

DEPARTMENT OF MICROBIOLOGY, K.U., KURUKSHETRA

Revised M.Sc. SYLLABUS w.e.f. 2014-2015

Semester I

Paper	Internal	External	Marks	Time
MBY 101 Microbial World - I	20	80	100	3 hrs
MBY 102 Microbial World - II	20	80	100	3 hrs
MBY 103 Elements Of Molecular Biology	20	80	100	3 hrs
MBY 104 Microbial Biochemistry	20	80	100	3 hrs
TOTAL	80	320	400	

Semester II

Paper	Internal	External	Marks	Time
MBY 201 Lab Techniques in Microbiology	20	80	100	3 hrs
MBY 202 Microbial Physiology & Metabolism	20	80	100	3 hrs
MBY 203 Microbial Genetics	20	80	100	3 hrs
MBY 204 Cell Biology & Immunology	20	80	100	3 hrs
Lab Course I (based on MBY 101 & MBY 201)	10	40	50	6 hrs
Lab Course II (based on MBY 102 & MBY 202)	10	40	50	6 hrs
Lab Course III (based on MBY 103 & MBY 203)	10	40	50	6 hrs
Lab Course IV (based on MBY 104 & MBY 204)	10	40	50	6 hrs
TOTAL	120	480	600	

Project training for 2 months in various research institutes/industries after II Semester (during Summer Vacations)

Semester III

Paper	Internal	External	Marks	Time
MBY 301 Food & Dairy Microbiology	20	80	100	3 hrs
MBY 302 Medical Microbiology	20	80	100	3 hrs
MBY 303 Microbial Biotechnology & Industrial Microbiology	20	80	100	3 hrs
MBY 304 Recombinant DNA Technology	20	80	100	3 hrs
TOTAL	80	320	400	

Semester IV

Paper	Internal	External	Marks	Time
MBY 401 Biostatistics & Computers	15	55	70	3 hrs
MBY 402 Credit Seminar	30	--	30	
MBY 403 Project Training Report	30(based on Seminar)	70(Dissertation & Viva)	100	
MBY 404 Environmental Microbiology	20	80	100	3 hrs
MBY 405 Agricultural Microbiology	20	80	100	3 hrs
Lab Course V (based on MBY 301 & MBY 302)	10	40	50	6 hrs
Lab Course VI (based on MBY 303 & MBY 304)	10	40	50	6 hrs
Lab Course VII (based on MBY 401)	10	40	50	6 hrs
Lab Course VIII (based on MBY 404 & MBY 405)	10	40	50	6 hrs
TOTAL	155	445	600	

SEMESTER I

MBY 101. MICROBIAL WORLD – I

Max.Marks:100 (Ext. 80+ Int. 20)

Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks.

Unit I:

History, development and scope of microbiology. Prokaryotic and eukaryotic cellular organisation. Simple staining and Gram staining technique of bacteria. Brief account of general methods of classifying the bacteria. Whittaker's five kingdom concept.

Unit II:

Cell arrangement and shapes of bacteria. Major characteristics (morphological, physiological, metabolic, ecological, cultural, serological, pathogenic, phylogenetic of microorganisms used in microbial taxonomy. Bergey's manual and its importance in classification. Brief account of different bacterial groups- sporulating bacteria, gram positive cocci, archaebacteria, actinomycetes, rickettsia & chlamydia, mycoplasma, spirochetes.

Unit III:

Nutritional types of bacteria. Concept of pure culture, methods of isolation of pure culture. Types of culture media. Maintenance and preservation of microbial cultures. Cultural characteristics of bacteria.

Unit IV:

Control of microorganisms by physical methods – Dry heat, moist heat, radiations, osmotic pressure, filtration methods; chemical methods-characteristics of an ideal antimicrobial chemical agent, phenols, alcohols, quaternary ammonium compounds, halogens, heavy metals and their compounds, aldehydes, ethylene oxide and their application. Antibiotic susceptibility testing. Mode of action of antibiotics-cephalosporin, chloramphenicol, ciprofloxacin, polymyxin B, sulphonamides. Antimicrobial drug resistance- Mechanism and spread.

Text and Reference Books:

1. Stainier RY, Ingraham JL, Wheelis ML & Palmer PR(2003). General Microbiology, MacMillan.
2. Tortora GJ, Funke BR & Case CL(2010). Microbiology: An introduction with Mastering Microbiology, 10th ed. Benjamin Cummings.

3. Madigan MT, Martinko JM, Stahl DA & Clark DP(2012). Brock Biology of Microorganisms, 13th ed., Benjamin Cummings
4. Mackie & McCartney Practical Medical Microbiology (1996). Collee JG, Fraser AG, Marmion BP & Simmons A (eds.), Churchill Livingstone, Edinburgh.
6. Atlas RM, Parks LC & Brown AL(1995). Laboratory Manual of Experimental Microbiology. Mosby-Year Book, Inc., Missouri.
7. Willey JM, Sherwood LM & Woolverton CJ DA(2008). Prescott, Harley and Klein's Microbiology, 7th ed., McGraw Hill International Edition, USA.
8. Cappuccino JG & Sherman N (2005).Microbiology –A Laboratory Manual Pearson Education Inc

LIST OF PRACTICALS

1. Preparation of culture media: Nutrient agar, Potato dextrose agar, Czapek-Dox agar.
2. Study of different isolation techniques
 - (a) Pour plate.
 - (b) Spread plate.
 - (c) Streak plate.
3. Staining techniques: -
 - (a) Simple staining
 - (b) Gram staining
 - (c) Negative staining
 - (d) Endospore staining.
 - (e) Capsule staining
4. Standard plate count.
5. Antibiotic sensitivity test.
6. To demonstrate antimicrobial activity of given sample
7. Biochemical tests for identification of bacteria- Indole production, Methyl red, Voges Prausker, Citrate utilization test, Carbohydrate fermentation test, Nitrate reduction test, Urease test.

MBY 102. MICROBIAL WORLD – II

Max.Marks:100 (Ext. 80+ Int. 20)
Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit I

Fungi- Classification of fungi. Kirk et al. system of classification. Modes of Reproduction in fungi.

Fungi as saprotrophs & their role in decomposition in cellulose, hemicellulose, pectin and lignin.

Types of mycosis, brief account of Dermatophytes, Chromomycosis, Cryptococcosis and

Aspergillosis.

Unit II

Algae- Structure, nutrition and Reproduction in algae. Distribution and classification of algae.

Economic importance of Algae as food, Source of agar-agar, alginate, diatomite and iodine etc,

antibiotics from algae, use in fisheries and malaria control.

Unit III

Virus- Nomenclature, Classification and Properties of viruses, Morphology and Structure of viruses-

Capsid and its symmetry with special reference to bacteriophage, Lytic and lysogenic cycle. Virioids

and Prions. Primary cell, Diploid cell strains, Continuous cell lines. One step growth curve, Detection of virus growth in cell culture.

Unit IV

Protozoa- Morphology, reproduction, modes of nutrition, modes of transmission, locomotory

organelles, encystment, excystment. Life cycle, pathogenic, mechanisms and control of parasitic

infections viz. amoebiasis, toxoplasmosis, malaria, sleeping sickness. giardiasis.

Text and Reference Books:

1. Barsanti L & Gualtieri P(2006). Algae: Anatomy, Biochemistry and Biotechnology, Taylor and Francis.

2. Arora DR & Arora B (2004). Medical Parasitology, 2nd ed., CBS Publishers, New Delhi.

3. Madigan MT, Martinko JM, Stahl DA & Clark DP(2012). Brock Biology of Microorganisms, 13th ed., Benjamin Cummings.

4. Landracker EM (1996). Fundamentals of the Fungi, 4th ed., Benjamin Cummings.

5. Carter JB & Saunders VA (2007) Virology-Principles and Applications, John Wiley and Sons

6. Alexopoulos CJ Mims CW & Blackwell M (1996). Introductory Mycology. 4th ed., John Wiley & Sons, USA.

7. Chatterjee KD (2007) Parasitology, 12th edition, Chatterjee Medical publishers India.

8. Atlas RM, Parks LC & Brown AL(1995). Laboratory Manual of Experimental Microbiology. Mosby-Year Book, Inc., Missouri.

9. Brown AE(2005). Benson's microbiological applications. TataMacGrawHill

LIST OF PRACTICALS

1. Lactophenol Cotton blue staining of mold- Preparation and examination of slides.

2. Cellotape preparation and examination of a mold.

3. Isolation of soil mycoflora.

4. Measurement of conidia/spores of a mold.
5. Identification of the common saprobic molds:
 - (a) *Aspergillus*
 - (b) *Penicillium*
 - (c) *Alternaria*
 - (d) *Curvularia*
 - (e) *Cladosporium*
 - (f) *Rhizopus*
6. Isolation and identification of algae from soil/water.
7. Enumeration of bacteriophage in a sample by plaque forming unit (PFU)
8. Isolation of free living protozoa from pond water.
9. Study of special features of parasitic protozoa: *Entamoeba histolytica*, *Giardia*, *Plasmodium*, *Toxoplasma*

MBY 103. ELEMENTS OF MOLECULAR BIOLOGY

Max.Marks:100 (Ext. 80+ Int. 20)

Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit-I

Transcription : General principle . Basic apparatus , Initiation , Elongation and termination , Types of RNA polymerases , Monocistronic and polycistronic RNA, Regulation at initiation , Alternate sigma factor , rho dependent and independent termination , hairpin and attenuation.

Unit -II

Maturation and processing of RNA: Methylation, Poly A tail, Capping, Cutting and degradation of tRNA, Splicing mechanism.

Basic feature of genetic code: Triplet code, Deciphering of genetic code , Degeneracy, Characteristics of genetic code, Variation in different organism, Wobble hypothesis.

Unit-III

Translation : Central dogma, Basic apparatus , initiation , elongation , termination , coupled transcription and translation , aminoacyl site , peptidyl site , , initiation ,

elongation , termination factors, aminoacyl tRNA synthetases, leader sequences , in vitro translation system. RNAi. Post translational modifications.

Unit-IV

Regulation of gene expression: Constitutive and inducible genes, Operon concept , catabolite repression, Positive and negative regulation, lac , trp . ara operon, stringent response , ppGpp, cAMP as regulatory molecules.

Text and Reference Books:

1. Maloy SR, Cronan JE & Freifelder D (2009). Microbial Genetics, Jones & Bartlett publishers.
2. Dale JW (2001). Microbial Genetics of bacteria, Jones & Bartlett publishers.
3. Lewin B (2008). gene XI , Oxford University press.
4. Freifelder D (2008). Molecular Biology Jones and Bartlett Publishers USA
5. Lodish et al (2007). Molecular Cell Biology W.H freeman.

LIST OF PRACTICALS

1. Demonstration of picking and patching colonies.
2. To perform Replica plating technique for transfer of bacterial cultures.
3. Isolation of Plasmid DNA by using alkaline lysis (miniprep through teaching kit).
4. Transformation of bacteria with plasmid DNA using CaCl_2 .
5. Preparation of genomic DNA from bacteria (CTAB method).
6. Demonstration of agarose gel electrophoresis.
7. To estimate the concentration and purity of DNA and RNA by spectrophotometric method
8. Colorimetric estimation of DNA.
9. Colorimetric estimation of RNA.

MBY 104. MICROBIAL BIOCHEMISTRY

Max.Marks:100 (Ext. 80+ Int. 20)
Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit –I

Enzyme Classification:-Specificity, active site, activity unit, isozymes. Enzyme kinetics. Michaelis-Menten equation for simple enzymes. Ribozyme and abzyme. Determination of kinetic parameters. Multistep reactions and rate limiting steps, enzyme

inhibition, allosterism. Principles of allosteric regulation.

Unit-II

Basic aspects of bioenergetics:- Entropy, enthalpy, e-carriers, e-donors, inhibitors, uncouplers, energy bond. Flow of energy through biosphere, strategy of energy production in the cells, oxidation –reduction reactions, coupled reactions, group transfer, ATP production , Free energy and spontaneity of reaction ΔG , ΔG° , $\Delta G'$ & equilibrium , basic concepts of acid , base, pH and buffers.

Unit-III

Structure and classification of macromolecules: - Proteins, carbohydrates, lipids and nucleic acids. Vitamins and their role as co-enzymes. Denovo and salvage pathways of synthesis of purine and pyrimidine.

Unit-IV

Cell metabolisms: - catabolic principles & breakdown of carbohydrates and anaplerotic reaction. β – oxidation of fatty acids. Deamination of amino acids and urea cycle. Biosynthesis of lipids – fatty acids. Triacyl glycerol, phospholipids and regulation of fatty acid metabolism.

Text and Reference Books:

1. Nelson DL & Cox MM(2008). Lehninger's Principles of Biochemistry 5th ed., WH Freeman & Company
2. Berg JR, Tymoczko CZ & Stryer L(2006). Biochemistry, 6th ed., WH Freeman & Company
3. Conn E.E. & Stumpf PK (1988) Outline of Biochemistry John Wiley & Sons.
4. Sawhney SK & Singh R(1996). Introductory Practical Biochemistry, Narosa Publishing House Pvt Ltd, New Delhi.
5. Mahajan R, Sharma J & Mahajan RK(2010). Practical Manual of Biotechnology. Vayu Education of India, New Delhi.

LIST OF PRACTICALS

1. Preparation of various buffers: phosphate buffer, sodium carbonate-bicarbonate buffer,
2. Estimation of protein in a given sample using Bradford method.
3. General test for carbohydrates-Molisch's/Anthrone.
4. Test to distinguish between monosaccharides and reducing disaccharides- Barfoed's.
5. Test for ketoses- Seliwanoff's.
6. Test for pentoses- Bial's
7. Test for galactose- mucic acid
8. Test for glycerol-Acrolein
8. Chemical estimation of proteins by Lowry's method.
9. Chemical estimation of sugars by DNS method.
10. Detection of reducing and non reducing sugars.

SEMESTER II

MBY 201 : LAB TECHNIQUES IN MICROBIOLOGY

Max.Marks:100 (Ext. 80+ Int. 20)

Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit I

Principles and working of bright field microscope, fluorescent microscope, phase contrast microscope, electron microscope (SEM & TEM), dark field microscopy. confocal microscopy. Flow cytometry- flurochromes, fluorescent probe and working principle.

Unit II

Principles of types of blotting, immunoblotting-Southern, Northern, Western and Dot blots. Electroimmunodiffusion, Immunofluorescence, Radioimmunoassay, and Enzyme linked immunosorbent assay. DNA microarray techniques and its applications.

Unit III

Polyacrylamide gel electrophoresis (PAGE), agarose gel electrophoresis, native PAGE, SDS-PAGE, 2D electrophoresis. Gel filtration, ion exchange & affinity chromatography, paper chromatography, Thin Layer Chromatography, HPLC, GC-basic concept.

Unit IV

Centrifugation, ultracentrifugation, and its application. Density gradient , sedimentation. Spectroscopy – UV, IR, NMR. X-ray diffraction, circular dichromism for microbiologists. Methods of bacterial and enzyme immobilization, their advantages and applications.

Text and Reference Books:

1. Freifelder. Physical biochemistry, freeman company.
2. Wilson K & Walker J(2005). Principles and Techniques of Biochemistry and Molecular Biology, 6th ed.,Cambridge University Press.
3. David Sheehan(2009). Physical Biochemistry: Principles and Applicatons, John Wiley & Sons Ltd, Chichester, England,
4. Upadhyay, upadhyay & Nath. Biophysical chemistry.
5. Sawhney SK & Singh R(1996). Introductory Practical Biochemistry, Narosa Publishing House Pvt Ltd, New Delhi.
6. Cappuccino JG & Sherman N(2005).Microbiology –A Laboratory Manual Pearson Education Inc
7. Skoog, Holler & Nieman. Principles of Instrumental Analysis.

8. Mahajan R, Sharma J & Mahajan RK(2010). Practical Manual of Biotechnology. Vayu Education of India

LIST OF PRACTICALS

1. Working of microscope.
2. Various types of Electroimmunodiffusion.
3. Isolation of proteins from bacterial culture by ammonium sulphate ppt. and NaCl extraction.
4. Demonstration of PAGE and SDS-PAGE.
5. To study principle and working of spectrophotometer.
6. Demonstration of thin layer chromatography.
7. Demonstration of paper chromatography.

MBY: 202. MICROBIAL PHYSIOLOGY AND METABOLISM

Max.Marks:100 (Ext. 80+ Int. 20)

Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit-I

Morphological types of prokaryotes. Structure & functions of cell wall of archaebacteria, gram positive & gram negative bacteria, cell membrane, capsule, flagella, pili, gas vesicles, carboxysomes, magnetosomes, nucleoid, bacterial endospore. Reserve food material- poly β -hydroxy butyrate, poly-phosphate granules, sulphur inclusions, cyanophycin granules. Peptidoglycan synthesis. Cell differentiation – sporulation and germination in Bacillus.

Unit-II

Microbial growth and its measurement, growth curve, generation time. Batch, continuous, synchronous and diauxic growth. Modes of reproduction. Cultivation of microorganisms. Factors affecting growth-solutes, pH, temperature and oxygen. Transport of nutrients across the cell membrane- passive, facilitated, active transport and group translocation. Bioluminescence in bacteria.

Unit-III

Metabolites-primary, secondary and precursor. ATP generation, oxidative and substrate level phosphorylation, electron transport chain. Carbohydrate metabolism- Glycolysis,

Entner Doudoroff pathway, Krebs cycle, glyoxalate pathway and gluconeogenesis. CO₂ fixation and reverse TCA.

Unit-IV

Anoxygenic and oxygenic photosynthesis. Brief account of chemolithotrophy - Sulphur, iron and hydrogen oxidation, nitrification and methanogenesis. Fermentations- definition and types, homo & heterolactic fermentation, ethanol, acetate, mixed acid, butanediol, butanol, acetone, ethanoacetate fermentation. Pasteur effect.

Text and Reference Books:

1. Gottschalk G(1986). Bacterial Metabolism, Springer,
2. Caldwell DR(2002). Microbial Physiology and Metabolism, 2nd ed., Star
3. Moat AG, Foster JW & Spector MP(2002). Microbial Physiology, 4th ed., John Wiley and Sons
4. Nelson DL & Cox MM(2008). Lehninger's Principles of Biochemistry, 5th ed., WH Freeman & Company
5. Berg JR, Tymoczko CZ & Stryer L(2006). Biochemistry, 6th ed., W.H. Freeman and Company
6. Madigan MT, Martinko JM, Stahl DA & Clark DP (2012). Brock Biology of Microorganisms, 13th ed., Benjamin Cummings.
7. Prescott LM, Harley JP & Klein DA(2005). Microbiology, McGraw Hill International Edition, USA.
8. Atlas RM, Parks LC & Brown AL (1995). Laboratory Manual of Experimental Microbiology. Mosby-Year Book, Inc., Missouri.
9. Cappuccino JG & Sherman N (2005). Microbiology-A Laboratory Manual, Pearson Education Inc
7. Willey JM, Sherwood LM & Woolverton CJ DA(2008). Prescott, Harley & Klein's Microbiology, 7th ed., McGraw Hill International Edition, USA.
9. Brown AE (2005). Benson's microbiological applications. TataMacGrawHill

LIST OF PRACTICALS

1. Determination of size of bacteria
2. Detection of motility of bacteria by hanging drop technique
3. Study of growth of bacteria
4. Detection of gelatin liquefaction
5. Detection of protease production
6. Detection of amylase production
7. Effect of pH on the growth of bacteria
8. Effect of temperature on the growth of bacteria
9. Effect of osmotic pressure on the growth of bacteria
10. Determination of thermal death time and thermal death point.

MB 203. MICROBIAL GENETICS

Max.Marks:100 (Ext. 80+ Int. 20)

Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit - I

Essential of genetics:A brief Overview of Microbial genetics. Beginning of experimental proof of DNA:Transforming principle contribution of Griffith, Macleod, Avery, McCarty, Hershey and Chase. RNA as a genetic material, DNA and RNA structure, different types of DNA. Denaturation and Renaturation Kinetics , Cot value, DNA polymerases , Proof reading activity , C- value paradox , Superhelicity in DNA, Linking No. , Topological Properties, Mechanism of action of Topoisomerases.

Unit-II

Maintenance of Structure of DNA. DNA damage and repair:Base excision, mismatch. SOS and Recombination repair. Mutation: Molecular basis of mutation, significance and harmful effects of mutations, Ames Test.Transposable genetic elements, mechanism and significance of transposition.

Unit-III

Maintenance of Genetic Information. DNA replication: General principle, Initiation, Elongation and Termination. Semi-conservative replication, different modes of replication, Replication in retroviruses, Inhibitors of DNA replication, Relationship between cell cycle and Replication.

Unit-IV

Genetic recombination in Bacteria. Bacterial Conjugation:Sex Factor, Hfr factor, $F^+ \times F^-$ —cross, interrupted mating, mapping genes in bacteria.

Bacterial Transformation-The Discovery of transformation, competence, molecular mechanism of transformation, mapping by transformation. Bacterial Transduction-DNA transfer by Transduction, Specialized and generalized transduction. co- transduction and linkage , mapping by co-transduction.

Text and Reference Books:

1. Maloy SR, Cronan JE Jr. & Freifelder D(Reprint 2009). Microbial Genetics, 2nd ed., Narosa Publishing House
2. Snyder L & Champness W(2007). Molecular Genetics of Bacteria, 3rd ed., ASM Press
3. Gardner JE, Simmons MJ & Snustad DP(1991). Principles of Genetics. John Wiley & Sons

4. Nelson DL & Cox MM(2008).Lehninger's Principles of Biochemistry 5th ed., W.H. Freeman and Company
5. Mahajan R, Sharma J & Mahajan RK(2010). Practical Manual of Biotechnology. Vayu Education of India,New Delhi.

LIST OF PRACTICALS

1. To perform antibiotics susceptibility test.
2. Isolation of antibiotic resistant bacterial population by gradient plate method.
3. Determination of Minimum Inhibitory concentration (MIC) of antibiotics.
4. Isolation of thermotolerant mutants of a bacterial/yeast culture by spread plating technique.
5. UV mutagenesis of a given bacterial culture.
6. To perform genetic recombination (conjugation) in bacteria (through teaching kit).
7. To perform genetic recombination (Transformation) in bacteria (through teaching kit)

MBY 204 : CELLULAR MICROBIOLOGY AND IMMUNOLOGY

Max.Marks:100 (Ext. 80+ Int. 20)

Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit I:

Introduction: - emergence of cellular microbiology, cellular biology underlying prokaryotic and eukaryotic interactions: ultra-structure, genome expression, pathogenicity island.

Unit II:

Prokaryotic and eukaryotic signalling mechanisms: - eukaryotic cell to cell signalling, endocrine signalling, and cytokines prokaryotic signalling: quorum sensing and bacterial pheromones intracellular signalling, signalling pathways.

Unit III:

Innate immunity, factors affecting innate immunity. Acquired immunity- natural and artificial immunity, active and passive immunity. Antigen, hapten and adjuvants.
Immunoglobulins-types, structure and functions.

Unit IV:

Lymphoid organs and cells of immune system, cellular and humoral immune response. Brief account of Complement system and Major histocompatibility complex.

Immunology in health and disease- autoimmunity, immunodeficiencies hypersensitivity; concept of immunotherapy.

Vaccines- Prerequisites of a good vaccine, Types of vaccine- viral, bacterial, recombinant, DNA, subunit vaccines.

Text and Reference Books:

1. Henderson et al.(1999). Cellular Microbiology. Wiley.
2. De Bruijn et al.(1998). Bacterial Genomes. Chapman & Hall.
3. Goldsby, Kindt & Osborne(2006). Kuby's Immunology WH Freeman & co.
4. Tizard(1995). An Introduction to Immunology.Harcourt Brace College Publication
5. Delves PJ & Roitt IM(2006). Roitt's Essential Immunology, 11th ed., Wiley-Blackwell
6. Mackie & McCartney Practical Medical Microbiology (1996). Collee, J.G., Fraser, A.G., Marmion, B.P. and Simmons, A (eds.), Churchill Livingstone,Edinburgh.
7. Atlas RM, Park LC & Brown AL(1995).Laboratory Manual of Experimental Microbiology. Mosby-YearBook,Inc.,Missouri
8. Dorman CJ(1994).Genetics of Bacterial Virulence, Blackwell.

LIST OF PRACTICALS

1. To study chemotactic behaviour of given culture of bacteria.
2. To perform mechanism of infection by bacterial invasion of the host cell.
3. Determination of total leucocytes count
4. Determination of differential leucocytes count
5. Determination of total erythrocytes count
6. Ouchterlony Double Immunodiffusion technique
7. Radial Immunodiffusion technique
8. Agglutination reactions
9. Haemagglutination reactions

SEMESTER III

MBY 301. FOOD MICROBIOLOGY

Max.Marks:100 (Ext. 80+ Int. 20)
Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit I

Intrinsic and extrinsic factors affecting microbial growth in foods: Intrinsic factors (Nutrient contents, pH, moisture contents/water activity, antimicrobial barriers, Antimicrobial substances), Extrinsic factors (relative humidity, temperature, gaseous atmosphere).

Composition of milk, sources of microorganisms in milk and their control. Number and type of microorganisms present in milk. Microbiological examination of milk and milk products. Legal standards for milk and milk products, grading of milk and certified milk, microbiology of lactic cultures, dairy products manufactured.

Unit-II

Microbial spoilage of foods: Microbiology of spoilage of specific foods – Bread, Cakes, Fresh fruits and vegetables, Juices, Meat and meat products, Poultry, Eggs, Sea foods, Fish. Food preservation (protection): Heat, Low temperature storage, Freezing, Dehydration and water availability, Lyophilization, Osmotic pressure, Filtration, Irradiation, Chemical preservatives.

Unit-III

Food borne intoxication and infections-Major differences and examples of infective and toxic types, Botulism, Staphylococcal food poisoning, *Clostridium perfringens* food poisoning, *Bacillus cereus* gastroenteritis, Salmonellosis, *Escherichia coli* diarrhea and colitis, *Vibrio cholerae*. Fungal poisonings: *Aspergillus*, *Penicillium*, *Claviceps*, *Fusarium*.

Unit-IV

Sauerkraut, pickles, bread, yogurt, silage, baker's yeast production from microorganisms. Microbes as sources of single cell protein (SCP), advantages of SCP. Edible and poisonous mushrooms, production of Mushroom- *Agaricus*, *Volvariella* and *Pluteus*.

Text and Reference Books:

1. Adams MR & Moss MO(1995). Food Microbiology, Royal Society of Chemistry Publication, Cambridge.
2. Frazier, WC & Westhoff, DC(1998). Food Microbiology. Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi.
3. Ray, Bibek(1996). Fundamental Food Microbiology, CRC Press.
4. Jay JM et al. (2005). Modern Food Microbiology. 7th ed., Springer Science.
5. Montville TJ, Matthews KR, Food Microbiology: An Introduction, 2nd ed., ASM Press (2008)
6. Robinson R K(2002). Dairy Microbiology Handbook, 3rd ed., John Wiley & Sons

LIST OF PRACTICALS

1. Isolation and Identification of microorganisms from spoiled foods.
 - (a) Bread
 - (b) Fruits
 - (c) Meat
 - (d) Cake

2. Enumeration of bacteria in milk and presumptive test for coliforms.
3. To study Litmus milk reactions.
4. To perform methylene blue reduction test of raw and pasteurized milk.
5. Isolation of Lactobacilli and Streptococci from curd.
6. Sauerkraut production in the lab.
7. Isolation of important bacteria involved in food spoilage (*Bacillus*, *Escherchia*, *Staphylococcus*).
8. Identification of common molds involved in food spoilage (*Aspergillus*, *Penicillium*, *Cladosporium*, *Fusarium*, *Rhizopus*, *Mucor*).

MBY 302: MEDICAL MICROBIOLOGY

Max.Marks:100 (Ext. 80+ Int. 20)
Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit I:

Normal microflora of human body-skin, oral cavity, respiratory tract, gastrointestinal tract and urogenital tract. Significance of normal microflora. Gnotobiotic animals and their use. Sources of infection for man: exogenous infections – patient, carriers (healthy, convalescent, paradoxical, chronic), infected animals, soil and endogenous infections.

Unit II:

Host-pathogen interaction- colonization, invasion, virulence, nosocomial infections, septicemia, septic shock, transmission and spread of infection. Pathogenic properties of bacteria. Virulence Factors, Non-specific antibacterial defence of host.

Unit III:

Bacterial diseases (with reference to morphology, pathogenesis, epidemiology and lab diagnosis) caused by *Staphylococcus aureus*, *Haemophilus influenza*, *Neisseria gonorrhoeae*, *Mycobacterium tuberculosis*, *Treponema pallidum*. Exotoxins and endotoxins. Mode of action of tetanus, botulinum, diphtheria and cholera toxins. Methods for measurement of virulence.

Unit IV:

Viral diseases (with reference to morphology, pathogenesis, epidemiology and lab diagnosis) caused by small pox, influenza, Hepatitis, Rabies, AIDS. Cultivation of animal Viruses- Animal inoculation,

Embryonated eggs and Cell culture. Cytopathic effect. Modes of transmission of viruses. Antiviral drugs: acyclovir, amantadine, AZT, idoxuridine, interferon.

Text and Reference Books:

1. Mims CA(2004). Medical Microbiology, 3rd ed, Mosby
2. Carter JB & Saunders VA (2007) Virology-Principles and Applications, John Wiley and Sons
3. Paniker CKJ(2007). Ananthanarayan and Paniker's Textbook of Microbiology, Orient Longman Pvt. Limited, India.
4. Greenwood D, Slack RCB & Peutherer JF(2006). Medical Microbiology, A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis & Control, Churchill Livingstone, Elsevier, India.
5. Baron EJ, Peterson LR & Finegold SM Mosby (1990). Bailey and Scott's Diagnostic Microbiology
6. Brooks GF, Butel JS, Morse SA, Melnick JL, Jawetz E & Adelberg EA (2004). Jawetz M & Adelberg's Medical Microbiology, 23rd ed, Lange Publication.
7. Mackie & McCartney Practical Medical Microbiology (1996). Collee JG, Fraser AG, Marmion BP & Simmons A (eds.), Churchill Livingstone, Edinburgh.
8. Zuckerman AJ, Banatwala JE & Pattison JR(2009). Principles & Practice of Clinical Virology, John Wiley & sons Ltd.
9. Brown AE(2005). Benson's microbiological applications, TataMacGrawHill

LIST OF PRACTICALS

1. Detection of susceptibility to dental caries
2. Bacteriological examination of skin and throat.
3. Bacteriological examination of urine sample.
4. Viable count of bacteria in urine sample.
5. Dnase agar tests and coagulation test for identification of *Staphylococcus*.
6. Optochin sensitivity test and bile solubility test for *Streptococcus*.
7. Isolation of enteric pathogens from stool by direct plating method.
8. Determination of minimal inhibitory concentration (MIC) and MBC.
9. Cultivation and enumeration of coliphages from sewage.
8. General tests for identification of bacteria from clinical samples including IMViC test, Carbohydrate fermentation test, Nitrate reduction test, Triple sugar agar test Urease test, Catalase test, Oxidase test

MBY 303. MICROBIAL BIOTECHNOLOGY & INDUSTRIAL MICROBIOLOGY

**Max.Marks:100 (Ext. 80+ Int. 20)
Time: 3 hrs**

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit- I

Isolation, Screening, Improvement and maintenance of industrial organisms, Fermenter design and instrumentation, immobilized cell reactor, solid state fermentation (SSF) , substrates for industrial fermentation.

Unit -II

Fermentation System: Primary and secondary metabolites, batch, fed batch and continuous fermentation system, fermentation kinetics, chemostat, turbidostat, gas exchange and mass transfer.

Unit -III

Downstream processing (DSP) and product recovery. Production of Biofertilizers, Biopesticides, Edible Mushroom, Single Cell Protein (SCP), steroid conversion and biotransformation.

Unit - IV

Biotechnological applications of microbes in the commercial production of the following:

Alcoholic beverages: Beer, Whisky

Organic acids: Citric, lactic and acetic acid.

Microbial enzymes: amylases, proteases and lipases.

Antibiotics: penicillin, tetracycline

Amino acids: Glutamic acid, lysine.

Text and Reference Books:

1. Stanburry et al. (2011). Principle of fermentation technology Pergamon Press.
2. Reed G (2001). Industrial Microbiology CBS Publisher.
3. Cruger & Cruger, (2005), Microbial Biotechnology, Panima Press
4. Moo-Young M, Cooney CL & Humphery AE (1985). Comprehensive Biotechnology-The Principles, Applications & Regulations of Biotechnology in Industry, Agriculture & Medicine, Pergamon Press
5. Atlas RM, Park LC & Brown AL (1995). Laboratory Manual of Experimental Microbiology. Mosby-YearBook, Inc., Missouri

LIST OF PRACTICALS

1. Isolation of amylase producing bacteria from soil
2. Preparation of standard curve of reducing sugars by DNS method
3. Quantitative estimation of amylolytic potential of isolated bacterial culture
4. Isolation of yeasts from natural environment

5. To perform an experiment to show the Ethanol fermentation by yeast.
6. Quantitative estimation of ethanol by distillation method
7. Demonstration of surface fermentation
8. Demonstration of submerged fermentation
9. Demonstration of solid state fermentation
10. Whole cell immobilization of bacterial cell using calcium alginate

MBY 304. RECOMBINANT DNA TECHNOLOGY

Max.Marks:100 (Ext. 80+ Int. 20)
Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit I

Core techniques and essential enzymes used in rDNA technology: -Restriction digestion, ligation and transformation.

Unit –II

Cloning vectors:-Plasmids, phages and cosmids, cloning strategies, cloning and selection of individual genes ,gene libraries : c DNA and genomic libraries.

Unit –III

Specialised cloning strategies:- Expression vectors, promoter probe vectors, vectors for library construction- artificial chromosomes.

Unit –IV

DNA sequencing methods:- Dideoxy and chemical method. Sequence assembly, Automated sequencing, Genome sequencing, and physical mapping of genomes.
PCR- Methods and applications

Text and Reference Books:

1. Old & Primrose (1994). Principles of gene manipulation. Blackwell Scientific Publications.
2. Sambrook & Russel (2001). Molecular Cloning, 3rd volume. CSH Press.
- 3.Genome Analysis. 4th volume. (2000). CSH Press.
4. Lewin B(2004). Genes VIII, International Edition, Pearson Education

5. Alberts B, Johnson A, Lewis J, Raff M, Roberts K, & Walter P(2008). Molecular Biology of the Cell, 5th ed., Garland Science Publishing
6. Fritsch J & Maniatis EF(1999). Molecular Cloning A laboratory Manual, Cold Spring Harbor Laboratory

LIST OF PRACTICALS

1. To isolate plasmid DNA from a given culture
2. To prepare agrose gel and to run the plasmid DNA samples
3. Isolation of chromosomal DNA
4. Plant DNA extraction by Phenol: Chlorophorm method
5. Estimation of proteins in given samples by Lowry method.
6. To carry out the extraction of proteins from given culture.
7. To develop competent cells of *E.coli*
8. To carry out the transformation by competent *E. coli* cells.
9. Extraction of DNA from Onion.
10. To test the given sample for purity of DNA content.

SEMESTER IV

MBY 401. BIOSTATISTICS AND COMPUTERS

Max.Marks:70 (Ext. 55+ Int. 15)
Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit- I

Introduction to computer: Classification of computers –computer generation-low , medium and high level languages .Software and hardware –operating systems , compilers and interpreters , mini , main frame and super computer , their characteristics and applications .BIT ,BYTE and WORD ,Computer memory and its types. Data representation and storage –binary codes, binary systems and its relationship to Boolean Operations.

Unit-II

Microsoft excel: Data entry, graphs, aggregate functions- formulations and functions (students are expected to be familiar with all operations).Different numbers systems and conversions. Input output devices, secondary storage media. Internet:How internet works? Significance.

Unit-III

Biostatistics: Statistics, its meaning and objectives .Population samples, frequency tables and their graphs, measures of central tendency (mean, mode, median) and their dispersion. Concepts of moments, Skewness and kurtosis. Intuitive definition of random variables, probability mass function and probability density function, expectation and variance .Standard distribution ; binomial , Poisson and normal distribution with their important properties and significance.

Unit-IV

Fitting of main distributions and testing of goodness –of – the –fit with special reference to χ^2 - test, t –test, Z-test. Fitting of trends; linear and quadratic with least square method. Lines of regression, coefficient of correlation, coefficient of variation and their significance. Analysis of variance; one way and two way classification.

Text and Reference Books:

1. Rosne B(2005). Fundamentals of Biostatistics, Cengage Learning
2. Zar JH(2009). Biostatistical Analysis, Pearson Education 5th ed.
3. Campbell RC (1989).Statistics for Biologists, Cambridge university press.
4. Daniel WW (1995). Biostatistics: A Foundation for Analysis in Health Science, 6th ed., John Wiley
5. Snedecar GW & Cochran WG (1967). Statistical Methods, Oxford Press.
6. White Ron (2001) .How Computers Work? Techmedia.

LIST OF PRACTICALS

1. Find the mean, median and mode of the following temperatures recorded in an experiment in the laboratory:

81,94,64,80,75,69,96,66,80,91,85 and 79

2. Calculate variance and standard deviation for the following frequency distribution.

Marks (x): 10 20 30 40 50 60

No. of students (f): 7 13 25 10 4 1

3. What is correlation? Describe various types of correlation.

4. Find out the Karl pearson coefficient of correlation for the following data:

X: 1 2 3 4 5

Y: 6 8 10 12 14

5. Increase in weights of 10 animals fed on diet A for certain period are

10,6,16,17,13,12,8,4,14,15,9. Another independent random sample of 12 animals fed on diet B, gave the increase 7,13,22,15,12,14,18,8,21,23,10 and 17. By applying the independent t-test whether diet A and B differ significantly as regards their effect on the weight.

6. Convert $(11001)_2 = ()_{10}$

7. What are the five basic operation performed by any computer system?
8. List the different input and output devices?
9. Differences between 1st and 2nd generation computers
10. What is bit, byte and word?

MBY 402. Credit Seminar

MBY 403. Project Training Report

MBY 404. ENVIRONMENTAL MICROBIOLOGY

Max.Marks:100 (Ext. 80+ Int. 20)
Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.
- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit I

Water microbiology. Significance, Major waterborne diseases and their preventive measures. Sewage treatment system (primary, secondary, tertiary and final). Disinfection of potable water supplies. Biological indicators of water safety and their assessment.

Unit II

Soil Microbiology – Biodiversity of soil, Interactions between soil microorganisms. Microbe-Microbe interactions-interaction within a single microbial population, positive & negative interactions, Interactions between diverse microbial populations-Neutralism, Commensalism, Mutualism, Synergism, Competition, Amensalism, Parasitism & Predation.

Unit III

Microbiology of Air. Diversity of microorganisms in air and their significance. Droplet nuclei, aerosol. Night fungal flora. Determination of the microbial content of the air. Aeroallergens. Microbial Communities & Ecosystem- Structure & dynamics of microbial communities, diversity & Stability of microbial communities; population selection within communities: r & k Strategies; Succession within microbial communities; microbial communities in nature- microbes within Macro-communities, their structure & functions.

Unit IV

Microbial bioremediation- Bioremediation, biodegradation of major groups of environmental pollutants, mechanisms of metabolizing different classes of organic pollutants, prospects of microbial application to toxic waste treatment. Biodeterioration and Bioremediation. Biodegradation of xenobiotic compounds.

Text and Reference Books:

1. Mitchell RG & Ji-Dong(2010). Environmental Microbiology, 2nd ed, Wiley-Blackwell
2. Barton LL & Northup DE(2008). Microbial Ecology, John Wiley & Sons
3. Martin Alexander (1977). Soil Microbiology. John Wiley.
4. Paul EA(2007). Soil Microbiology, Ecology and Biochemistry. 3rd Ed. Academic Press.
5. Campbell R (1983). Microbial Ecology. Blackwell.
6. Atlas RM & Bartha R (1993) Microbial Ecology, Benjamin Cummings Publishing Co, Redwood City, CA.
7. Mahajan R, Sharma J & Mahajan RK(2010). Practical Manual of Biotechnology. Vayu Education of India, New Delhi
8. Pepper I.L. & Gerba C. P. Environmental Microbiology: Laboratory manual. Elsevier Academic press.
9. Burlage R.S., Atlas R., Stahl D., Geesey G. & Sayler G. (1998) Techniques in Microbial Ecology. Oxford University press, Inc.

LIST OF PRACTICALS

1. Detection of coliforms in water by multiple tubes fermentation test (Presumptive, confirmed, completed test).
2. Enumeration of water microflora by SPC.
3. To determine the quality of water sample using membrane filter method.
4. Determination of BOD of water.
5. Determination of COD of water
6. Isolation of soil microflora (bacteria and fungi) by serial dilution agar plate method
7. Study of indoor and outdoor microflora by petriplate exposure technique.

MBY 405. AGRICULTURAL MICROBIOLOGY

Max.Marks:100 (Ext. 80+ Int. 20)

Time: 3 hrs

INSTRUCTIONS FOR THE PAPER- SETTERS AND CANDIDATES

- Nine questions of equal marks should be set.
- Question 1 consisting of number of short answer type questions (having no internal choice) spread over the whole syllabus should be compulsory.
- Eight questions, two questions from each unit (I, II, III, IV) should be set.

- Candidates will be required to attempt five questions in all, selecting one question from each unit (I, II, III, IV) and the compulsory question 1.
- All questions will carry equal marks

Unit I

Role of microbes in biogeochemical cycles- Carbon cycle, Nitrogen cycle, Sulphur cycle, phosphorous cycle. Factors affecting the movement of microorganisms in soil- Adsorption to soil particles, soil physical properties, plant roots, soil animals and human beings.

Unit II

Ecophysiological interactions in microbes & higher plants- Interaction with plant roots, interaction with aerial plant structures microbial diseases of plant with specific examples of mycorrhiza, lichens, Rhizobacteria. Phosphate solubilizing bacteria and fungi (including mycorrhiza), potassium solubilizing bacteria and fungi (including mycorrhiza).

Unit III

Nitrogen fixation- Biochemistry of N_2 fixation, properties of terrestrial nitrogen fixing organisms, free living diazotrophs. Symbiotic nitrogen fixation: Rhizobium-Legume association, Actinorhizal associations, contribution of symbiotic nitrogen fixation. Denitrification.

Unit IV

Biocontrol – Concept, types, mode of action & applications of biopesticides and bioherbicides, Biopesticides- classification, advantages. Major biopesticides based on bacteria, viruses & fungi (*Bacillus thuringiensis* (Bt) toxin, Boverin, DeVine, Collego).

Biofertilizer- Mass cultivation of microbial inoculants; green manuring; algalization; *Azolla*.

Microbial products and plant health: PGPR (plant growth promoting rhizobacteria)

Text and Reference Books:

1. Paul EA. (2007). Soil Microbiology, Ecology and Biochemistry. 3rd Ed. Academic Press.
2. Varnam AH & Evans MG (2000). Environmental Microbiology, Manson Publishing Ltd.
3. Christon J.Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills (2007). Manual of Environmental Microbiology, ASM Press
4. Spencer JFT, Alicia L & Ragout de Spencer (2004). Environmental Microbiology: Methods and Protocols. Springer,
5. Paul EA. (2007). Soil Microbiology, Ecology and Biochemistry. 3rd Ed. Academic Press.
6. Burlage R.S., Atlas R., Stahl D., Geesey G. & Sayler G. (1998) Techniques in Microbial Ecology. Oxford University press, Inc.

LIST OF PRACTICALS

1. To demonstrate the liberation of ammonia from nitrogenous organic compound (ammonification).
2. To demonstrate the reduction of nitrates to nitrogen gas (denitrification).
3. Isolation of rhizosphere and nonrhizosphere microflora.

4. Isolation of cellulose degrading microorganisms from soil.

5. Identification of pathogenic fungi:

(a) *Puccinia*

(b) *Colletotrichum*

(c) *Phytophthora*

6. Isolation of *Rhizobium* from root nodules.

7. Isolation of antibiotic producing bacteria from soil.