.
- b. Zoonotic viral infections: Rabies disease and Japanese encephalitis
- c. Water born and contact diseases: HAV and HBV
- d. Sexually transmitted diseases: Herpes simplex virus and AIDS

Unit - IV

- a. Study of etiology, pathogenesis, epidemiology and prevention of Amoebiasis, Malaria, Ascariasis, Ancylostomiasis.
- b. Study of etiology, pathogenesis, epidemiology and prevention of Dermatophytosis (Microsporum, Trichophyton and Epidermophyton)
- c. Systemic mycosis, Coccidiomycosis, Histoplasmosis.
- d. Opportunistic mycosis: Candidiasis, Cryptococcosis, Aspergillosis.

Recommended Books

1. Medical Microbiology by Sherries Medical Microbiology, Patrik R Murray, Elsevier Saunders, 7th edition 2017.
2. Jwetz, Melnick and Adelberg's, Medical Microbiology, Mc Graw Hill Education, 28th edition, India, Pvt. Ltd
3. Medical Microbiology, Edited by Michael Ford, Oxford University press-
4. Bailey and Scott's, Diagnostic Microbiology, Recent Edition.
5. Pocket Medical Dictionary, 2016 Edition.
6. Cruickshank, Medical Microbiology Vol. I and II.

7. Molecular Microbiology: Diagnostic Principles and Practice. 3rd Edition. David H. Persing, et al. Practices of Sequencing Quality Assurance, Chapter 53. American Society of Microbiology Press. 2016
8. Jayaram Paniker. Text book of Medical parasitology (8th edition).
9. Panjarathinam R Orient Longman. Text book of Medical Parasitology, Kindle edition, Orient Blackswan Private Limited (16 December 2020).
10. Sumeeta Khurana and Abhishek Mewara, Textbook of Medical Parasitology, Universities Press India Pvt. Ltd. 29 June 2021.
11. Clinical Virology, (ASM books) 4th Edition by Douglas D. Richman, Richard J. Whitley and Frederick G. Hayden, ASM Press, Wiley. American Society for Microbiology, 2016.
12. Ryan & Sherris Medical Microbiology, Eighth Edition, McGraw Hill.

Semester - IV Practical Paper - I

MBP 405: MEDICAL MICROBIOLOGY

1. Preparation of different types of culture media for identification of pathogens: Blood Agar, Chocolate Agar, Mannitol Salt Agar, Wilson Blair Agar, Bismuth sulfite Agar, TSI Agar etc.
2. Different types of staining techniques for identification of pathogens: Gram's staining, Acid Fast staining, Albert staining, Capsular staining, Endospore staining, etc.
3. Identification of various pathogenic bacteria by biochemical, enzymatic and serological methods.
4. Bacteriological examination of urine, blood, pus, sputum, stool specimens. from patients for diagnosis of disease
5. Animal inoculation technique.
6. Microscopic studies of virus-infected materials.
7. Handling of lab animals.
8. Examination of pathogenic fungi under microscope (Dermatophytes, *Candida* spp.)
9. Isolation of *Cryptococcus neoformans* from bird fecal matter
10. Examination of stool for helminthes & Entamoeba.
11. Examination of blood smears to identify malarial parasites.
12. Isolation, observation and identification of normal microbial flora of human body.

Spotters

1. Smallpox
2. HSV infection
3. Staphylococcal skin Infection
4. Tetanus infection
5. *Corynebacterium* infection
6. EMB plate
7. Measles
8. Mumps
9. *Candida albicans* infection of the tongue
10. Ringworm infection
11. *Microsporium*
12. *Histoplasma capsulatum*
13. *Cryptococcus neoformans*
14. Elephantiasis
15. Leishmaniasis

Semester - IV
Paper - III
MBT 403: MICROBIAL TECHNOLOGY

Unit – I

- a. Importance of microbes in food microbiology: yeasts, filamentous fungi and bacterial contamination of foods.
- b. Factors influencing food spoilage (intrinsic and extrinsic)
- c. Food poisoning and food borne infections (bacterial, viral, fungal and protozoa), bacterial and fungal toxins.
- d. Detection of microbial contamination of foods: Direct microscopic count (DMC), standard plate count, MPN method, reductase tests, membrane filters and molecular methods

Unit – II

- a. Contamination and spoilage of cereals, cereal products, fruits, vegetables, meats, meat products, fish, sea foods, eggs, poultry and canned foods.
- b. General principles of food preservation- Physical and Chemical methods.
- c. Dairy microbiology: Normal flora of milk and milk products, spoilage of milk and milk products. Fermented milk products: acidophilus milk, bifidus milk, yoghurt, manufacture of cheese, evaluation of milk quality.
- d. Microbial food fermentation: Fermentation in food processing, role of microorganisms in food fermentation. Microbial products of food; SCP, mushrooms, oriental foods Fermented beverages (fruit and cereal based) and fermented meat and meat products.

Unit – III

- a. Yeasts fermentation and yeast products: Production of active dry baker's yeast, instant yeast, quality of baker's yeast, production of brewer's yeast, wine yeast food and fodders yeast.
- b. Industrial production of enzymes: cellulases, amylases, proteases, phytases, pectinases, lipases, glucose isomerases, Immobilization of enzymes and cells and their applications.
- c. Scope, utility and methodology of biotransformation, biotransformation of antibiotics, steroids and non-steroids.
- d. Probiotics and Synbiotics. Food sanitation, food quality control agencies and their regulations.

Unit – IV

Detailed study of industrial production and applications of the following:

- a. Biopesticides – Bacterial, viral and fungal
- b. Biofertilizers – Nitrogen fixers, PSM, mycorrhizae
- c. Biopolymers – Extracellular polymers, xanthans, dextrans, poly β hydroxyl alkanates
- d. Biosurfactants – Classification, production and application

Recommended Books

1. Adams, M.R. and Moss. M.O. 2007 Food Microbiology Royal society of Chemistry Pub Cambridge.
2. Banwart, G.S. 1989 Basic Foor Microbiology
3. Chaplin, M.F. & Bucke.C 1990 Enzyme Technoogy Cambridge.
4. Diliello Methods in Food and Dairy Microbiology
5. Fellows P. J 2009 Food Processing Technology Principles and Practice, Third Edition

Published by: CRC Press

6. Frazier, W.C. and Werthaff, D.C. 1998 Food Microbiology 4th edition. Tata Mc Grow Hill New Delhi
7. Hui Y H 2006 Food Biochemistry and Food Processing Blackwell
8. Joshi, V.K. Ashok Pondey 1999 Biotechnology and Food fermentation Vol. I & II.
9. Katherine Smart 2003 Brewing Yeast Fermentation Performance John Wiley & Sons Inc
10. Prescott and Dunn's, Industrial Microbiology 4th edition.
11. Robison, R.K. 1990 Dairy Microbiology.
12. Thomas J. Montville, Karl Matthews, 2005 Food Microbiology: An Introduction: Amer Society for Microbiology

Semester – IV Practical Paper - II

MBP 406: MICROBIAL TECHNOLOGY

1. Enumeration of microorganisms from food, feed, vegetable and fruits.
2. Methylene blue reductase test for milk quality.
3. Microbial reactions in litmus milk.
4. Assay of cellobiohydrolase.
5. Assay of endogluconase.
6. Production and assay of α - amylase.
7. Production and assay of β – amylase.
8. Production and assay of protease.
9. Production and assay of lipase.
10. Production and assay of asparaginase.
11. Production and assay of phosphatase.
12. Biotransformation of organic compounds through MOS.

Spotters:

1. Infected food
2. Infected vegetables
3. Infected fruits
4. Aflatoxin
5. Mushroom spawn
6. Cropping (Casing)
7. Biopesticides
8. VAM spores by funnel technique
9. Baker's yeast
10. Cheese
11. Yoghurt
12. Curd
13. *Trichoderma* powder
14. Antagonistic activity

Semester – IV
Paper – IV
MBT 404: PHARMACEUTICAL MICROBIOLOGY

Unit - I

- a. Microorganisms affecting pharmaceutical industry – The atmosphere, water, skin & respiratory flora of personnel, raw-materials, packing, equipments, building, utensils etc.
- b. Types of microorganisms occurring in pharmaceutical products. Microbiological spoilage prevention of pharmaceutical products.
- c. Preservation of pharmaceutical products; antimicrobial agents used as preservatives, evaluation of the microbial stability of formulation.
- d. Sterilization in pharmaceutical industry. Good manufacturing practices in pharmaceutical industry

Unit - II

- a. History of chemotherapy – plants and arsenicals as therapeutics, Paul Ehrlich and his contributions, selective toxicity and target sites of drug action in microbes.
- b. Development of synthetic drugs – Sulphanamides, antitubercular compounds, nitrofurans, nalidixic acid, metronidazole group of drugs.
- c. Antibiotics - The origin, development and definition of antibiotics as drugs, types of antibiotics and their classification. Non-medical uses of antibiotics.
- d. Cosmetics microbiology- testing methods and preservation. Antimicrobial preservation efficacy and microbial content testing

Unit - III

- a. Principles of chemotherapy – Clinical and lab diagnosis, sensitivity testing, choice of drug, dosage, route of administration, combined/mixed multidrug therapy, control of antibiotic/drug usage.
- b. Mode of action of important drugs – Cell wall inhibitors (Beta-lactam – e.g. Penicillin).
- c. Bacterial resistance to quinolones. membrane inhibitors (polymyxins), macromolecular synthesis inhibitors (streptomycin), antifungal antibiotics (nystatin)
- d. Rapid screening of multi-drug resistant bacterial genes from different sources

Unit - IV

- a. The drug resistance – The phenomenon, clinical basis of drug resistance, biochemistry of drug resistance, genetics of drug resistance in bacteria.
- b. Microbiological assays: Assays for growth-promoting substances, nutritional mutants and their importance, vitamin assay, amino acid assay
- c. Assay for growth inhibiting substances – Assay for non-medicinal antimicrobials (Phenol coefficient/RWC). Drug sensitivity testing methods and their importance. Assay for antibiotics
- d. Determination of MIC, the liquid tube assay, solid agar tube assay, agar plate assay (disc diffusion, agar well and cylinders cup method). Introduction to pharmacokinetics and pharmacogenomics.

Recommended Books

1. Disinfection, sterilization and preservation. Block, S.S. (ed). Lea and Febiger, Baltimore
2. Pharmaceutical Microbiology. Hufe, W.B. and Russel, AD. Blackwell Scientific, Oxford
3. Manual of Clinical Microbiology. Lennette, EH. (ed). Pub: American Society for Microbiology, Washington.
4. Biochemistry of antimicrobial action. Franklin, DJ. and Snow, GA. Pub: Chapman & Hall.
5. Antibiotics and Chemotherapy. Garrod, L.P., Lambert, HP. And C'Grady, F. (eds). Publ: Churchill Livingstone.
6. Antibiotics. Lancini, G. and Parenti, F. Pub: Springer-Verlag.
7. The Molecular Basis of antibiotic action. Ga.e, EF. et al. Publ: Wiley, New York.
8. Antimicrobial Drug action. Williams, RAD., Lambart, PA. & Singleton, P. Pub: Bios Sci.

9. Microbiological Assays. Hewitt.
10. Antiviral Drugs. Kargor, S.
11. Burger's Medicinal chemistry Vol. I – III. Ed. Nanfield E. World.
12. The control of antibiotic resistant bacteria. Stuart, Harris and Harris.
13. Indian Pharmacopea; United States Pharmacopea; British Pharmacopea.

**Semester – IV
Practical Paper - II**

MBP 406: PHARMACEUTICAL MICROBIOLOGY

1. Sampling of pharmaceuticals for microbial contamination and load (syrups, suspensions, creams and ointments, ophthalmic preparations)
2. Bioassay of chloramphenicol by plate assay method or turbidometric assay method.
3. Determination of D value, Z value for heat sterilization in pharmaceuticals.
4. Neutralization test – Plaque neutralization, Haeme adsorption test.
5. Determination of antimicrobial activity of a chemical compound (Phenol, resorcinol, thymol, formaldehyde) to that of phenol under Standardization experimental conditions.
6. Sterility testing methods for pharmaceutical and cosmetic products
7. Tests for disinfectants (Phenol coefficient/RWC)
8. Determination of antibacterial spectrum of drugs/antibiotics
9. Chemical assays for antimicrobial drugs
10. Testing for antibiotic/drug sensitivity/resistance
11. Determination of MIC valued for antimicrobial chemicals
12. Microbiological assays for antibiotics (Liquid tube assay, agar tube assay, agar plate assays)
13. Efficacy testing of preservatives like parabens

Spotters:

1. Syrups
2. Creams
3. Ointment
4. D-value
5. Z-value
6. Plaque neutralization
7. Heame adsorption test
8. Antimicrobial activity
9. Sterility testing
10. Tetracycline
11. Minimal inhibitory concentration (MIC)
12. Synthetic drugs
13. Cosmetic product (any available product)