

SYLLABUS

FOR

M.Sc. SEMESTER PATTERN IN

MICROBIOLOGY

RASHTRASANT TUKADOJI MAHARAJ

NAGPUR UNIVERSITY,

NAGPUR (M.S.)

INDIA

2012-2013

Onwards

**SYLLABUS
FOR
M.Sc. SEMESTER PATTERN IN MICROBIOLOGY SUBJECT, RASHTRASANT TUKADOJI MAHARAJ
NAGPUR UNIVERSITY,
NAGPUR (M.S.) INDIA**

SEMESTER – I (THEORY)

			MARKS
PAPER - I	MB1-T001	MICROBIAL DIVERSITY AND EVOLUTION (MDE)	100
PAPER - II	MB1-T002	MICROBIAL METABOLISM (MM)	100
PAPER - III	MB1-T003	ENZYMOLGY AND TECHNIQUES (ET)	100
PAPER - IV	MB1-T004	MICROBIAL ECOLOGY (ME)	100
<u>PRACTICALS</u>			
PRACTICAL-I	MB1-LAB1		80+20
PRACTICAL-II	MB1-LAB2		80+20
SEMINAR	MB1-INT1		25

SEMESTER – II (THEORY)

			MARKS
PAPER - I	MB2-T005	ADVANCE TECHNIQUES IN MICROBIOLOGY (ATM)	100
PAPER-II	MB2-T006	MEMBRANE STRUCTURE AND SIGNAL TRANSDUCTION (MSST)	100
PAPER-III	MB2-T007	MICROBIAL METHODS FOR ENVIRONMENT MANAGEMENT (MMEM)	100
PAPER - IV	MB2-T008	MICROBIAL METABOLITES (MMT)	100
<u>PRACTICALS</u>			
PRACTICAL-III	MB2-LAB3		80+20
PRACTICAL-IV	MB2-LAB4		80+20
SEMINAR	MB2-INT2		25

SEMESTER – III (THEORY)

			MARKS
PAPER-I	MB3-T009	MEDICAL MICROBIOLOGY AND PARASITOLOGY (MMP)	100
PAPER - II	MB3-T010	IMMUNOLOGY AND IMMUNODIAGNOSTICS (IID)	100
PAPER-III	MB4-T011	BIOINFORMATICS (BIF)	100
PAPER-IV	MB4-T012	MICROBIAL FERMENTATION TECHNOLOGY (MFT)	100
<u>PRACTICALS</u>			
PRACTICAL-V	MB3-LAB5		80+20
PRACTICAL-VI	MB3-LAB 6		80+20
SEMINAR	MB3-INT3		25

SEMESTER – IV (THEORY)

			MARKS
PAPER-I	MB4-T013	MOLECULAR BIOLOGY AND GENETICS (MBG)	100
PAPER-II	MB3-T014	VIROLOGY (VIR)	100
PAPER – III	MB3-T015	DRUGS, VACCINES AND DELIVERY SYSTEMS (DVD)	100
PAPER - IV	MB4-T016	RECOMBINANT DNA TECHNOLOGY (RDT)	100
<u>PRACTICALS</u>			
PRACTICAL-VII	MB4-LAB7		80+20
PROJECT WORK	MB4-PROJ		80+20
SEMINAR	MB4-INT4		25

SEMESTER-I
Paper-I
Microbial Diversity and Evolution (MDE)
MB1- T001

UNIT-I: - Microbial Evolution and Systematic

Evolution of Earth and early life forms.

Primitive life forms:-RNA world, molecular coding, energy and carbon metabolism, origin of Eukaryotes, endosymbiosis.

Methods for determining evolutionary relationships:-Evolutionary chronometers, Ribosomal RNA sequencing, signature sequences, phylogenetic probes, microbial community analysis.

Derivation of Microbial Phylogeny:- characteristics of domain of life, classical taxonomy, chemotaxonomy, bacterial speciation.

UNIT-II: -Microbial Diversity: Archea

General Metabolism and Autotrophy in archea

Phylum Euryarchaeota:-Halophilicarchaea, methanogens, thermoplasma.

Phylum Crenarchaeota:-Energy metabolism, Thermoproteales, sulfolobales, desulfolobales.

Phylum Nanoarchaeota:-Nanoarchaeum.

Heat stable biomolecules and extremophiles, Evolutionary significance of hyperthermophiles.

UNIT-III :-Microbial Diversity: Bacteria

Phylum Proteobacteria:-Free living N₂ fixing bacteria, purple phototrophic bacteria nitrifying bacteria, sulphur and iron oxidizing bacteria, sulphate and sulphur reducing bacteria.

Phylum prochlorophytes and cyanobacteria,

Phylum: Planctomyces,

Phylum; Verrucomicrobia.

UNIT-IV :- Microbial Diversity.

Phylum: Cytophaga, Phylum: Green Sulfur Bacteria. Phylum: Deinococci.

Phylum: Green non –sulfur bacteria.

Phylum: Branching Hyperthermophiles, Thermotoga and Aquifex.

Phylum: Nitrospira and Deferribacter.

SEMESTER-I
Paper-II
Microbial Metabolism(MM)
MB1-T002

UNIT-I: - Carbohydrate and Lipid

Carbohydrates as informational Molecules:-Sugar code, Plant Lectins: - ConA,GS4,WGA.

Animal:-Galectin A, MBP_1. Viral:-HA, VPI. Bacterial:- LT,CT.

Reverse TCA cycle, Biosynthesis of cell wall polysaccharides and bacterial peptidoglycan.

Lipid:-Membrane lipids, biosynthesis of membrane phospholipids, ketone bodies.

UNIT-II: - Proteins and Nucleic acids

Proteins:-Determination and characteristics of alpha-helix and β -sheets. Concept of protein domain and motif, common motifs and their role in metabolism, protein folding and denaturation curves, role of chaperones and chaperonins, Biosynthesis of all amino acids.

Nucleic acids:-Structural details of Duplex DNA, Unusual structures: palindrome, inverted repeats, mirror repeats, triplet DNA,G tetraplex ,secondary structure of RNA purine and pyrimidine biosynthesis, degradation and regulation, salvage pathway, Inhibitors.

UNIT-III: - Photosynthesis

Anoxygenic photosynthesis:-Green sulphur bacterial, non-sulphur bacterial, purple phototrophic bacteria.

Oxygenic photosynthesis:-Cyanobacterial.

Chemolithotrophy:- Hydrogen oxidation and autotrophy in hydrogen bacteria. Oxidation of reduced sulphur compounds and Iron.

Bioluminescence

UNIT-IV:-Nitrogen and Sulphur metabolism and methanogenesis.

Nitrification and Anammox. Nitrate reduction and Denitrification.

Nitrogen fixation: Symbiotic, nonsymbiotic. Sulphate reduction.

Methanogenesis, Acetogenesis, Acetate use and autotrophy.

SEMESTER-I
Paper-III
Enzymology and Techniques (ET)
MB1-T003

UNIT-I: - Enzymes kinetics

Overview of Michaelis-Menten equation and its transformation, Evaluation of kinetic parameters, Kinetics of bisubstrate reaction, multistep reactions, kinetics of enzyme inhibition, Classification of enzymes

UNIT-II: - Catalytic mechanisms

Concept of active site, determination of active site, acid –base catalysis, covalent catalysis, metal ion cofactors, proximity and orientation effects, preferential binding.

Active site determination and mechanism of lysozyme, Active site determination and mechanism of serine protease.

UNIT-III: - Regulation of Enzyme activity

Allosterism, Kinetic analysis of allosteric enzymes

Covalent Modification, Feed -back inhibition

Membrane bound enzymes, isoenzymes and marker enzymes.

Constitutive and inducible enzymes.

UNIT-IV: - Techniques

Protein: ligand binding studies: association and dissociation constants, co-operative ligand binding MWC or concerted model, sequential model.

Enzyme biosensors: General concept, glucose biosensor. Industrial applications of enzymes. Protein engineering.

SEMESTER-I
Paper-IV
Microbial Ecology (ME)
MB1-T004

UNIT-I: - Microbial Ecosystems

Population, guilds, communities, homeostatis, Environment and microenvironment.

Biofilms. Terrestrial environment, deep surface microbiology. Fresh water environment, lake and river microbiology. Marine Microbiology and Hydrothermal vents.

UNIT-II: - Diversity, stability and succession

Diversity indices, dominance indices, information statistics indices, Shannon index, Brillouin Index, Rank abundance diagrams, community similarity analysis, Jaccard Coefficient, Sorensen coefficient, cluster analysis. Community stability, stability hypothesis, Intermediate-disturbance hypothesis.

Meaning of succession: Tolerance and inhibition patterns of succession, theories of succession.

UNIT-III: - Ecology and Genetics

Genetic structure of population:- Genotype frequency, allele frequencies.

Hardy-Weinberg Law: - Assumptions, predictions, derivation, extension and natural selection.

Measuring genetic variation at protein level, measuring genetic variation at DNA level.

Factors effecting gene frequencies:- Mutation, Random genetic drift, migration, Hardy-Weinberg natural selection, Assortative mating, Inbreeding.

UNIT-IV: -Interactions and Ecosystem Management

Microbial Interactions: Competition and coexistence, Gause hypothesis, syntrophy, commensalism and Mutualism, predation, parasitism, and antagonism, Interaction with plants and animals.

Concept of sustainable development: microbial technology and sustainable development.

Management and improvement of waste land/barren land.

Oil spills, damage and management petroleum and oil shore management.

PRACTICAL-I
MB1-LAB1
LABORATORY EXERCISE 1

- 1) Detection of enzyme activity of lipase, Urease, invertase, protease, Tween 80 hydrolysis.
- 2) Determination of kinetic constant of amylase: -Amylase activity, V_{max} , K_m .
- 3) Effect of pH and temperature on amylase activity.
- 4) Effect of inhibitors on amylase activity.
- 5) Estimation of protein:
- 6) Production, isolation and purification of enzyme and determination of fold purification (any one enzyme)
- 7) Estimation of sucrose in presence of glucose.
- 8) UV absorption of proteins, DNA and RNA.
- 9) Estimation of L-leucine by colorimetric method.
- 10) Determination of pK_a of an amino acid.

Minimum seven experiments must be performed in the semester.

PRACTICAL-II
MB1-LAB2
LABORATORY EXERCISE 2

- 1) Isolation and microscopic examination of Myxobacteria, Thiobacteria and Ferrobacteria.
- 2) Isolation of microflora from different ecological niches such as freshwater, mangroves, salt pan bed, hot water spring, acid –zone soil, rhizosphere etc. (any two niches)
- 3) Demonstration microbial Interactions: -competition, syntrophy, antagonism and isolation of nitrogen fixing bacteria.
- 4) Development of biofilm on metal strips.
- 5) Microbial production and processing of polysaccharide schizophyllan.
- 6) Production of protoplast.
- 7) Isolation and purification of Photosynthetic pigments.
- 8) Determination of Shannon index as a measure of evenness H/H_{max} from garden soil.
- 9) Isolation of sulphate reducing bacteria.
- 10) Isolation of bacteria capable of degrading polycyclic aromatic hydrocarbons from oil contaminated earth.

Minimum seven experiments must be performed in the semester.

SEMESTER-II
Paper –I
Advance Techniques in Microbiology (ATM)
MB2-T005

UNIT-I: - Biophysical Techniques-I

Determination of size, shape and Molecular weight of Macromolecules:- by Viscosity, CD/ORD, Light scattering, diffusion sedimentation and Centrifugation techniques.

UNIT-II: -Biophysical Techniques-II

Electrophoresis: Agarose Gel, SDS-page, two-dimensional gel electrophoresis, capillary electrophoresis, immune-electrophoresis.

UNIT-III: -Microscopical Techniques.

Electron Microscopy: SEM, TEM, Staining procedures and microscopy. Fluorescent Microscopy: Staining procedures and Microscopy, FISH. Laser scanning, confocal microscopy. Scanning tunneling and atomic force microscopy. Immunoelectron microscopy, cryoelectron microscopy.

UNIT-IV: -Other advance techniques

Blotting techniques: Western, southern, northern, Radioimmunoassay. NMR and its biological importance. Site-directed mutagenesis, transcriptional start point mapping.

SEMESTER-II
Paper-II
Membrane structure and Signal Transduction (MSST)
MB2-T006

UNIT-I: - Structure and organization of membranes

Mitochondria, endoplasmic reticulum, prokaryotic membrane, membrane junctions (Gap & tight junctions), techniques for membrane study: electron microscopic method, membrane vesicles, differential scanning calorimetry, fluorescence photobleaching recovery, flow cytometry.

UNIT-II: - Membrane Transport

Active and Passive transport, uniport, ATP powered pumps, non-gated ion channels, cotransport by symporters and antiporters, transepithelial transport.

UNIT-III: - Signal Transduction

General concept of cell signaling, G-protein coupled receptors and their effectors. RTK and MAP Kinases. Down regulations of pathways. Cytokine receptors and their mechanism (JAK-STAT pathway).

UNIT-IV: - Bacterial signal transduction

Basic two component system. Histidine kinase pathway Sporulation as a model of bacterial signal transduction. Osmoregulatory pathways. Heat shock proteins. Mating types of yeast.

SEMESTER-II
Paper-III
Microbial Methods for Environment Management (MMEM)
MB2-T007

UNIT-I: - Eutrophication, Biodeterioration and Biomagnification

Eutrophication: Microbial changes induced by organic and inorganic pollutants, factors influencing eutrophication process and control of eutrophication.

Biodeterioration: Definition and concept of biodeterioration, biodeterioration of woods and pharmaceutical products.

Biomagnification: concept and consequences, Biomagnifications of chlorinated hydrocarbons and pesticides.

UNIT-II: - Biotransformation and Bioleaching, Biodegradation

Biotransformations: metals and metalloids, mercury transformations, biotransformation of pesticides such as hexachlorobenzene.

Bioleaching: Bioleaching of ores, leaching techniques and applications.

Biodegradation: Biodegradation of plastics.

UNIT-III: - Pollution Management

Waste water management using activated sludge, aerated lagoons, trickling filter, rotary biological contractors, fluidized bed reactors, stabilization ponds. Concept of phytoremediation and applications.

UNIT-IV: - Global Environmental Problems

Ozone depletion, UV-B, green house effect, acid rain, their impact and biotechnological approaches for management. Acid mine drainage and associated problems. Global warming and climate change.

SEMESTER-II
Paper –IV
Microbial Metabolites(MMT)
MB2-T008

UNIT-I:- Overview of metabolites

Metabolites: General account of metabolites, secondary metabolites. Classification, structure and mode of action of secondary metabolites. Plants secondary metabolites: Digitoxine, Salicylic acid, Mycotoxins-Aflatoxin, Ochratoxin, Patulin.

Biopolymers: Polypeptides (collagen, casein and serum albumin), Polynucleotides and polysaccharides (amylose, amylopectin, alginate, cellulose) and other biopolymers like chitin, Xanthan, dextrin, Gellan, Pullulan, curdlan and hyaluronic acid.

Polyamines: Brief outline and functions of polyamines. Synthesis of linear polyamine-putrescine, cadaverine, spermidine and spermine.

UNIT-II:- Antimicrobial drugs: Secondary metabolites

Antibiotics: History and discovery of antibiotics, Antibiotic resistance, Mechanisms of antibiotic resistance.

Structure and mode of action of antibiotics:

Aminoglycosides (Amikacin), Carbapenems (Imipenim), macrolids (Azithromycin), Nitrofurans (nitrofurantoin), Penicillins (Amoxicillin), Quinolones (gatifloxacin/Ciprofloxacin), Sulphonamides (sulfamethoxazole), Tetracyclines (doxycyclines), Chloramphenicol, Fluconazole.

UNIT-III:- Pigments as secondary metabolites

General account of pigments, Chlorophylls, Carotenoids of eukaryotes, phycobiliproteins. Hemoglobin, Myoglobin, Melanin and bile pigments. Microbial pigments: Bacteriochlorophylls, Carotenoids of prokaryotes, rhodopsin and accessory pigments (Pulcherrimin, indigoidin, violacein) Defensive role of pigments.

UNIT-IV:- Microbial vitamins

Characteristics of fats and water soluble vitamins.

Structure, function and chemistry of: Retinol (vitamin A), Riboflavin (vitamin B₂), Cyanocobalamin (Vitamin B₁₂) and ascorbic acid (vitamin C).

Deficiency diseases in

humans: Xerophthalmia, BeriBeri, Pellagra, Scurvy, Keratomalacia, osteoporosis, Osteomalacia, Cheilosis, Glossitis, Pernicious anemia and Erythroid hypoplasia.

PRACTICAL-III
MB2-LAB3
LABORATORY EXERCISE 3

- 1) Separation of DNA by agarose gel electrophoresis and estimation of DNA by Diphenylamine method.
 - 2) Estimation of RNA by Orcinol method.
 - 3) Separation of amino acids by paper chromatography.
 - 4) Separation of serum proteins by paper electrophoresis.
 - 5) Thin layer chromatography of mycotoxins
 - 6) SDS-Page of proteins.
- 7) Performance of affinity chromatography.
- 8) Performance of Gel filtration chromatography.
- 9) Demonstration of blotting technique.[any one].
- 10) Ion exchange chromatography

Minimum seven experiments must be performed in the semester.

PRACTICAL-IV
MB2-LAB4
LABORATORY EXERCISE 4

- 1) Estimation of Riboflavin/Thiamine by fluorometric method.
- 2) Production of antibiotic as secondary metabolite and its assay[any one antibiotic].
- 3) Microbial production of Dextran/xanthan as secondary metabolites.
- 4) Membrane disruption and separation subcellular organelles.
- 5) Production of microbial pigments using any pigment producing organism.
- 6) Biotransformation of toxic chromium (+6) into nontoxic (+3) by pseudomonas species.
- 7) Microbial dye decolorization.
- 8) Isolation of Mercury resistant bacteria.
- 9) Isolation of salmonella and bacteriophages from waste water/sewage.
- 10) Determination of Laboratory bioleaching process.

Minimum seven experiments must be performed in the semester.

SEMESTER-III
Paper-I
Medical Microbiology and Parasitology (MMP)
MB3-T009

UNIT-I: - Infection

Infection: Definition, Types, stages of infection, process of infection.

Establishment of pathogenic microorganisms: Entry, spread and tissue damage. Mechanism of bacterial adhesion, colonization and invasion of mucous membranes of respiratory, enteric and urogenital tracts. Aggressins and toxins.

UNIT-II: - Bacteriology

Pathogenic Bacteria: Morphological characteristics, Pathogenesis and Laboratory diagnosis including rapid methods of following pathogenic bacteria;

Klebsiellapneumoniae; Proteus Vulgaris; Proteus mirabilis; Shigelladysenteriae; Pseudomonasaeruginosa; Vibrio Cholerae; Streptococcus pneumoniae.

New emerging infections: -*Streptococcus suis; community associated Methicilin resistant Staphylococcus aureus(MRSA), Bordetellapertusis, Clostridium difficile, Multi drug resistant tuberculosis.*

UNIT-III: - Mycology

Pathogenic Fungi: Morphological characteristics, pathogenesis and laboratory diagnosis of following pathogenic fungi;-

Microsporium; Trichophyton; Histoplasma capsulatum; Blastomyces dermatitidis; Candida albicans; Cryptococcus neoformans; Pneumocystis carinii.

UNIT-IV: - Parasitology

Parasites: *Entamoeba histolytica; Giardia Lamblia; Plasmodium vivax; Leishmania donovani.*

Helminths: *Taenia saginata; Taenia solium; Hymenolepis nana; Schistosoma haematobium.*

SEMESTER-III
Paper –II
Immunology and Immunodiagnosics (IID)
MB3-T010

UNIT-I: - Overview of the Immune system and CMI

Cells involved in Immune system: Hematopoiesis, Lymphocytes, mononuclear phagocytes, Antigen presenting cells, Granulocytes.

Lymphoid organ: Lymphatic system, Primary and Secondary lymphoid organs.

Complement System: Pathways of complement activation, regulation of complement system, Biological functions of complement system.

Inflammation: Intracellular cell adhesion molecules, Mechanism of cell migration, Inflammation. Pathways of antigen processing and presentation.

Cell Mediated Immunity: General properties of effector T cells, Cytotoxic T Cells, Natural Killer cells, Antibody-Dependent cell mediated cytotoxicity. T-Cell dependent and T-cell independent defense mechanisms.

UNIT-II: - Specific Immune Response

Cancer and the Immune system: Origin and Terminology, Malignant Transformation of cells, oncogenes and cancer induction, Tumor Antigens, Immune surveillance theory, Tumor evasion of the Immune system, Cancer Immunotherapy.

Transplantation Immunology: Immunological basis of Graft Rejection, Mechanism of Graft rejection. Immunosuppressive therapy: General and specific. Clinical Transplant.

Tolerance: Central and peripheral tolerance to self antigens, Mechanism of induction of natural tolerance.

UNIT-III: - Immune Dysfunction

Immunodeficiency disorders: - Phagocytic cell defect (Chediak-Higashi syndrome); B-cell deficiency (Bruton's X-linked hypogammaglobulinemia); T-cell deficiency disorder (DiGeorge Syndrome); Combined B-cell & T-cell deficiency disorder (SCID-Severe combined immunodeficiency diseases, Wiskott-Aldrich syndrome); Complement deficiencies and secondary immunodeficiency conditions carried by drugs, nutritional factors & AIDS.

Autoimmunity and autoimmune diseases:-General consideration, Etiology, Clinical categories, Diagnosis and treatment. RA(Rheumatoid arthritis); SLE (Systemic Lupus Erythematosus); Guillain-Barre Syndrome; Multiple sclerosis; Myasthenia gravis; Grave's disease; Goodpasture syndrome, Autoimmune haemolytic disease; Pernicious anaemia.

Hypersensitivity :- Type I, Type II, Type III & Type IV

UNIT-IV: - Immunodiagnosics

Precipitation reactions:Immunodiffusion, immunoelectrophoresis,

Agglutination reactions: Bacterial Agglutination, Hemagglutination, Passive agglutination, Reverse passive agglutination and agglutination inhibition.

Immunodiagnostic techniques:Radioimmuno assay, ELISA, Chemiluminiscenceimmuno assay, Western blotting technique, Complement fixation test, Immunofluorescence, Immunoelectron microscopy.

SEMESTER-III
Paper-III
Bioinformatics (BIF)
MB3-T011

UNIT-I: - General

Database types, levels of omics, genome projects.

C-value paradox, reassociation kinetics.

Data researches and pairwise alignments:-

Dot Plots, Simple alignments, Dynamic programming global and local alignments

BLAST, FASTA, Scoring matrices, and alignment scores. Multiple sequence alignments. Pattern of substitution within genes, substitution number estimations, molecular clocks.

UNIT-II: - Phylogenetics

Phylogenetic trees, distance matrix method, maximum likelihood approach, multiple sequence analysis, Parsimony, Inferred ancestral sequence, consensus trees, comparison of phylogenetic methods.

UNIT-III: - Genomics and Gene recognition

Prokaryotes genomes, prokaryotic gene structure GC content prokaryotic gene density, eukaryotic genomes, eukaryotic gene structure, ORF, GC content expression, Transposition, Repetitive elements, gene density.

UNIT-IV: - Protein Structure and proteomics

Protein structure level, Protein folding modeling structure prediction, RNA secondary structure prediction, Inhibitors and drug design, ligand screening empirical methods and prediction techniques, post translational modification prediction.

SEMESTER-III
Paper-IV
Microbial fermentation Technology (MFT)
MB3-T012

UNIT-I:- General Principles of Fermentation

Bioreactors: Bioreactor types, immobilized bioreactors, types of fermentation.

Fermentation kinetics and Monod's Model: -Growth kinetics and Monod's Model, Substrate-accelerated death, specific growth rate, stringent response, Ntr and Pho system, growth limiting substrate, maintenance energy, growth yield and product formation.

Process optimization: factors of optimization, rheology of fermentation fluid, oxygenation, and oxygen transfer kinetics. chemostat, turbidostat.

UNIT-II:- Downstream Processing and scale up.

Downstream processes: types of processing units and systems, Storage and packaging methods.

Scale up; scale down, criteria involved in scale up.

Productivity, power requirements Basic control theory.

UNIT-III: - Industrial Fermentation Products

Biofuels:-Ethanol, Hydrogen, Methane

Antibiotics:- β -lactum antibiotics (Synthetic penicillin), Streptomycin, Cephalosporin.

Biopreservative: Lactobacillus sakei. Biopolymers:-Xanthan, Polyhydroxyalkanoates.

Thermostable enzymes:-Proteases. Biosurfactants: a comparative account.

UNIT-IV:-Food and Healthcare products

SCP, various types and processes. Carotenoids

Aminoacids:-Lysine, Glutamic acid.

Vitamins:-riboflavin, Vit. B12. Fatty acids (Palmitate, oleate).

PRACTICAL-V
MB3-LAB5
LABORATORY EXERCISE 5

- 1) Different staining:
 - Acid fast staining,
 - Giemsa staining,
 - Leishmann staining,
 - Flurochrome staining
 - Special staining methods to demonstrate granules, capsule and spores.
- 2) Isolation of pathogens from clinical samples pus, blood and urine.
- 3) Conventional and rapid methods of isolation and identification of following pathogenic bacteria, fungi and parasites.
 - **Bacteria:** Staphylococcus aureus; Escherichia coli; Klebsiella pneumoniae; Proteus vulgaris; Proteus mirabilis; Salmonella typhi; Salmonella paratyphi; Shigella dysenteriae; Shigella flexneri; Pseudomonas aeruginosa; Vibrio cholera. {Any five}
 - **Fungi:** Candida albicans; Cryptococcus neoformans; Microsporum; trichophyton; Histoplasma capsulatum. [any one]
 - **Parasite:** Entamoeba histolytica, Giardia lamblia, Plasmodium sp; Trichomonas vaginalis; Taenia solium, Taenia saginata [any one].
- 4) Antibiotic sensitivity testing by various methods:
 - Kirby-Bauer's disc diffusion method.
 - Well plate method.
 - Broth dilution method.
 - Agar dilution method.
 - E-strip method for MIC testing.

PRACTICAL-VI
MB3-LAB 6
LABORATORY EXERCISE 6

Section A

- Diagnostic immunologic principles and methods of followings:
- Immunodiffusion
- Immunoelectrophoresis
- Blood grouping
- Widal[slide and tube]tests.
- TRUST[Toludine red unheated serum test]
- Syphcard test
- Australian latex antigen test.
- Antistreptolysin 'o'test[ASO]
- Pregnancy test.
- Rhematoid arthritis test[RA]
- RPR[rapid plasma reagin]test.
- Treponemapallidumhaemagglutination test.
- One step test for Qualitative detection of HBs.
- ELISA[Enzyme linked immunosorbent assay]-HIV and HBs.
- Separation and characterization of lymphocytes from blood and demonstration of lymphocyte population.

SECTION B

- Determination of microbial reaction kinetics for an inhibitory substrate in a fed batch system.
- Determination of the parameters of oxygen transfer.
- Immobilization of cells/Enzymes.

Section B is compulsory and minimum ten experiments from Section A

SEMESTER-IV
Paper-I
Molecular Biology and Genetics (MBG)
MB4-T013

UNIT-I: - Replication Repair and Recombination

Replication:-Initiation-Priming in E.Coli and Eukaryotes.

Elongation:-Holoenzyme and processivity of replication.

Termination:-In prokaryotes and eukaryotes.

DNA Repair:-Direct reversal of DNA damage, Base excision repair by nucleotide excision.

Homologous recombination:-Rec BCD; gene conversion.

UNIT-II: - Gene Expression

Transcription:-Comparative study of prokaryotic and eukaryotic transcription process, Class I, II, III promoters, Enhancers and silencers, General and specific transcription factors.

Post transcriptional events:-mRNA, rRNA and tRNA processing through splicing mechanism, trans splicing, RNA editing, post transcriptional control of gene expression, **gene silencing** RNA interference, Catalytic RNA and antisense RNA.

Translation:-Initiation, elongation and termination mechanism. Post translational modifications.

UNIT-III: - Gene Regulation Expression

Lac, Arabino and trp operons.

Chromatin remodeling and mRNA and protein degradation control.

UNIT-IV:- Genetics of Bacteria and Bacteriophages

Gene mapping in bacteria by conjugation, transformation and transduction.

Mapping bacteriophage gene by recombination analysis, deletion mapping and complementation.

Transposons: Bacterial, P elements and retroposons.

SEMESTER-IV
Paper-II
Virology (VIR)
MB4-T014

UNIT-I: - History, Classification and composition of viruses

- Brief outline on discovery of viruses (Origin and evolution), Terminology, Differentiation with other groups of microorganisms.
- Nomenclature and classification of viruses (Regenmortel et.al.2005, 8th Report of ICTV).
- Genetic classification
- Morphology and structure of viruses (size and shape/symmetry).
- Chemical composition of viruses (viral capsid, spikes, envelopes and types of viral nucleic acids).
- Assay of Viruses.

UNIT-II:-Bacterial viruses

Bacteriophages- Structural organization; life cycle (Extracellular phase; attachment, penetration of nucleic acid, transcription, translation, replication, maturation and release of phage particles) of Φ X174, T4, lambda, M₁₃ and M_{UPhages}. Bacteriophage typing, One step growth curve.

UNIT-III:-Animal and Plant viruses

Life cycle, pathogenesis and laboratory diagnosis of following viruses.

Animal Viruses:-

RNA viruses: Picorna, Orthomyxo, Rhabdovirus and HIV.

DNA viruses: Pox, Herpes, Adeno and Hepatitis viruses.

Oncogenic viruses: Papova viruses, EB virus, HTLV viruses.

Plant virus: TMV, Cauliflower mosaic virus, potato virus.

UNIT-IV:-General methods of Diagnosis and antiviral drugs

Serological methods: -Haemadsorption; Haemadsorption inhibition; haemagglutination; Haemagglutination inhibition(HAI); Complement fixation, Immunofluorescence methods. ELISA and Radioimmunoassays(RIA).

Antiviral agents: Types of IFN, induction and Molecular basis of antiviral effect of interferon
Structure and Mechanism of action of:
Amantadine, Rimantidine, Vidarabine, Acyclovir, Ganciclovir, Ribavirin, Foscarnet, Stavudine,
Lamivudine.

NNRTIS(non-nucleoside RT inhibitors)- Nevirapine; Delavirdine and Efavirenz.

Protease inhibitors- Saquinavir, Indinavir and Ritonavir.

SEMESTER-IV
Paper-III
Drugs, Vaccines and Delivery systems(DVD)
MB4-T015

UNIT-I: - DRUGS-I

Drug latention and Prodrug: History, carrier-linked prodrugs, bioprecursorsprodrugs, carboxylic acids and alcohols, amines, carboxyl compounds.

Drug-microbe: Host relationship, mechanism of drug action and drug resistance.

Antiinfective agents:Iodophores (providone-Iodine),Benzylkonium chloride, genital violet, mercury compounds.

Antifungal agents:Clotrimazole, Ketoconazole, Tolnaftate, Amphotericin B, Nystatin, Griscofulvin.

Antitubercular agents: Isoniazid, Ethambutol, rifamycin ,cycloserine.

UNIT-II: - DRUGS-II

Antiprotozoal agent:Metranidazole, 8-hydroxyquinoline

Antimalarials:Quininesulphate, Chloroquine, Primaquine phosphate, Pyrimethamine.

Histamines and Antihistaminicagents: Cimetidine, Ramitidine, Omeprazole.

Analgesic agents:Morphine and their derivatives anti-inflammatory analgesics-Phenylbutazoneamdoxyphenbutazone, Prostaglandins.

UNIT-III: - Vaccines

Active and passive prophylactive measures.

Conventional bacterial and viral vaccines and their administration.

New generation vaccines (bacterial, viral) Edible vaccines.

UNIT-IV:-Drug delivery mechanism and testing.

Conventional drug delivery systems. Advance delivery mechanisms. Drug designing.

Non-automated in vitro drug susceptibility testing.

Rapid tests for susceptibility testing, and antibiotic assay in body fluid.

SEMESTER - IV
Paper –IV
Recombinant DNA technology (RDT)
MB4-T016

UNIT-I: - Molecular Cloning Methods.

DNA cloning, restriction enzymes, cloning vectors, genomic library ,cDNA library and chromosome libraries.

Screening and identification of genes, Expression vectors, heterologous probes, oligonucleotide probes, microarrays.

PCR: Steps, advantages, limitations, application, RT-PCR,

UNIT-II:- Other molecular tools for studying genes

Restriction mapping: DNA sequencing dideoxy and pyrosequencing, DNA fingerprinting.

S1 Mapping, primer expressions, Dnasefootprinting, DMS footprinting.

Nuclear run on transcription, reporter gene transcription.

UNIT-III:- Tissue Culture and stem cell technology

Tissue culture: Tissue culture media and supplements, serum-free media, cell lines and cryopreservation of cells. Primary culture, subculture, suspension culture techniques, transformation and immortalization. Quantitation and characterization of cells.

Stem cell technology-embryonal stem cell and multipotent stem cells, present perspective.

UNIT-IV:- RDT Products.

Tissue plasminogen activator [TPA].Tissue growth factor B. Dnase; **PDGF**.

GEMS/GMO.

Transgenic plants and plant products, Comparative account.

Practical-VII
MB4-LAB7
LABORATORY EXERCISE 7

- 1) Isolation of genomic DNA of bacteria.
- 2) Isolation of plasmid DNA.
- 3) Amplification of DNA by PCR.
- 4) Restriction digestion and RFLP
- 5) Demonstration of bacterial transformation.
- 6) Demonstration of cloning
- 7) Demonstration of UV induced mutagenesis in *E.coli*.
- 8) Demonstration of ligation.

Minimum five experiments must be performed.

PROJECT WORK
MB4-PROJ

Project must contain following subsection:-

- Introduction, Aims and objectives, short literature review, materials and methods, experiments and results, discussion, conclusion and references.
- 50% marks each shall be evaluated by external and internal examiner respectively

Appendix – I

Scheme of teaching and examination under credit based semester pattern for M.Sc. Programme in all subjects except Mathematics and M.Sc. (Tech) Applied Geology

Sr. No.	Semester	Paper Code	Course Code	Theory Paper/Practical (Title)	Teaching Scheme (Hrs/week)			Credits	Examination Scheme					
					Th	Pr.	Total		Duration (Hrs)	Max Marks		Total Marks	Min. Passing Marks	
										External Marks	Internal Marks		Th.	Pr.
1.	I	I	MB1-T001	Microbial Diversity and Evolution (MDE)	4		4	4	3	100		100	40	
2.	I	II	MB1-T002	Microbial Metabolism (MM)	4		4	4	3	100		100	40	
3.	I	III	MB1-T003	Enzymology and Techniques (ET)	4		4	4	3	100		100	40	
4.	I	IV	MB1-T004	Microbial Ecology (ME)	4		4	4	3	100		100	40	
5.	I		MB1-LAB1	Laboratory Exercise 1		8	8	4	3-8*	80	20	100		40
6.	I		MB1-LAB2	Laboratory Exercise 2		8	8	4	3-8*	80	20	100		40
7.	I		MB1-INT1	Seminar	2		2	1	---		25	25	10	
Total					18	16	34	25				625	170	80

Sr. No.	Semester	Paper Code	Course Code	Theory Paper/Practical (Title)	Teaching Scheme (Hrs/week)			Credits	Examination Scheme					
					Th.	Pr.	Total		Duration (Hrs)	Max Marks		Total Marks	Min. Passing Marks	
										External Marks	Internal Marks		Th.	Pr.
1.	II	I	MB2-T005	Advance Techniques in Microbiology (ATM)	4		4	4	3	100		100	40	
2.	II	II	MB2-T006	Membrane structure and Signal Transduction (MSST)	4		4	4	3	100		100	40	
3.	II	III	MB3-T007	Microbial Methods for Environment Management (MMEM)	4		4	4	3	100		100	40	
4.	II	IV	MB2-T008	Microbial Metabolites (MMT)	4		4	4	3	100		100	40	
5.	II		MB2-LAB3	Laboratory Exercise 3		8	8	4	3-8*	80	20	100		40
6.	II		MB2-LAB4	Laboratory Exercise 4		8	8	4	3-8*	80	20	100		40
7.	II		MB2-INT2	Seminar	2		2	1	---		25	25	10	
Total					18	16	34	25				625	170	80

Sr. No.	Semester	Paper Code	Course Code	Theory Paper/Practical (Title)	Teaching Scheme (Hrs/week)			Credits	Examination Scheme					
					Th	Pr.	Total		Duration (Hrs)	Max Marks		Total Marks	Min. Passing Marks	
										External Marks	Internal Marks		Th.	Pr.
1.	III	I	MB3-T009	Medical Microbiology and Parasitology (MMP)	4		4	4	3	100		100	40	
2.	III	II	MB3-T010	Immunology and Immunodiagnostic (IID)	4		4	4	3	100		100	40	
3.	III	III	MB3-T011	Bioinformatics (BIF)	4		4	4	3	100		100	40	
4.	III	IV	MB3-T012	Microbial Fermentation Technology (MFT)	4		4	4	3	100		100	40	
5.	III		MB3-LAB5	Laboratory Exercise 5		8	8	4	3-8*	80	20	100		40
6.	III		MB3-LAB6	Laboratory Exercise 6		8	8	4	3-8*	80	20	100		40
7.	III		MB3-INT3	Seminar	2		2	1	---		25	25	10	
Total					18	16	34	25				625	170	80

Sr. No.	Semester	Paper Code	Course Code	Theory Paper/Practical (Title)	Teaching Scheme (Hrs/week)			Credits	Examination Scheme					
					Th.	Pr.	Total		Duration (Hrs)	Max Marks		Total Marks	Min. Passing Marks	
										External Marks	Internal Marks		Th.	Pr.
1.	IV	I	MB4-T013	Molecular Biology and Genetics (MBG)	4		4	4	3	100		100	40	
2.	IV	II	MB4-T014	Virology (VIR)	4		4	4	3	100		100	40	
3.	IV	III	MB4-T015	Drugs, Vaccines and Delivery system (DVD)	4		4	4	3	100		100	40	
4.	IV	IV	MB4-T016	Recombinant DNA Technology (RDT)	4		4	4	3	100		100	40	
5.	IV		MB4-LAB7	Laboratory Exercise 7		8	8	4	3-8*	80	20	100		40
6.	IV		MB4-PROJ	Project Work		8	8	4	3-8*	80	20	100		40
7.	IV		MB4-INT4	Seminar	2		2	1	---		25	25	10	
Total					18	16	34	25				625	170	80

Note: Th = Theory; Pr = Practical/lab; *= If required, for two days

- In each semester students will have to give seminar or any topic relevant to the syllabus encompassing the recent trends and development in that field. The topic of the seminar will be decided at the beginning of each semester in consultation with the supervising teachers. The student has to deliver the seminar which will be followed by discussion. The seminar will be open to all the teachers of the department, invitees, and students.**
- The student will have to carry out the research based project work in lieu of practical in the fourth semester in the department or depending on the availability of placement; he/she will be attached to any of the national/regional/private research institute/organization. The student in consultation with supervisor will finalize the topic of the project work at the beginning of the third semester.**
- Each theory paper is supposed to cover minimum 60 clock hours (15 clock hours per unit) of teaching and 240 clock hours per semester for all four papers.**

4. One credit course of theory will be of one clock hour per week of 25 marks running for 15 weeks and credit course of theory will be of four clock hours per week of 100 marks running for 15 weeks.
5. One credit course of practical will consist of two hours of laboratory exercise of 25 marks running for 15 weeks and four credit course of practical will consist of eight hours of laboratory exercise of 100 marks running of 15 weeks.

APPENDIX B

MASTER OF SCIENCE (MICROBIOLOGY)

TWO YEAR (FOUR SEMESTERS) DEGREE COURSE

A) Pattern of Question Paper

1. Four units in each paper.
2. One question on each unit.
3. Fifth question on all units.
4. Maximum marks of each paper 100
5. Projects shall be evaluated by internal and external examiners. 20 marks of project shall be given by internal and 80 marks by external examiners each.
6. Duration of question paper is 3 hours.
7. Practical/lab examination of 100marks. Distribution of marks shall be 20internal and 80 external.

B) Absorption scheme:

1. While switch over to current semester system failure students should get three chances to clear old semester pattern.
2. To get admission in the third semester students should clear first semester including theory as well as practical/lab.

C) Grade Point Average (GPA) and Course Grade Point Average (CGPA)

SCORE (out of 100)	GRADE POINT AVERAGE (out of 10)
90 to 100	10
80 to 89	09
70 to 79	08

On clearing a paper, based on the cumulative score (out of 100) in that paper, a student will be given Grade Point Average (GPA) (Maximum of 10, and minimum of 4) for that paper on the following basis.

60 to 69	07
55 to 59	06
50 to 54	05
40 to 49	04
Below 40	00 or fail

On clearing all the papers in a semester, a student will be allotted a Semester Grade Point Average (SGPA) for that particular semester. As the pattern given above does not have differential weights for papers, the SGPA of a student for a particular semester will be the average of the GPA's for all the papers.

A student will be allotted a Course Grade Point Average (CGPA) after clearing all the four semesters. Again as there is no differential weight system for semesters, the CGPA of a student will be the average of the four SGPA's of that student.

The CGPA can be converted to the usual /conventional divisions in the following way.

CGPA	Equivalent class/division
9.00 to 10.00	First class (outstanding)
8.00 to 8.99	First class (excellent)
7.00 to 7.99	First class with distinction
6.00 to 6.99	First class
5.50 to 5.99	Higher second class
5.00 to 5.49	Second class
4.00 to 4.99	Pass class
Below 4.00	Fail

APPENDIX –C
MASTER OF SCIENCE (MICROBIOLOGY)
TWO YEAR (FOUR SEMESTERS) DEGREE COURSE

EXPERIMENTAL PROJECT WORK

SCHEME / GUIDELINES FOR THE STUDENTS, SUPERVISORS & EXAMINERS:

Candidates are required to submit an Experimental Project Work on a related research topic of Microbiology.

The Experimental Project Work will be evaluated by the examiners.

The work will carry total 100 marks. Every candidate shall submit two copies of the Experimental Project Work (typed & properly bound) at least one month prior to commencement of the final Practical/lab Examination M.Sc.-II (i.e.4th Semester) through Head/Course-coordinator/Director of the Department/Centre or the Principal of the College concerned along with the certificate signed by the supervisor/guide and declaration by the candidate that the work is not submitted to any University or organization for the award of the degree.

The supervisors for the Experimental Project Work shall be from the following.

A person selected by the duly constituted Selection Committee in the relevant subject and approved by the University, exclusively for P.G. course.

OR

A person selected by the duly constituted Selection Committee of the University approved by the University and appointed as a full time regular teacher at U.G. level in the relevant subject and having at least 15 years teaching experience.

OR

A person selected by duly constituted Selection Committee of R.T.M. Nagpur University, approved by the University and appointed as full time regular teacher at UG level having M. Phil degree with 10 years teaching experience at UG level, or a person who has Ph.D. Degree, with 5 years teaching experience in relevant subject.

OR

Scientists of National Laboratories/ Regional Research Laboratories who are approved by dint of their appointments in such facilities by the Union Government / the State Government / Nagpur University / Other Universities recognized by UGC with at least in the Grade Pay of Rs.8000/-.

Students will be assigned the topic for Experimental Project Work by their respective supervisors. Topics of Experimental Project Work of students shall be forwarded to Controller of Examination for an appointment of

External Examiners. Experimental Project Work shall be evaluated by both external and internal examiner in the respective Department / Center / Affiliated Colleges.

The examiner will evaluate the Experimental Project Work taking into account the following considerations.

- 1] Coverage of subject matter
- 2] Arrangement & Presentation
- 3] References

General Instructions/Directions.

The syllabus to be implemented with effect from session 2012-13.

Each paper is supposed to cover minimum 60 clock hours of teaching and 240 clock hours per semester for all the four papers.

Each Question paper shall have five questions with equal marks/credits.

There will be four long questions one question from each unit. A long question can be subdivided into two short questions.

Fifth question shall comprise of four very short question one question of each unit.

There shall be internal choice from each unit.

Practical examination shall be of minimum 12 hours and may spread over two days,

There shall be at least one major and two minor experiments in the practical examination

Minimum passing marks are per the marks/credit annexure.

Every student shall be required to participate in educational/industrial tour at least once during PG course.

List of recommended books

- The Biochemistry of copper By: Jack Peisach, Phillip Aisen.
- Biochemistry: -By: Rex Montgomery.
- Lehninger Principles of Biochemistry By: -David L. Nelson and Cox
- Metabolic Pathways. By: -David M. Greenberg.
- Harper's Biochemistry By: Robert K. Murray.
- Enzymes: By: Trevor Palmer.
- Enzyme structure and mechanism By: Alan Fersht.
- Methods in Enzymology By: S. Berger, A. Kimmel.
- Fundamentals of Enzymology By: N. Price, L. Stevens.
- Immobilization of Enzymes and cells. By: Gordon Bickerstaff.
- Industrial Microbiology By: A. H. Patel
- Industrial Microbiology By: L. E. Casida.
- Food Microbiology. By: William C. Frazier, Dennis C. Westhaff.
- Prescott and Dunns Industrial microbiology. By: Gerald Reed.
- Basic Food Microbiology. By: George J. Banwart.
- Medical Microbiology. By: G. F. Brooks, J. S. Butel, S. A. Morse.
- Text book of Microbiology. By: Ananthanarayan and Panikar.
- Medical Microbiology. By: B. S. Nagoba and A. Pichare.
- Clinical Microbiology and Infection control. By: Elaine Larson.
- Bacterial Pathogenesis; Molecular and cellular mechanism. By: Camilla Loch and Michel Simonet.
- Medical Microbiology. By: David Greenwood.
- Medical Microbiology. By: J. P. Duguid.
- Small Dna tumor viruses. By: Kevin Gaston.
- Viruses and Interferon; current research. By: Karen Mossam
- Lentiviruses and Macrophages: Molecular and Cellular interactions. By: Moira Desport.
- The Biology of Animal viruses. By: C. A. Mims.
- Animal virology. By: David Baltimore, A. Huang, C. Fox
- Oncogenic viruses and host cell genes. By: E. Kurstak, Karl Maramorosch.
- Bacterial and Bacteriophage Genetics. By: Edward A. Birge.
- Molecular Genetics of Bacteria. By: J. W. Dale.
- Molecular Biology of the gene. By: J. D. Watson, N. H. Hopkins, J. W. Roberts, J. A. Steitz & A. M. Weiner.
- Microbial Genetics. By: Maloy {T. A}. Jones and Bartlett publications.
- Mobile DNA. By: Nancy Craig, Martin Gellatallan, Lambowitz.
- Methods of General and Molecular biotechnology. By: Philip Gerhardt ASM publication.
- Recombinant DNA. By: Watson J. D.
- Essentials of Molecular Biology. By: Malcinski.
- Molecular genetics of Bacteria. By: Larry, Synder and Wendy Champness.
- Molecular biology. By: F. Weaver. WCB/MCGraw Hill.
- Molecular Biology of Gene. Watson et al, Benjamin-cumminas, USA.
- Molecular Biotechnology. Glick-1994.
- Genetic Engineering By: Sandya Mitra.
- Environmental Microbiology By: Ralph Mitchell, John Wiley and Sons Inc.
- Environmental Biotechnology By: C. F. Froster and D. A. John Wase, Elis Horwood.
- Biocatalysis and Biodegradation: Microbial Transformation of organic compounds.

- y:Lawrence p.Wacekett.
- A manual of environment Microbiology.By:ChristonJ.hurst,ASM publication.
- Biodegradation and bioremediation Academic pressBY:San Diego.
- Biotechnology in the sustainable environment,Plenumpress,NYBasic principles of Geomicrobiology.
- By:A.D.Agate.
- Environmental MicrobiologyBy:R.M.Maier,I.C.Papper and C>P>Gerba.
- Methods in Microbiology:Lynch and Hobbie.
- Experimental Microbial Ecology.By:Arosison Academic Press.
- Advances in Applied microbiology.By:D.Pearlman academic press.
- Microbiology of Extreme environments,edited by Clive Edward,Open University press,Milton Keynes.
- Principles of Biochemistry.By:DonaldJ.voet,JudithG.Voet,CharlotteW.Pratt.
- Brock Biology of Microorganisms.By:John M. Martinko.
- Introduction to Genetic analysis.By:Griffiths,Wessler.lewontin,Gelbart,Suzuki,Miller.
- Biophysical Chemistry VOL:I,II,III;The conformation of biological macromolecules.
- By:Cantor and Schimmel.
- Hans-Peter schmauder,Michaelschweizer,LilianM.Schweizer.
- Ecology,Theories and applications.By:PeterStiling.
- Environmental Science working with the Earth.By:Miller.
- Genetics A Molecular Approach.By:PeterJ.Russell.
- Culture of Animal Cells; a manual of basic technique.By:R.IANFreshney.
- Molecular Biology.RobertF.Weaver.
- Microbial Biotechnology,Principles and Applications.Lee Yuan Kun.
- Microbial Biotechnology,Fundamentals of Applied Microbiology.
- By:AlexanderN.Glazer.HiroshiNikaido.
- Process Biotechnology Fundamentals.By:S N Mukhopadhyay.
- Textbook of Organic Medicinal and Pharmaceutical Chemistry.By:JaimeN.Delgado William A.Remers.
- KubyImmunologyBy:Kindt,Goldsey,Osborne.
- ImmunologyBy:Roitt,Brostoff,male.
- ImmunologyBy:DavidMale,Jonathanbrostoff,DAVID B ROTH,IvanRoitt.
- The elements of ImmunologyBy:FahimHalim Khan.
- ImmunologyBy:RichardA.Goldsby,Thomas J Kindt,Barbaraa.Osborne,Janiskuby.
- Fundamental immunologyWilliamE.Paul.
- Biophysical ChemistryBy:UpadhayaUpadhyayaNath.
- Manual of Diagnostic MicrobiologyWadher B.J. and Bhoosreddy G.L.
- Basic Immunology by Bhoosreddy G.L. and Wadher B.J.

