DEPARTMENT OF BOTANY AND MICROBIOLOGY

REVISED SYLLABUS

M.Sc. (MICROBIOLOGY)

Effective from academic session 2013-2014

HNB Garhwal University
(A Central University)
Srinagar-Garhwal, Uttarakhand

SYLLABUS

HNB GARHWAL UNIVERSITY, SRINAGAR-GARHWAL

DEPARTMENT OF BOTANY & MICROBIOLOGY

Master of Science

MICROBIOLOGY

(Two Year Course- Semester System)

2013 Onwards

Admission to Master's Program in Microbiology shall be through entrance examination conducted by University and the program shall be based on the choice based credit system in which credit defines the quantum of content/ syllabus prescribed for a course system and determines the number of hours of instruction per week.

The student shall be eligible for admission to a Master's Degree Program in Microbiology after he/she has successfully completed a three year undergraduate degree or earned prescribed number of credits through the examinations conducted by University as equivalent to an undergraduate degree. The fee structure would be as per University ordinances for Professional Courses but the fee once deposited by the candidate would not be refundable under any circumstances barring security fee.

Core courses prescribed for every Semester shall be mandatory for all students registered for the Master's Program in Microbiology and shall carry minimum 54 credits. There shall be Elective courses offered in semester III and IV and shall carry a minimum of 18 credits. A self-study course would comprise of maximum 09 credits of which minimum 03 credits shall be mandatory which shall not be included while calculating grades. The student may choose self-study course either only in one of the three semesters (II/III/IV) or one each in all the three semesters. The self study course shall be based on advanced topics of elective courses of III semester.

In order to qualify for a two year master's degree, a student must acquire a minimum of 72 credits including a minimum of 18 credits in electives choosing at least two elective (leading to a minimum 06 credits) in Semester III offered either by the parent department or other departments and one qualifying self-study course of minimum 03 credits.

The dissertation is an elective course of 09 credits and is mandatory for every student. The dissertation would be allotted in the beginning of III Semester and candidate would submit the report during IV Semester examination. The dissertation may be in the form of a field based minor research work/ project work/ practical training. The students may complete the dissertation work in the department/ other research institutes/ industries/ hospitals etc.

A candidate has to secure a minimum of 51 percent marks in aggregate (Two Sessional Tests marks plus End-Term Examination marks) to pass.

SCHOOL OF LIFE SCIENCES
PAPER CODES
PROGRAMME- M.Sc. MICROBIOLOGY

M.Sc. I Semester (July- November)

Code	Paper	Credits				MM
		L	T	P	C	
SLS/MIC/C001	General Microbiology	3	0	0	3	100
SLS/MIC/C002	Fundamentals of Biochemistry	3	0	0	3	100
SLS/MIC/C003	Cell Biology	3	0	0	3	100
SLS/MIC/C004	Molecular Biology and Microbial Genetics	3	0	0	3	100
SLS/MIC/C005	Laboratory Course-I	0	0	3	3	100
SLS/MIC/C006	Laboratory Course-II	0	0	3	3	100
				Total		**600**

Core Credits= 18

M.Sc. II Semester (December-April)

Code	Paper	Credits				MM
		L	T	P	C	
SLS/MIC/C007	Microbial Physiology and Metabolism	3	0	0	3	100
SLS/MIC/C008	Immunology	3	0	0	3	100
SLS/MIC/C009	Biological Techniques	3	0	0	3	100
SLS/MIC/C010	Recombinant DNA Technology	3	0	0	3	100
SLS/MIC/C011	Laboratory Course-I	0	0	3	3	100
SLS/MIC/C012	Laboratory Course-II	0	0	3	3	100
				Total		**600**

Core Credits= 18 with additional 03 Credits of Self Study*

M.Sc. III Semester (July- November)

Code	Paper	Credits				MM
		L	T	P	C	
SLS/MIC/C013	Medical Microbiology	3	0	0	3	100
SLS/MIC/C014	Industrial Microbiology	3	0	0	3	100
SLS/MIC/C015	Laboratory Course-I	0	0	3	3	100
SLS/MIC/E01A	Food and Dairy Microbiology	3	0	0	3	100
SLS/MIC/E01B	Drug Designing and Nanobiotechnology	3	0	0	3	100
SLS/MIC/E01C	Genomics and Proteomics	3	0	0	3	100
SLS/MIC/E01D	Epidemiology	3	0	0	3	100
SLS/MIC/E01E	Bioprocess Technology	3	0	0	3	100
SLS/MIC/E02A	Agricultural Microbiology	3	0	0	3	100
SLS/MIC/E02B	Microbial Diversity	3	0	0	3	100
SLS/MIC/E02C	Pharmaceutical Microbiology	3	0	0	3	100
SLS/MIC/E02D	Infection and Immunity	3	0	0	3	100
SLS/MIC/E02E	Intellectual Property Rights	3	0	0	3	100
SLS/MIC/E003	Laboratory Course-II	0	0	3	3	100
				Total		**600**

Total Credits = 18 (Core Credits 09+ Elective Credits 09) with additional 03 Credits of Self Study*

M.Sc. IV Semester

Code	Paper	Credits				MM
		L	T	P	C	
SLS/MIC/C016	Environmental Microbiology	3	0	0	3	100
SLS/MIC/C017	Research Methodology	3	0	0	3	100
SLS/MIC/C018	Laboratory Course-I	0	0	3	3	100
SLS/MIC/E004	Dissertation	0	0	9	9	100
					Total	**400**

Total Credits = 18 (Core Credits 09+ Elective Credits 09) with additional 03 Credits of Self Study*

Grand Total: Core Credits 54+ Elective Credits 18= 72

***** With a total of 09 Credits (3+3+3 Credits in II, III and IV semester) of Self Study (2 Seminars equivalent to 2 Sessional Tests plus one End term written examination).

Maximum Marks for each paper is 100 (Sessional Tests-40 + End Term Test- 60).

** 01 Credit= 01 hour of lecture/instructions per week; 01 Credit course= 15 hours of lectures per semester.

*** 03 hours of laboratory course shall be considered equivalent to 01 hour of lecture.

The 2- Year Masters Programme will have the following components:

1. **Core course:** Minimum 54 credits.

2. **Elective course:** Minimum 18 credits choosing at least two Electives (leading to a minimum 06 credits) in Semester III offered either by the parent department or other departments and one Elective course as Dissertation (09 credits) in IV Semester.

3. **Self study course:** Maximum 09 credits (one minimum 03 credits shall be mandatory but not to be included while calculating grades).

Dissertation

Dissertation is an elective mandatory for every student. The dissertation is to be allotted in the beginning of III Semester and report would be submitted at the time of IV Semester examination.

The distribution of marks for the Dissertation will be as below:

Periodical Presentation : 20 Marks
Dissertation : 60 Marks
Viva Voce : 20 Marks
Total : 100 Marks

The dissertation would carry 09 credits in all. Dissertation shall be evaluated jointly by the supervisor and one external examiner.

SYLLABUS OF M.Sc. MICROBIOLOGY
I & II SEMESTERS

I SEMESTER

SLS/MIC/C001: GENERAL MICROBIOLOGY

Unit I: History and Classification

Discovery of microorganisms; Conflicts over spontaneous generation; Golden era of microbiology; Kingdom classification of microorganisms: Haeckel's three kingdom concept, Whittaker's five kingdom concept, Six kingdom classification, Eight kingdom classification, Three domain concept of Carl Woese; Differences between prokaryotes and eukaryotes; Techniques used in microbial classification (Morphological, chemotaxonomic and genetic methods); Tools for systematics (Phylogenetic, numerical and polyphasic taxonomy); Scope and relevance of microbiology.

Unit II: Basics of Microbiology

Microbial nutrition; Culture media; Culture techniques for isolation of pure culture; Cultivation of aerobic and anaerobic bacteria; Preservation methods; Microbial growth: Growth curve of batch and continuous cultivation, Diauxic growth curve, Generation time, Growth kinetics, Asynchronous and synchronous growth, Measurement of growth, Factors affecting growth; Control of microbial growth: Physical and chemical agents.

Unit III: General Bacteriology

Bergey's system of bacterial classification; Brief account of Gracilicutes, Fermicutes, Mendosicutes and Tenericutes; Ultrastructure of bacterial cell: Morphology of bacteria, Structure and properties of cell wall and cell membrane, Cell wall synthesis, Capsule (Types, composition and function), Ultrastructure and functions of flagella, cilia, pili, s-layer, cytoplasmic inclusions, ribosomes and nucleoid; Bacterial reproduction; Characteristic features of Archaea.

Unit IV: General Virology

Discovery of viruses; Characteristic feature of viruses, viroids, virusoids and prions; Baltimore scheme of classification; Morphology and ultrastructure: Capsids and their arrangements, Types and composition of envelopes, Viral genome (Types and structures); Isolation and cultivation of viruses using embryonated eggs, experimental animals and cell culture; Serological tests; Multiplication of viruses; Assay of viruses by physical and chemical methods (Protein, nucleic acid, radioactive tracers and electron microscopy); Genetic analysis of viruses by classical genetic methods (PCR and nucleic acid hybridization); Infectivity assay (Plaque method, pock method and end point methods); Bacteriophage: Structural organization, Cultivation, Replication, One step growth curve, Eclipse phase, Phage production, Burst size.

Unit V: General Mycology, Phycology and Protozoology

Mycology: General features, Mycelial organization and structure, Nutrition, Cultivation, Reproduction, Classification, Salient features of Ascomycetes, Basidiomycetes, Zygomycetes and Deuteromycetes, Characteristics of Lichens and Mycorrhiza; Phycology: General features of different algal groups with respect to thallus structure, nutrition and reproduction, Cultivation of algae, Distribution of microalgae in different classes, Classification schemes for algae, Economic aspects of algae and algal biotechnology; Systemic position of cyanobacteria; Distinguishing characters of cyanobacteria and diatoms; Protozoology: Cell structure, Nutrition, Reproduction, Life cycle, Classification; Salient features of Dinoflagellates.

Reference Books

1. Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's microbiology. McGraw-Hill, New York.
2. Black, J.G. Microbiology: Principles and exploration. John Wiley and Sons, New Jersey.
3. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
4. Pommerville, J.C. Alcamo's fundamentals of microbiology. Jones and Bartlett Learning, Sudbury.
5. Wheelis, M. Principles of modern microbiology. Jones and Bartlett Learning, Sudbury.
6. Stanier, R.Y., Ingraham, J.L., Wheelis, M.L. and Painter, P.R. General microbiology. MacMillan Press, London.
7. Sclegel, H.G. General microbiology. Cambridge University Press, Cambridge.
8. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R. Microbiology. McGraw-Hill, New York.
9. Tiwari, S.P., Sharma, R. and Singh, R.K. Recent advances in microbiology. Nova Science, New York.
10. Topley, W.W.C., Wilson, S.G.S. and Parker, M.T. Topley and Wilson's principles of bacteriology, virology and immunity. Edward Arnold, London.
11. Dimmoc, N.J., Easton, A.J. and Leppard, K.N. Introduction to modern virology. Wiley-Blackwell, New Jersey.
12. Levy, J.A., Conrat, H.F. and Owens, R.A. Virology. Prentice Hall, New Jersey.
13. Primrose, S.B. Introduction to modern virology. John Wiley and Sons, New Jersey.
14. Burnett, J.H. Fundamentals of mycology. St. Martin's Press, New York.
15. Mehrotra, R.S. and Aneja, K.R. An introduction to mycology. New Age International (P) Limited, New Delhi.
16. Alexopoulos, C.J. and Bold, H.C. Algae and fungi. MacMillan Press, London.
17. Graham, L.E. and Wilcox, L.W. Algae. Prentice Hall, New Jersey.
18. Vashishta, B.R. Algae. S. Chand and Company, New Delhi.
19. Sharma, O.P. Textbook of algae. Tata McGraw-Hill Education, New Delhi.
20. Kumar, H.D. Introductory phycology. East-West Press, New Delhi.

I SEMESTER

SLS/MIC/C002: FUNDAMENTALS OF BIOCHEMISTRY

Unit I: Acid-base Chemistry and Bioenergetics

Acid-base chemistry: Bronsted concept of conjugate acid-conjugate base pairs, Ionization of solutions, pH, Important biological buffers, Henderson-Hasselbalch equation, Buffer capacity, Polyproteic acids, Amphoteric salt, Ionic strengths; Bioenergetics: Concept of free energy, Standard free energy, Enthalpy, Entropy, High energy phosphate compounds, Phosphate group transfer, Free energy of hydrolysis of ATP, Oxidation-reduction, Redox potential; Energy generation in biological systems: Phosphorylation and electron transport chain, Electron carriers, Artificial electron donors, Inhibitors and uncouplers of oxidative phosphorylation, Chemiosmotic theory of ATP synthesis.

Unit II: Carbohydrates

Classification, nomenclature, structure, general properties and functions of simple carbohydrates; Complex carbohydrates: Mucopolysaccharides, Amino sugars, Bacterial cell wall sugars, Sugar alcohols, Glycoconjugates; Metabolism: Glycolysis, Citric Acid Cycle, Pentose Phosphate pathway, Glyoxylate cycle, Entner-Doudoroff pathway, Gluconeogenesis, Regulation of carbohydrate metabolism.

Unit III: Lipids

Classification, nomenclature, general properties and functions of lipids; Fatty acids; Saponification, acid value and iodine value of fats; Rancidity of fats; Prostaglandins and their physiological significance; Storage and structural lipids; Vitamins: Structure and function of fat soluble vitamins; Metabolism: Biosynthesis of fatty acids, triacylglycerols, membrane phospholipids, cholesterol, steroids and isoprenoids, Beta oxidation and its regulation, LDL and HDL, Regulation of cholesterol biosynthesis.

Unit IV: Proteins and Nucleotides

Proteins: Structural features and classification of amino acids, General reactions of amino acid metabolism (Transamination, decarboxylation, oxidative and non-oxidative deamination of amino acids), Urea cycle, Peptide bond, Properties and functions of primary, secondary, tertiary and quaternary structure of proteins, Ramachandran plot, Factors affecting secondary and tertiary structures, Hydropathy index, Protein domain and motifs, Determination of primary structure of polypeptide; Nucleotides: Structure of purines and pyrimidines, Synthesis of purines and pyrimidines, Regulation of nucleotide biosynthesis, Degradation of purines and pyrimidines.

Unit V: Enzymes

General characteristics of enzymes; Co-enzymes; Holoenzymes; Prosthetic groups; Enzyme nomenclature; Classification of enzymes; Active site; Transition state; Activation energy; Enzyme activity; Specific activity and turn over number; Isozymes; Mechanism of enzyme catalysis; Enzyme kinetics for single substrate and multi-substrate reactions; Reaction mechanisms of enzymes (Acid base and covalent catalysis); Reversible and Irreversible inhibition of enzymes; Effect of pH and temperature on enzyme activity; Allosteric enzymes; Determination of active site and turn over number.

Reference Books

1. Atkins, P. and Paula, J.D. Atkins' physical chemistry. Oxford University Press, Oxford.
2. Segel, I.H. Biochemical calculations. John Wiley and Sons, New York.
3. Nelson D.L. and Cox, M.M. Lehninger principles of biochemistry. W.H. Freeman and Company, New York.
4. Berg, J.M., Tymoczko, J.L. and Stryer, L. Biochemistry. W.H. Freeman and Company, New York.
5. Garrett, R.H. and Grisham, C.M. Biochemistry. Cole Publishing Company, California.
6. Voet, D. and Voet, J.G. Biochemistry. John Wiley and Sons, New York.
7. Conn, E.E., Stumpf, P.K., Bruening, G. and Doi, R.Y. Outlines of biochemistry. John Wiley and Sons, New York.
8. Robert, M., Bender, D., Botham, K.M., Kennelly, P.J., Rodwell, V. and Weil, P.A. Harper's illustrated biochemistry. McGraw-Hill, New York.
9. White, A., Handler, P., Smith, E., Hill, R. and Lehman, J. Principles of biochemistry. Mc-Graw Hill, New York.
10. Jain, J.L. Fundamentals of biochemistry. S. Chand and Company, New Delhi.
11. Palmer, T. Enzymes: Biochemistry, biotechnology and clinical chemistry. Horwood Publishing Company, Chinchester.

I SEMESTER

SLS/MIC/C003: CELL BIOLOGY

Unit I: Architecture of Plasma Membrane and Solute Transport
Plasma membrane: Composition of membrane, Fluid mosaic model, Membrane fluidity, Membrane dynamics, Membrane fusion; Solute transport across membranes: Diffusion (Simple and facilitated), Active transport (Primary and secondary), Pumps and transporters, Ion channels (Ligand gated and voltage gated channels), Trans-epithelial transport, Mechanism of regulation of intracellular transport.

Unit II: Intracellular Compartmentalization of Cell
Structure, organization and functions of nucleus, mitochondria, chloroplast, endoplasmic reticulum, golgi body, peroxisome, lysosome and endosomes; Cytoskeleton: Actin filaments, microtubules and intermediate filaments; Cell motility; Integrating cell into tissue: Cell junctions, Cell- Cell adhesions, Cell – extracellular matrix adhesion; Protein targeting; Molecular mechanism of vesicular trafficking.

Unit III: Cell Signaling
Basic signaling mechanisms (Paracrine, endocrine and autocrine signaling); Mechanism of signal transduction: Signaling molecules, Ligand-receptors interaction, Transmembrane and intracellular signaling, Cell surface receptors (G protein-coupled, enzyme-linked and ion channel-linked receptors), Second messengers and their role in signal transduction, Signal integration, Signal amplification, Target cell adaptation.

Unit IV: Cell Cycle and Cell Division
Cell cycle: Molecular events, Cyclin, CDKs, Checkpoints in cell cycle, Intracellular control of cell cycle events, Abnormalities in cell cycle: Oncogenesis (Causes, proto-oncogenes and tumor suppresser genes, Oncogenic mutations); Cell division: Molecular mechanism of mitosis and meiosis.

Unit V: Cell Death Pathways
Necrosis; Autophagy; Senescence; Apoptosis: Mechanisms of apoptosis, Signals triggering apoptosis, Apoptosis inducing factors, Apoptosis in cancer, immune system and organ transplants.

Reference Books

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. Molecular biology of the cell. Garland Science, New York.
2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H. and Matsudaira, P. Molecular cell biology. W.H. Freeman and Company, New York.
3. Cooper, G.M. and Hausman, R.E. Cell: Molecular approach. ASM Press, Washington, D.C.
4. de Robertis, E. D. P. and de Robertis, E.M.F. Cellular and molecular biology. Saunders, Philadelphia.
5. Pollard, T.D., Earnshaw, W.C. and Schwartz, J.L. Cell biology. Saunders, Philadelphia.
6. Karp, G. Cell and molecular biology- Concepts and experiments. John Wiley and Sons, New York.

I SEMESTER

SLS/MIC/C004: MOLECULAR BIOLOGY AND MICROBIAL GENETICS

Unit I: Chromosome Structure

Experimental evidences for nucleic acid as carrier of genetic information; Chemical and physical properties of genetic material; Structure and types of DNA; Topological properties of DNA; Stabilizing interactions (Van der Walls, electrostatic, hydrogen bonding and hydrophobic interactions); DNA denaturation and renaturation kinetics; C- value Paradox; Cot curves; Junk DNA; Helix-coil transition; DNA supercoiling (Linking number, twist and writhe); Packaging of DNA into chromosome; Euchromatin and Heterochromatin; Chromosome banding; Centromere and Telomere; Giant chromosome; Split genes; Overlapping genes; Pseudogenes; Cryptic genes; Constitutive and inducible genes; Multigene families.

Unit II: Replication, Transcription and Translation

DNA replication in prokaryotes and eukaryotes: Experimental evidence, Modes of replication, Origin of replication, Structure and function of DNA polymerases, Mechanism of replication, Inhibitors of replication; Transcription in prokaryotes and eukaryotes: General principles, RNA polymerases, Mechanism of transcription, Post transcriptional modifications of mRNA, rRNA and tRNA; Structure features and functions of mRNA, t-RNA (Initiator and elongator class of tRNA), r-RNA and sn-RNA, Degradation and surveillance of mRNA, Inhibitors of transcription; Basic features of genetic code; Translation in prokaryotes and eukaryotes: Structure of ribosomes, Mechanism of translation, Post translational modifications, Protein degradation, Non ribosomal polypeptide synthesis, Inhibitors of translation.

Unit III: Recombination, Transposition, Mutation and Repair mechanism

Recombination: Types, Models for homologous recombination (The Holliday model and Double strand break repair model), Genetic consequences of the mechanism of homologous recombination, Proteins involved in recombination; Transposition: Insertion sequences and transposable elements in prokaryotes and eukaryotes, Mechanism of transposition, Genetics and evolutionary significance of transposable elements; Mutations: Types and causes of mutations, Mutagens, Molecular basis of mutagenesis, Screening chemicals for mutagenicity; DNA damage and repair: Types of DNA damage (Deamination, oxidative damage, alkylation and pyrimidine dimmers) and repair pathways (Photoreactivation, methyl directed mismatch repair, very short - patch mismatch repair, nucleotide excision repair, base excision repair, transcription- coupled repair, postreplication daughter strand gap repair, recombination repair and SOS system).

Unit IV: Regulation of Gene Expression

Coordinated control of clustered genes in prokaryotes: Operon concept, Positive and negative control, Structure and regulation of *lac*, *trp* and *arb* operon, DNA binding motifs in regulatory proteins; Regulation of gene expression: Riboswitches, Role of activators, enhancers, insulators and transactivators, RNA interference, Antisense RNA, Epigenetics (CpG islands, DNA methylation, histone modifications and role of epigenetics in gene regulation), Chromatin remodelling (Role of various remodelling proteins such as NURF, ACF, CHRAC, SWI-SNF and locus control regions in gene regulation).

Unit V: Microbial Genetics

Bacterial plasmids: Types of plasmids, F plasmids and their use in genetic analysis, Replication mechanism of plasmids, Compatibility and incompatibility, Mobilizable plasmids,

Copy number of plasmids, Fertility inhibition, Donation and conduction; Gene transfer mechanisms: Transformation (Competence factor, natural transformation in *Bacillus subtilis* and *Haemophilus influenza*, artificial transformation and molecular mechanism of transformation), Conjugation (F^+ X F^- mating, Hfr, Hfr X F^-, and F', mechanism of conjugation and sexduction), Transduction (Mechanism of generalized and specialized transduction, LFT and HFT lysate), Transfection; Phage genetics: Life cycle and uses of T4, lambda, P1, M13 and ϕX 174 phage in microbial genetics, Regulation of lytic and lysogeny in lambda phage; Fungal genetics: *Saccharomyces cerevisiae* and *Neurospora* genomes as model genetic systems; Gene conversion.

Reference Books

1. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H. and Matsudaira, P. Molecular cell biology. W.H. Freeman and Company, New York.
2. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. Lewin's genes. Jones and Bartlett Learning Publishers, Sudbury.
3. Nelson D. L. and Cox, M.M. Lehninger principles of biochemistry. W.H. Freeman and Company, New York.
4. Snustad, D.P. and Simmons, M.J. Principles of genetics. John Wiley and Sons, New York.
5. Malacinski, G.M. and Friefelder, D. Essentials of molecular biology. Jones and Bartlett Learning, Sudbury.
6. Synder, L.J., Peters, E., Henkins, T.M. and Champness, W. Molecular genetics of bacteria. ASM Press, Washington, D.C.
7. Maloy, S.R., Cronan, J.E. and Freifelder, D.M. Microbial genetics. Jones and Bartlett Learning, Sudbury.
8. Hartwell, L. Genetics: From genes to genome. McGraw-Hill, New York.
9. Weaver, R. Molecular biology. McGraw-Hill, New York.
10. Watson, J.D., Baker, T., Bell, S.P., Gann, A., Levine, M. and Lodwick, R. Molecular biology of the gene. Pearson Education, New Jersey.
11. Karp, G. Cell and molecular biology- Concepts and experiments. John Wiley and Sons, New York.
12. Klug, W.S. and Cummings, M.R. Concepts of genetics. Prentice Hall, New Jersey.

I SEMESTER

SLS/MIC/C005: LAB COURSE-I
(Based on Theory Papers SLS/MIC/C001 and SLS/MIC/C002)

1. Safety rules of working in microbiology lab, disposal of cultures, calibration, validation and maintenance of instruments.
2. Principles and working of instruments used in microbiology lab.
3. Media preparation and its sterilization.
4. Isolation and enumeration of bacteria and fungi from given sample.
5. Isolation and maintenance of pure culture of bacteria and fungi.
6. Isolation and enumeration of bacteriophage from sewage water.
7. Staining of bacterial cell (Simple staining, gram staining and negative staining).
8. Staining of fungal cell.
9. Staining of endospore and capsule.
10. Study of morphology of algae.
11. Symptomatology of infection of plant pathogens.
12. Measurement of bacterial cell size using micrometer.
13. Safety rules of working in lab, hazard from chemicals, handling of chemicals, disposal of chemicals, recording of scientific experiments, calibration, validation and maintenance of instruments.
14. Calculation of moles, molarity, molality and normality of given solution.
15. Calculation of pH of given solution.
16. Preparation of solutions and buffers of different concentrations and pH.
17. Qualitative tests for sugars, amino acids, proteins and lipids in given sample.
18. Quantitative estimation of sugar in given sample.
19. Quantitative estimation of protein in given sample.
20. Estimation of lipid concentration in given sample.
21. Determination of acid value, saponification and iodine value of fats and oils.
22. Determination of activity of given enzyme.
23. Determination of K_m and V_{max} of given enzyme.
24. Determination of optimum pH and temperature of given enzyme.
25. Determination of temperature and pH stability of given enzyme.

Reference Books

1. Cappucino, J. and Sherman, N. Microbiology: A laboratory manual. Benjamin/Cummings Publishing Company, San Francisco.
2. Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. William C. Brown, Dubuque.
3. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.
4. Atlas, R.M., Brown, A.E. and Parks, L.C. Laboratory manual of experimental microbiology. Mosby College Publishing Company, St. Louis.
5. Kannan, K. Laboratory manual in general microbiology. Panima, New Delhi.
6. Holt, J.G. and Krieg, N.R. Bergey's manual of determinative bacteriology. Lippincott Williams and Wilkin, Philadelphia.
7. Jayaraman, J. Laboratory manual in biochemistry. New Age International (P) Limited, New Delhi.

8. Sawhney, S.K. and Singh, R. Introductory practical biochemistry. Narosa Publishing House, New Delhi.
9. Segel, I.H. Biochemical calculations. John Wiley and Sons, New York.
10. Plummer, D.T. Introduction to practical biochemistry. Mc-Graw Hill, New York.
11. Boyer, R.F. Modern experimental biochemistry. Prentice Hall, New Jersey.
12. Gerhardt, P. Manual of methods for general bacteriology. ASM Press, Washington, D.C.
13. Barnett, M. Microbiology laboratory exercises. William C. Brown, Dubuque.
14. Wilson, K. and Walker, J.M. Principles and techniques of practical biochemistry. Cambridge University Press, Cambridge.

I SEMESTER

SLS/MIC/C006: LABCOURSE-II
(Based on Theory Papers SLS/MIC/C003 and SLS/MIC/C004)

1. Study of different stages of mitosis.
2. Study of different stages of meiosis.
3. Study of mechanism of diffusion.
4. Study of mechanism of exosmosis and endosmosis.
5. Effect of isotonic, hypotonic and hypertonic solutions on cell.
6. Preparation of splenocytes.
7. Quantitative estimation of DNA by diphenyl amine (DPA) and spectrophotometric method.
8. Quantitative estimation of RNA by orcinol and spectrophotometric method.
9. Determination of quality of DNA by spectrophotometric method.
10. Isolation of genomic DNA from bacterial culture.
11. Visualization of DNA by agarose gel electrophoresis.
12. Determination of T_m of given DNA sample.
13. Study of effect of temperature and pH on denaturation of DNA.
14. Study of effect of different concentrations of urea on denaturation of DNA.
15. Mutagenesis in given bacterial culture by U.V. radiation.
16. Demonstration of photoreactivation mechanism in bacteria.
17. Demonstration of dark repair mechanism in bacteria.
18. Demonstration of conjugation in bacteria.
19. Isolation of antibiotic resistant bacteria by gradient plate method.

Reference Books

1. Sambrook, J. and Russell, D.W. Molecular cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.
2. Miller, J.H. Experiments in molecular genetics. Cold Spring Harbor Lab Press, New York.
3. Murray, R.G.F., Wood, W.A. and Krieg, N.B. Methods for general and molecular bacteriology. ASM Press, Washington, D.C.
4. Chaitanya, K.V. Cell and molecular biology: A lab manual. PHI Learning, New Delhi.
5. Celis, J.E. Cell biology: A laboratory handbook. Elsevier, Amsterdam.

II SEMESTER

SLS/MIC/C007: MICROBIAL PHYSIOLOGY AND METABOLISM

Unit I: Microbial Photosynthesis and Inorganic Metabolism

Photosynthesis: General characteristics of photosynthetic bacteria, Brief account of photosynthetic and accessory pigments, Mechanism of oxygenic and anoxygenic photosynthesis, Photosynthetic electron transport system, Photophosphorylation, Dark reaction; Inorganic metabolism: Characteristic features of chemolithotrophs, Mechanism of sulphur, iron, hydrogen and nitrogen oxidations; Mechanism of energy generation in methylotrophs and methanogens.

Unit II: Nitrogen and Sulphur Metabolism

Nitrogen metabolism: Nitrogen fixation (Characteristics of nitrogen fixing bacteria, biochemistry of nitrogenase complex, nitrogenase types, functions of *nif* genes, symbiotic nitrogen fixation and regulation of nitrogenase), Inorganic nitrogen metabolism, Assimilation of inorganic nitrogen, Regulation of nitrate assimilation; Sulphur metabolism: Free and bound pathways of assimilation of sulphate into cysteine, Glutathione and its role in sulphur metabolism.

Unit III: Microbial Respiration and Fermentation

Respiration: Aerobic respiration, Components of electron transport chain in aerobic bacteria, Anaerobic respiration, Mechanism of oxygen toxicity; Fermentation: Glucose, acetic acid, lactic acid, butyric acid, propionic acid and mixed acid fermentation.

Unit IV: Microbial Transport and Communication

Bacterial transport system: Donnan equilibrium, Thermodynamics of various transport systems, Osmosis, Plasmolysis, Osmotic pressure of electrolyte and non-electrolyte transport protein, PEP-PTS system in relation to catabolite repression, ABC transporter, Protein secretion pathways in bacteria; Communication mechanisms in prokaryotes: Intercellular signaling (Pheromones mediated signaling and quorum sensing), Intracellular signaling (Two component system and phosphorelay system).

Unit V: Microbial Stress Response

Osmotic stress and osmoregulation, Mechanism of transition from aerobic to anaerobic, Oxidative stress and its regulation, pH stress and acid tolerance response, Thermal stress and heat shock response, Nutrition stress and starvation-stress response, Stringent response, Sporulation and morphogenesis (Endospores: Physiological and genetic aspects of sporulation, Activation, germination and outgrowth).

Reference Books

1. Foster, J.W. and Spector, M.P. Microbial physiology. John Wiley and Sons, New York.
2. Gottschalk, G. Bacterial metabolism. Springer-Verlag, New York.
3. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
4. Brun, Y.V. and Shimkets, L.J. Prokaryotic development. ASM Press, Washington, D.C.
5. Rose, A.H. Advances in microbial physiology. Academic Press, New York.
6. David, W., Drummond, J.T. and Fuqua, C. Physiology and biochemistry of prokaryotes. Oxford University Press, New York.
7. Caldwell, D. R. Microbial physiology and metabolism. Star Publishers, California.

8. Lengeler, J.W., Drews, G. and Schlegel, H.G. Biology of the prokaryotes. Blackwell Science, New York.
9. Rhodes, P.M. and Stanbury, P.F. Applied microbial physiology: A practical approach. IRL Press, Oxford.

II SEMESTER

SLS/MIC/C008: IMMUNOLOGY

Unit I: Immune System and Immunity

History of immunology; Innate and acquired immunity; Determinants of innate immunity; Hematopoiesis; Cells and organs of immune system: B lymphocyte, T lymphocyte, NK cells, Monocyte/Macrophages, Dendritic cells, Eosinophils, Basophils, Neutrophils, Mast cells, Organization and structure of lymphoid organs and their role in immunity; Humoral and cell-mediated immunity; Nonspecific immune mechanisms: Surface defenses, Tissue defenses, Opsonization, Inflammatory reactions.

Unit II: Antigens and Antibodies

Antigens: Structure and properties; Haptens; Adjuvents; Immunogenicity; Immunoglobulin: Structures, Heterogeneity, Types and subtypes, Properties (Physiochemical and biological), Antibody effector mechanism, Antibody receptors, Antibody diversity, Immunoglobulin gene recombination, Theories of antibody production, Effect of somatic mutations on the antibody diversity, Ab class switching, Antibody responses *in vivo*, Affinity maturation development of memory, Recombinant antibodies, Monoclonal antibodies (General properties and applications), Hybridoma technology; Antigen – antibody reactions: Precipitation and agglutination reactions; Immunodiagnostic techniques: Immunoelectrophoresis, RIA, ELISA, Chemiluminescence immunoassay, Western blotting, Complement fixation test, Immunofluorescence, Flow cytometry.

Unit III: Complement system, Cytokines and Major Histo-compatibility Complex

Complement System: Structure, properties and functions of different components, Complement activation pathways (Classical, alternate and lectin pathways), Biological consequences of complement activation, Complement assay; Structure and function of various cytokines; Cytokine receptors; Antigen presenting cells; Structure and functions of MHC and HL-A system; Antigen processing and presentation.

Unit IV: Humoral and Cell Mediated Immune Response and Regulation

B- cell receptor; Development and differentiation of B cells; Negative regulation; T – cell receptor complex; Genomic organization of T- cell receptor locus; Development and differentiation of T cells; Positive and negative regulation; Immune Response: T -Cell independent defense mechanisms, T- Cell dependent defense mechanisms; Cell mediated cytotoxicity: T cytotoxic cells, Natural Killer (NK) Cells,Antibody dependent cell cytotoxicity (ADCC), Macrophage-mediated cytotoxicity.

Unit V: Immunopathology and Transplantations

Immunopathology: Rh- blood groupings, Hypersensitivity reactions (Antibody mediated type I, anaphylaxis, type II- antibody dependent cell cytotoxicity, type III-immune complex mediated reactions and type IV-delayed hypersensitivity reactions), Immune surveillance, Self tolerance, Autoimmune diseases, Immunodeficiency; Tumor immunology: Tumor specific antigens, Immune response to tumor, Tumor escape mechanisms, Immunotherapy of cancer, Immunotoxins; Transplantation: Graft vs. host reaction and rejection; Immunization: Active and passive; Vaccines.

Reference Books

1. Kindt, T.J., Goldsby, R.A., Osborne, B.A. and Kuby, J. Kuby immunology. W.H. Freeman and Company, New York.
2. Male, D.K. Immunology: An illustrated outline. Elsevier Health Sciences, Philadelphia.
3. Abbas, A.K., Lichtman, A.H.H. and Pillai, S. Cellular and molecular immunology. Saunders, Philadelphia.
4. Delves, P.J., Martin, S.J., Burton, D.R. and Roitt, I.M. Roitt's essential immunology. Wiley-Blackwell, New Jersey.
5. Tizard, I.R. Immunology: An introduction. Saunders, Philadelphia.
6. Playfair, J.H.L. Immunology at a glance. Blackwell Scientific Publications, Oxford.
7. Abbas, A.K. and Lichtman, A.H.H. Basic immunology: Functions and disorders of the immune system. Saunders, Philadelphia.
8. Chapel, H., Haeney, M., Misbah, S. and Snowden, N. Essentials of clinical immunology. Wiley, New Jersey.
9. Palyfair, J.H.L. and Chain, B.M. Immunology at a glance. Wiley- Blackwell, New Jersey.
10. Coico, R. and Sunshine, G. Immunology: A short course. Wiley- Blackwell, New Jersey.
11. Rao, C.V. Immunology. Alpha Science International, New Delhi.
12. Pathak, S. and Palan, U. Immunology: Essential and fundamental. Science, New Hampshire.

II SEMESTER

SLS/MIC/C009: BIOLOGICAL TECHNIQUES

Unit I: Microscopy and Biosensors

Microscopy (Principles and applications): Light, phase contrast, fluorescence and confocal microscopy, Scanning and transmission electron microscopy; Biosensors: Introduction and principles, First, second and third generation instruments, Cell based biosensors, Enzyme immunosensors.

Unit II: Centrifugation

Basic principle and applications of centrifugation; Centrifugal force; Sedimentation rate; Sedimentation coefficient; Common centrifuges used in laboratory (Clinical, micro, high speed, ultra and industrial centrifuges); Types of rotors (Fixed- angle, swinging bucket and continuous tubular); Types of centrifugation (Principle and applications): Preparative (Differential and density gradient centrifugation) and analytical centrifugation.

Unit III: Chromatography

General principle and applications of chromatography; Types of chromatography (Principles and applications): Adsorption chromatography, Ion exchange chromatography, Affinity chromatography, Size exclusion chromatography, Thin layer chromatography, Gas chromatography, High pressure liquid chromatography (HPLC), Fast protein liquid chromatography (FPLC), Supercritical fluid chromatography.

Unit IV: Electrophoretic Techniques

General principle and applications of electrophoresis; Types of electrophoresis (Principles and applications): Paper electrophoresis, Moving boundary electrophoresis, Agarose gel electrophoresis, Polyacrylamide gel electrophoresis (SDS-PAGE, Native-PAGE, Denaturing-PAGE and Reducing-PAGE), Isoelectric focusing (IEF), Pulse field gel electrophoresis (PFGE), Disc gel electrophoresis, Isotachophoresis.

Unit V: Spectroscopy and Radiotracer Techniques

Spectroscopic methods (Principle and applications): UV, Visible, IR, NMR, Fluorescence, ESR, Atomic absorption, CD, ORD and Raman Spectroscopy; Mass Spectrometry: Principles and application of MALDI-MS, Fast atom bombardment, Field desorption and electrospray Ionization; Radiotracer techniques:Applications of radioisotopes in biology, Radioactive labelling, Properties and units of radioactivity, Radioactive isotopes and half-life, Safety rules in handling of radioisotopes, Measurement of radioactivity (GM counter, gamma counter and liquid scintillation counter), Autoradiography: Principle and its applications.

Reference Books

1. Wilson, K. and Walker, J. Principles and techniques of biochemistry and molecular biology. Cambridge University Press, Cambridge.
2. Robyt, J.F. and White, B.J. Biochemical techniques: Theory and practice. Waveland Press, Long Grove.
3. Holme, D.J. and Peck, H. Analytical biochemistry. Longman Group Limited, London.
4. Chatwal, G. and Anand, S. Instrumental methods of chemical analysis. Himalaya Publishing House, Mumbai.

5. Miller, J. Chromatography: Concepts and contrasts. John Wiley and Sons, New York.
6. Message, G.M. Practical aspects of gas chromatography/ mass spectrometry. John Wiley and Sons, New York.
7. Kremmer, T. and Boross, L. Gel chromatography: Theory, methodology, applications. John Wiley and Sons, New York.
8. Hamilton, R.J. and Sewell, P.A. Introduction to high performance liquid chromatography. Chapman and Hall Limited, London.
9. Sharma, V.K. Techniques in microscopy and cell biology. Tata McGraw-Hill, New Delhi.
10. Westermeier, R. Electrophoresis in practice. Wiley-Blackwell, New Jersey.
11. Hames, B.D. Gel electrophoresis of proteins: A practical approach. Oxford University Press, Oxford.
12. Ford, T.C. and Graham, J.M. An introduction to centrifugation. Bios, New York.
13. Spencer, M. Fundamentals of light microscopy. Cambridge University Press, Cambridge.
14. Hayat, M.A. Principles and techniques of electron microscopy: Biological applications. Cambridge University Press, Cambridge.
15. Price, R.L. and Jerome, W.G. Basic confocal microscopy. Springer-Verlag, New York.
16. Rost, F.W.D. Fluorescence microscopy. Cambridge University Press, Cambridge.
17. Ploem, J.S. and Tanke, H.J. Introduction to fluorescence microscopy. Oxford University Press, Oxford.
18. Keeler, J. Understanding NMR spectroscopy. John Wiley and Sons, New York.
19. Straughan, B.B. and Walker, S. Spectroscopy. Chapman and Hall Limited, London.
20. Davies, A.M.C. and Creaser, C.S. Analytical applications of spectroscopy. Royal Society of Chemistry, California.
21. Thornburn, C.C. Isotopes and radiations in biology. Butterworths, Oxford.
22. Wang, C.H. and Willis, D.L. Radiotracer methodology in biological science. Prentice Hall, New Jersey.
23. Sambrook, J. and Russell, D.W. Molecular cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.

II SEMESTER

SLS/MIC/C010: RECOMBINANT DNA TECHNOLOGY

Unit I: Principles and Tools of Gene Cloning

Introduction to recombinant DNA technology; Isolation of nucleic acids: DNA (Genomic, plasmid and bacteriophage), RNA; Enzymes used in genetic engineering (Restriction endonucleases, ligase, polymerases, kinase, alkaline phosphatase and terminal transferase); Cloning vectors: Characteristic features and applications of vectors based on plasmids (*E. coli* and yeast), phages (M13 and λ bacteriophage), cosmids, phasmids, artificial chromosome vectors (PAC, BAC, YAC and HAC), vectors for plants and animal cells and shuttle vectors.

Unit II: Strategies of Gene Cloning

Gene cloning: Steps of cloning, Selectable markers, Formation of DNA fragments using linkers, adaptors and homopolymer tails, Introduction of DNA into host cells (Bacteria, plant and animal cells); Library construction: Synthesis of cDNA, Construction of cDNA and genomic library; Obtaining clone of a specific gene: Problem of selection, Direct selection, Marker rescue, Selection strategies for recombinant produced by different vectors, Methods of identification of clone from gene library.

Unit III: Expression of Cloned Gene in Heterologous System: Prokaryotes and Eukaryotes

Basic architecture of an expression vector; Critical components of an expression vector; Expression of fusion protein; Characteristic features of pBad, pEt, pcDNA3 and cytomegalovirus expression system; Inducible expression system; Promoter probe vectors; Model host systems: *E. coli,* Fungi, Mammalian cell lines, Insect cells, Transgenic plants and animals; Screening strategies; Identification and study of translation product of a cloned gene: HRT and HART techniques.

Unit IV: Sequence Detection, Amplification and Modification Techniques

Blotting techniques (Methodologies and applications): Southern, Northern and Western blotting; Probe labelling and hybridization; DNA sequencing (Chemical, enzymatic and automated methods); Sequence assembly for whole genome analysis; PCR: Principle and applications; Types of PCR (Principle and applications): Degenerate PCR, Multiplex PCR, Hot start PCR, *In situ* PCR, Nested PCR, Q-PCR, RACE, Real Time PCR, RT-PCR; Site directed mutagenesis (Methods and applications).

Unit V: Genome Analysis and Applications of RDT

Principles and applications of techniques used in genome analysis: Exon-intron trapping, R loop analysis, S1–mapping, Chromosome walking, Ribonuclease protection assay, Gel retardation assay, DNA foot printing, DNA fingerprinting, Chromatin immunoprecipitation, Antisense technology, Ribozyme technology; Applications of recombinant DNA technology in forensic science, therapeutics and agriculture; Biosafety and potential hazards of RDT.

Reference Books

1. Brown, T.A. Gene cloning and DNA analysis: An introduction. Wiley-Blackwell, New Jersey.
2. Primrose, S.B. and Twyman, R. Principles of gene manipulation and genomics. Wiley-Blackwell, New Jersey.

3. Nicholl, D.S.T. An introduction to genetic engineering. Cambridge University Press, Cambridge.
4. Glick, B.R., Pasternak, J.J. and Patten, C.L. Molecular biotechnology: Principles and applications of recombinant DNA. ASM Press, Washington, D.C.
5. Hartwell, L. Genetics: From genes to genome. McGraw-Hill, New York.
6. Old, R.W. and Primrose, S.B. Principles of gene manipulations. Blackwell Science, Oxford.
7. Winnacker, E.L. From genes to clones: Introduction to gene technology. Wiley-VCH, Germany.
8. Kingsman, S.M. and Kingsman, A.J. Genetic engineering: An introduction to gene analysis and exploitation in eukaryotes. Blackwell Science, Oxford.
9. Greene, J.J. and Rao, V.B. Recombinant DNA principles and methodologies. Marcel Dekker, New York.
10. Brown, T.A. Genomes. Wiley-Liss, Oxford.
11. Pevsner, J. Bioinformatics and functional genomics. Wiley-Blackwell, New Jersey.
12. Sambrook, J. and Russell, D.W. Molecular Cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.
13. Reece R.J. Analysis of genes and genomes. John Wiley and Sons, New York.
14. Recombinant DNA safety guidelines. Department of Biotechnology, Ministry of Science and Technology, Government of India, New Delhi.

II SEMESTER

SLS/MIC/C011: LAB COURSE-I
(Based on Theory Papers SLS/MIC/C007 and SLS/MIC/C008)

1. Study of effect of temperature, pH and salt concentration on growth of bacteria.
2. Determination of ability of bacteria to reduce nitrate.
3. Determination of ability of bacteria to produce H_2S.
4. Determination of presence of cytochrome oxidase in bacteria.
5. Determination of presence of catalase in bacteria.
6. Determination of ability of bacteria to produce acidic or neutral end product from glucose.
7. Determination of ability of bacteria to utilize sugars by oxidative or fermentative mode.
8. Study of different stages of sporulation in *Bacillus*.
9. Effect of pH, sugars, amino acids and inorganic ions on spore germination.
10. Separation and preservation of serum and plasma.
11. Determination of blood group and Rh factor.
12. Demonstration of agglutination reaction of bacterial cultures by slide agglutination test.
13. Quantitative estimation of antigen by radial immunodiffusion.
14. Detection and quantification of either antibody or antigen by ouchterlony double diffusion method.
15. Determination of concentration of antigen by rocket immunoelectrophoresis.
16. Determination of the presence of specific antibody for its antigen by Dot-ELISA method.
17. Determination of concentration of antigen by sandwich ELISA.
18. Detection of the presence of either specific antibody or specific antigen in a patient's serum by complement fixation test.

Reference Books

1. Cappucino, J. and Sherman, N. Microbiology: A laboratory manual. Benjamin/Cummings Publishing Company, San Francisco.
2. Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. William C. Brown, Dubuque.
3. White, D. and Hegeman, G.D. Microbial physiology and biochemistry laboratory: A quantitative approach. Oxford University Press, New York.
4. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.
5. Atlas, R.M., Brown, A.E. and Parks, L.C. Laboratory manual of experimental microbiology. Mosby College Publishing Company, St. Louis.
6. Kannan, K. Laboratory manual in general microbiology. Panima, New Delhi.
7. Holt, J.G. and Krieg, N.R. Bergey's manual of determinative bacteriology. Lippincott Williams and Wilkin, Philadelphia.
8. Rose, N.R., Hamilton, R.G. and Detrick, B. Manual of clinical laboratory immunology. ASM Press, Washington, D.C.
9. Weir, D.M. Handbook of experimental immunology. Blackwell Scientific Publications, New Jersey.
10. Stafseth, H.J., Stockton, J.J. and Newman, J.P. A laboratory manual for immunology. Burgess Publishing Company, Stockland.

II SEMESTER

SLS/MIC/C012: LAB COURSE-II
(Based on Theory Papers SLS/MIC/C009 and SLS/MIC/C010)

1. Separation and identification of amino acids by ascending and descending paper chromatography.
2. Separation and identification of sugars by paper chromatography.
3. Separation and identification of sugars by thin layer chromatography.
4. Verification of Lambert Beer's law.
5. Determination of molecular weight of DNA by agarose gel electrophoresis.
6. Separation and determination of molecular weight of proteins by SDS-PAGE.
7. Visualization of enzyme activity by NATIVE-PAGE.
8. Interpretation of UV spectra.
9. Interpretation of IR spectra.
10. Interpretation of NMR spectra.
11. Interpretation of Mass spectra.
12. Isolation of genomic DNA from plant sample.
13. Isolation of plasmid DNA from bacterial cell culture.
14. PCR amplification of DNA.
15. Restriction digestion of vector and DNA.
16. Ligation of DNA construct and vector.
17. Preparation of competent cells.
18. Introduction of recombinant DNA into bacterial cells and selection of recombinant clones.
19. Demonstration of inducible enzyme β-galactosidase in *E. coli*.
20. Expression of gene in *E. coli*.
21. Determination of similarity between different bacterial isolates using RFLP.

Reference Books

1. Jayaraman, J. Laboratory manual in biochemistry. New Age International (P) Limited, New Delhi.
2. Sawhney, S.K. and Singh, R. Introductory practical biochemistry. Narosa Publishing House, New Delhi.
3. Boyer, R.F. Modern experimental biochemistry. Prentice Hall, New Jersey.
4. Wilson, K. and Walker, J.M. Principles and techniques of practical biochemistry. Cambridge University Press, Cambridge.
5. Sambrook, J. and Russell, D.W. Molecular cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.
6. Miller, J.H. Experiments in molecular genetics. Cold Spring Harbor Lab Press, New York.

SYLLABUS OF M.Sc. MICROBIOLOGY
III & IV SEMESTERS

III SEMESTER

SLS/MIC/C013: MEDICAL MICROBIOLOGY

Unit I: Basics of Medical Microbiology

Normal microbiota of human body; Role of resident flora and human host; Routes of transmission of pathogens; Nosocomial infections; Collection, transportation and processing of clinical samples; Isolation and identification of pathogenic organisms; Quality control in medical microbiology laboratory.

Unit II: Pathogenesis and Antimicrobial Chemotherapy

Pathogenicity islands; Mechanism of pathogenesis: Mechanism of bacterial adhesion, colonization and invasion, Protein toxins (Classification and mode of action), Cytoskeletal modulation of host cell; Mechanism of action of antimicrobial agents; Methods of drug susceptibility testing: Kirby-Bauer's disc diffusion method, Stokes method, Agar dilution method, Broth dilution method, E-strip method; Emergence of drug resistance in bacteria (MRSA, ESBL and MDR TB); Resistance mechanism; Various types of vaccines for prevention of infectious diseases; National immunization program and immunization schedule.

Unit III: Bacterial Diseases

Clinical features, transmission, characteristics of causative organism, pathogenesis, laboratory diagnosis, prevention and control of bacterial diseases and clinical syndromes: Typhoid fever, Shigellosis, Cholera, Tuberculosis, Leprosy, Diphtheria, Tetanus, Anthrax, Rickettsial diseases, Meningitis, Septic arthritis, Conjunctivitis, Otitis media, Pneumonia, Gastroenteritis, Leptospirosis and Osteomyelitis, Sexually transmitted diseases, Urinary tract infections, Wound infections, Skin and soft tissue infections.

Unit IV: Viral Diseases

Clinical features, transmission, characteristics of causative organism, pathogenesis, laboratory diagnosis, prevention and control of viral diseases: Chicken pox, Herpes, Dengue, Chikungunya, Japanese encephalitis, Influenza, Measles, Mumps, Polio, Hepatitis, Rabies, HIV, Viral cancer, Prion diseases; Cytopathic effect of viral infection on host cells.

Unit V: Protozoal and Fungal Diseases

Clinical features, transmission, characteristics of causative organism, life cycle, pathogenesis, laboratory diagnosis, prevention and control of protozoal diseases: Amoebiasis, Giardiasis, Leishmaniasis, Malaria, Filariasis, Toxoplasmosis, Hydatid disease, Ancylostomasis, Ascariasis; Laboratory procedures for diagnosis of human parasites in blood, stool and tissue; Clinical features, transmission, characteristics of causative organism, pathogenesis, laboratory diagnosis, prevention and control of fungal diseases: Dermatophytosis, Cryptococcosis, Coccidiomycosis, Candidiasis, Pneumocystis, Blastomycosis, Histoplasmosis, Sporotrichosis, Aspergillosis, Mycotic keratitis, Otomycosis, Mycetoma.

Reference Books

1. Murrey, P.R., Rosenthal, K.S., Kobayashi, G.S. and Pfaller, M.A. Medical microbiology. Saunders, Philadelphia.
2. Baron, E.J., Peterson, L.R. and Finegold, S.M. Bailey and Scott's diagnostic microbiology. Mosby, St. Louis.

3. Dockrell, H., Zuckerman, M., Roitt, I.M. and Chiodini, P.L. Mim's medical microbiology. Elsevier, London.
4. Collee, J.C., Duguid, J.P., Fraser, A.C. and Marimon, B.P. Mackie and McCartney practical medical microbiology. Churchill Livingstone, London.
5. Ananthanarayanan, R. and Panicker, C.K.J. Text book of microbiology. Orient Longman, Hyderabad.
6. Koneman, E.W. Koneman's color atlas and textbook of diagnostic microbiology. Lippincott Williams and Wilkins, Philadelphia.
7. Topley, W.W.C., Wilson, S.G.S and Parker, M.T. Topley and Wilson's principles of bacteriology, virology and immunity. Edward Arnold, London.
8. Greenwood, D., Slack, R.B. and Peutherer, J.F. Medical microbiology. Churchill Livingstone, London.
9. Mahon, C.R. and Manuselis, G. Textbook of diagnostic microbiology. Saunders, Philadelphia.
10. Maza, L.M.D.L. Color atlas of medical bacteriology. ASM Press, Washington, D.C.
11. Garcia, L.S and Isenberg, H.D. Clinical microbiology procedures handbook. ASM Press, Washington, D.C.
12. Balows, A., Hausler, W.J., Ohashi, M. and Turano, A. Laboratory diagnosis of infectious diseases: Principles and practice. Springer-Verlag, New York.
13. Chakraborthy, P. A textbook of microbiology. New Central Book Agency Private Limited, Calcutta.
14. Morag, C. and Timbury, M.C. Medical virology. Churchill Livingston, London.
15. Dimmock, N.J. and Pimrose, S.B. Introduction to modern virology. Blackwell Scientific Publications, Oxford.
16. Flint, S.J., Racaniello, V.R., Enquist, L.W., Rancaniello, V.R. and Skalka, A.M. Principles of virology: Molecular biology, pathogenesis and control of animal viruses. ASM Press, Washington, D.C.
17. Karyakarte, R.P. and Damle, A.S. Medical parasitology. Books and Allied Private Limited, Kolkatta.
18. Paniker, J. Text book of medical parasitology. Jaypee Brothers Medical Private Limited, New Delhi.
19. Chander, J. A text book of medical mycology. Interprint, New Delhi.

III SEMESTER

SLS/MIC/C014: INDUSTRIAL MICROBIOLOGY

Unit I: Introduction to Industrial Microbiology
Primary and secondary metabolites; Scale up and scale down processes; Types of fermentation (Solid state, surface and submerged fermentation); Operational modes of fermentation (Batch, fed- batch and continuous).

Unit II: Basic Aspects of Fermentation
Media formulation; Sterilization; Inoculum development; Effect of temperature, pH and high nutrient concentration on fermentation; Basic fermenter design; Types of bioreactors; Downstream processing.

Unit III: Microbial Strain Improvement
Strategies for isolation and cultivation of desired microorganisms; Screening for the desired product; Strategies for strain improvement: Mutation, Protoplast fusion, Recombinant DNA technology, Novel strategies (Metabolic engineering, genome shuffling, ribosome engineering and epigenetic modification); Preservation of cultures after strain improvement programme.

Unit IV: Industrial Production Aspects I
Production aspects (Microbial strains, substrate, flow diagrams, product optimization and applications): Production of antibiotics (penicillin, D-cycloserine, streptomycin, tetracycline, bacitracin, nystatin and grieseofulvin), amino acid (glutamic acid and lysine), biopolymers (dextran, alginate, xanthan and pullulan) and steroids biotransformation.

Unit V: Industrial Production Aspects II
Production aspects (Microbial strains, substrate, flow diagrams, product optimization and applications): Production of enzymes (pectinase, amylase, lipase, protease, cellulase and xylanase), alcohol and alcoholic beverages, vitamins (B12 and riboflavin), organic acids (citric acid, acetic acid and lactic acid), ergot alkaloids and bioplastics (PHB and PHA).

Reference Books

1. Hershnergev, C.L., Queener, S.W. and Hedemen, Q. Genetics and biotechnology of industrial microorganisms. ASM Press, Washington, D.C.
2. Crueger, W. and Crueger, A. Biotechnology: A textbook of industrial microbiology. Sinauer Associates, Sunderland.
3. Reed, G. Prescott and Dunn's industrial microbiology. Globe Bookservices, London.
4. Demain, A.L and Davies, J.E. Manual of industrial microbiology and biotechnology. ASM Press, Washington, D.C.
5. Casida, J.E. Industrial microbiology. Wiley Eastern, New Delhi.
6. Patel, A.H. Industrial microbiology. MacMillan India Limited, New Delhi.
7. Stanbury, A.H., Whittaker, A. and Hall, S.J. Principles of fermentation technology. Pergamon Press, Oxford.
8. Richard, H., George, B., Hagemann, D. and Paul, L. Industrial microorganisms: Basic and applied molecular genetics. ASM Press, Washington, D.C.

III SEMESTER

SLS/MIC/C015: LAB COURSE-I
(Based on Theory Papers SLS/MIC/C013 and SLS/MIC/C014)

1. Biosafety guidelines and biosafety levels.
2. Prevalence of pathogenic microorganisms in clinical sample.
3. Isolation and biochemical characterization of pathogenic bacteria.
4. Isolation and identification of fungal pathogens from clinical specimens.
5. Determination of antimicrobial susceptibility of pathogens by disc diffusion test.
6. Determination of MIC and MBC concentration of antibiotics by broth dilution test.
7. Isolation and screening of bacterial and fungal cultures for enzyme production.
8. Estimation of enzyme production by microbial culture *via* liquid state fermentation.
9. Estimation of enzyme production by microbial culture *via* solid state fermentation.
10. Media formulation for enhanced enzyme production by microbial culture *via* liquid and solid state fermentation.
11. Optimization of culture conditions for enhanced enzyme production by microbial culture *via* liquid and solid state fermentation.
12. Production of wine from fruit juice.
13. Monitoring of sugar reduction during wine production.
14. Estimation of alcohol concentration in wine.
15. Estimation of vicinal diketone in beer.
16. Improvement of strain for increased yield by U.V. mutagenesis.

Reference Books

1. Collee, J.C., Duguid, J.P., Fraser, A.C. and Marimon, B.P. Mackie and McCartney practical medical microbiology. Churchill Livingstone, London.
2. Garcia, L.S and Isenberg, H.D. Clinical microbiology procedures handbook. ASM Press, Washington, D.C.
3. Murray, P.R., Baron, E.J., Jorgensen, J.H., Pfaller, M.A. and Yoke, R.H. Manual of clinical microbiology. ASM Press, Washington, D.C.
4. Balows, A., Hausler, W.J., Ohashi, M. and Turano, A. Laboratory diagnosis of infectious diseases: Principles and practice. Springer-Verlag, New York.
5. Faddin, J.F.M. Biochemical tests for identification of medical bacteria. Williams and Wilkins, Baltimore.
6. Baltz, R.H., Demain, A.L and Davies, J.E. Manual of industrial microbiology and biotechnology. ASM Press, Washington, D.C.
7. Leboffe, M.J. and Pierce, B.E. Microbiology: Laboratory theory and application. Morton Publishing Company, Englewood.
8. Singer, S. Experiments in applied microbiology. Academic Press, New York.
9. Kannan, K. Laboratory manual in general microbiology. Panima, New Delhi.
10. Holt, J.G. and Krieg, N.R. Bergey's manual of determinative bacteriology. Lippincott Williams and Wilkin, Philadelphia.

III SEMESTER

SLS/MIC/E01A: FOOD AND DAIRY MICROBIOLOGY

Unit I: Principles of Food Preservation
Factors influencing microbial growth in food; Asepsis; Food preservation: Principles, Physical methods (Dehydration, freeze drying, heat and irradiation), Chemical methods (Chemical preservatives and food additives); Canning; Processing for heat treatment (D, Z and F values) and working out treatment parameters; Microbiological quality standards of food.

Unit II: Contamination and Spoilage
Characterization of contamination and spoilage of cereals, sugar products, vegetables, fruits, meat and meat products, milk and milk products, fish and sea foods, poultry, beer and wines; Spoilage of fermented foods and canned foods.

Unit III: Foodborne Infections and Intoxications
Bacterial and nonbacterial infections and intoxications of *Brucella*, *Bacillus*, *Clostridium*, *Escherichia*, *Salmonella*, *Shigella*, *Staphylococcus*, *Vibrio*, *Yersinia*, *Listeria*, nematodes, protozoa, algae, fungi and viruses; Structure and functions of aflatoxins; Food born outbreaks; Laboratory testing procedures; Biosensors in food industry.

Unit IV: Food Safety and Quality Assurance
Food sanitation in manufacture and retail trade; Microbiological quality standards of food; Food control agencies and their regulations: FDA, EPA, CDC and ISI; Good Manufacturing Practice and Quality Systems; Plant sanitation (Employees health standards, waste treatment and disposal); ISO and Hazard Analysis and Critical Control Point (HACCP) system; Food Safety Act and Trade Regulations.

Unit IV: Production of fermented foods
Industrial production methods of bread, cheese, fermented vegetables (olives and cucumber), fermented dairy products (acidophilus milk, cheese and yoghurt),single cell proteins, pickles, sauerkraut, meat and fishery products (sausages and fish sauces); Production of oriental foods (mycoprotein, tempeh, soya sauce, idli, natto and poi) and beverages (vinegar, cider, sake and palm wines); Alcoholic beverages of Himalayan region; Genetically modified foods; Utilization and disposal of dairy by-product – whey; Probiotics.

Reference Books

1. Adams, M.R., and Moss, M.O. Food microbiology. Royal Society of Chemistry Publication, Cambridge.
2. Frazier, W.C. and Westhoff, D.C. Food microbiology. Tata McGraw Hill, New Delhi.
3. Stanbuty, P.F. and Hall, S.J. Principles of fermentation technology. Pergamon Press, Oxford.
4. Banwart, G.J. Basic food microbiology. CBS Publishers and Distributors, New Delhi.
5. Robinson, R.K. Dairy microbiology. Elsevier Applied Sciences, London.
6. James M.J. Modern food microbiology. CBS Publishers and Distributors, New Delhi.
7. Wood, B.J. Microbiology of fermented foods. Elsevier Applied Sciences, London.
8. Ayres, J.C., Mundt, O. and Sandinee, W.E. Microbiology of foods. W.H. Freeman and Company, New York.

9. Jay, M.J., Loessner, M.J. and Golden, D.A. Modern food microbiology. Springer Science and Business Media, New York.
10. Hobbs, B.C. and Roberts, D. Food poisoning and food hygiene. Edward Arnold, London.

III SEMESTER

SLS/MIC/E01B: DRUG DESIGNING AND NANOBIOTECHNOLOGY

Unit I: Drug Receptor Interactions

Receptors: Classification of receptors and receptor subtypes, Structure of receptors, Blood cell receptors for endogenous compounds, Neurotransmitters and their receptors, Receptor modulation and mimics, Receptor sites, Receptor cross-talk, Organ receptors, Non-liganded and constitutive receptor activation, r-DNA receptor bioassays, Desensitization of receptors, Receptors as targets for vaccines and newer drug development; Drug-receptor interactions: Active transport, Affinity and efficacy, Allosteric binding sites, Chirality and receptor binding, Signal transduction and second messenger system, Introduction of various classes of drugs based on their interaction with target site, Interaction of drugs with receptors, enzymes, DNA and carbohydrates.

Unit II: Drug Targeting and Drug Delivery Systems

Introduction and historical perspectives of drug delivery systems; Controlled, targeted and delayed drug delivery systems; Oral dosage forms: Diffusion, Dissolution system, Osmotic pumps, Ion exchange resin; Soluble delivery systems: Micro and nano systems; Injections; Routes of drug delivery systems; Stability profile; Barriers to proteins and peptide delivery; Lymphatic transportation of proteins; Site specific protein modification; Toxicology profile characterization; Cellular level events in targeting; Carrier systems for targeting; Specialized liposomes for drug targeting.

Unit III: Structure Activity Relationship

Structure activity relationship (SAR): Introduction and scope, Structure activity relationship illustrated with examples from sulphonamides, β-lactams, quinolones, nucleosides and alkaloids; Quantitative structure activity relationship (QSAR): Role of physicochemical, electronic (Hammett equation), lipophilicity (Hansch equation) and steric parameter (Taft equation).

Unit IV: Molecular Modelling

Quantum mechanical and molecular orbital methods; Introduction to semiempirical, molecular mechanics and *ab initio* techniques; Potential energy surface; Docking and modelling substrate-receptor interactions; Introduction to software tools for CADD.

Unit V: Nanobiotechnology

Functional principles of nanobiotechnology; Basic biology principles and practice of micro fabrication techniques; Atomic force microscopy; Biological production of metal nanoparticles and macromolecular assemblies; Bacterial structure relevant to nanobiotechnology; Cubosomes; Dendrimers; DNA nanoparticle conjugates; DNA octahedron; Fullerenes; Nanoshells; Carbon nanotubes; Nanopores; Nanostructured silicon; Viruses as nanoparticles; DNA based nanostructures: DNA-protein nanostructures, Self-assembled DNA nanotubes, Drug delivery tools *via* nanobiotechnology; Protein and peptide delivery; Tumor targeting and other diagnostic applications; Nanoparticle based immobilization assays; Quantum dots technology and its application; Immuno- nanotechnology; Biosensors and nanobiotechnology.

Reference Books

1. Silverman, R. Organic chemistry of drug design and drug action. Elsevier, London.

2. Gorden, E.M. and Kerwin, J.F. Combinatorial chemistry and molecular diversity in drug discovery. Wiley-Liss, Oxford.
3. Pirrung, M.C. Molecular diversity and combinatorial chemistry: Principles and applications. Elsevier, London.
4. Larsen, P.K. and Stromgaard, K. Textbook of drug design and discovery. CRC Press, Boca Raton.
5. Silverman, R.B. The organic chemistry of drug design and drug action. Elsevier, London.
6. Patrick, G.L. An introduction to medicinal chemistry. Oxford University Press, Oxford.
7. Gregoriadis, G. Drug carriers in biology and medicine. Academic Press, New York.
8. Chorghade, M.S. Drug discovery and development. John Wiley and Sons, New York.
9. Graly, J.O. and Joubert, P.H. Handbook of phase I / II clinical drug trials. CRC Press, Boca Raton.
10. Eisenberg, D. and Crothers, D. Physical chemistry with applications to the life sciences. Benjamin/ Cummings Publishing Company, Melano Park.
11. Niemeyer, C.M. and Mirkin, A. Nanobiotechnology: Concepts, applications and perspectives. Wiley, New York.
12. Donald, M. Nanobiotechnology of biomimetic membranes. Springer Verlag, New York.
13. deVilliers, M.M., Aramwit, P. and Kwon, G.S. Nanotechnology in drug delivery. Springer-Science, New York.
14. Kulkarni, S.S. Nanotechnology: Principles and practices. Capital Publishing Company, New Delhi.
15. Goosell, D.S. Bionanotechnology: Lessons from nature. John Wiley and Sons, New York.

III SEMESTER

SLS/MIC/E01C: GENOMICS AND PROTEOMICS

Unit I: Genome Anatomies

Introduction to structural, comparative and functional genomics; Applications of genomics; Anatomy of eukaryotic and prokaryotic genome; Genome size and complexity; Repetitive DNA content of genome; Introduction to gene networks and epigenetic analysis; DNA methylation analysis: Global DNA methylation analysis, Gene-specific methylation analysis, Methylation sensitive PCR, Quantitative methods of DNA methylation analysis; Sequencing of genome: Shot gun sequencing, High throughput sequencing; Methods for sequence assembly: Whole genome shot gun approach, Clone contig approach.

Unit II: Mapping genomes

Genetic mapping: DNA markers used (RFLP, SSLP and SNP), Gene mapping by linkage and pedigree analysis, Genetic mapping in bacteria, Limitations of genetic mapping; Physical mapping: Restriction mapping, Fluorescence *in situ* hybridization, Sequence tagged site mapping.

Unit III: Genome sequence analysis

Location of gene by sequence inspection, Techniques used for gene location: Northern hybridization, Zoo blotting, cDNA sequencing; Techniques used for transcript mapping (RACE and heteroduplex analysis); Location of exon and exon-intron boundaries; Determining function of individual genes: Homology analysis, Gene inactivation by homologous recombination (gene targeting and gene trapping), genome-wide mutagenesis, transposon tagging and RNA interference; Overexpression of genes; Directed mutagenesis; Determining pattern of gene expression: Reporter gene and immunocytochemistry; Human Genome Project: Strategies and implications.

Unit IV: Transcriptomics

Serial analysis of gene expression (SAGE); Massively parallel signature sequencing (MPSS); DNA chip and microarray; Tiling arrays; Applications of transcriptomics.

Unit V: Proteomics

Techniques used to study proteome: 2-D PAGE, Mass-Spectrometry, MALDI-TOF, Identifying proteins with posttranslational modifications; Fast parallel proteolysis; Protein sequencing; Identifying protein – protein interactions: Yeast two-hybrid system, Phage display library, Protein microarray, Affinity purification, Protein interaction maps; Chromatin immunoprecipitation; Applications of proteomics.

Reference Books

1. Brown, T.A. Genomes. Wiley-Liss, Oxford.
2. Pevsner, J. Bioinformatics and functional genomics. Wiley-Blackwell, New Jersey.
3. Reece, R.J. Analysis of genes and genomes. John Wiley and Sons, New York.
4. Gibson, G. and Muse, S.V. A primer of genome science. Sinauer Associates, Massachusetts.
5. Campbell, A.M. and Heyer, L.J. Discovering genomics, proteomics and bioinformatics. Benjamin/ Cummings Publishing Company, San Francisco.

III SEMESTER

SLS/MIC/E01D: EPIDEMIOLOGY

Unit I: **Basics of Epidemiology**
Introduction; Scope and applications of epidemiology in health care; Role, ethics and responsibilities of an epidemiologist; Relation between virulence and spread; Reservoirs of infection (Human, animal and non-living reservoirs); Types of carriers; Portals of entry and exit.

Unit II: Transmission of Disease
Sources of infection; Modes of disease transmission; Disease cycle; Role of remote sensing and geographical information in recognition of an epidemic; Serological surveys; Influence of behavioral or spatial factors on transmission; Spatial, temporal and social distributions of communicable diseases; History of outbreaks: SARS, Chikungunya, Hantavirus infection, Swine flu, Haiti cholera.

Unit III: Mathematical Modelling I
Transmission dynamics: Incidence, Prevalence, Morbidity, Mortality; Public health surveillance: Purpose and characteristics, Identifying health problems for surveillance, Collection of data for surveillance, Analysis and interpretation of data, Disseminating data and interpretation, Evaluating and improving surveillance.

Unit IV: Mathematical Modelling II
Epidemiological studies: Collection of frequency data, Descriptive, analytical and experimental studies, Cross-sectional, case-control and cohort studies, Models for developing epidemiological theory, Modelling tools, Population dynamics, Epidemiological statistics relating exposure and disease; Measures of risks: Frequency measures, Morbidity and mortality frequency measures, Natality measures, Measures of association, Measures of public health impact.

Unit V: Control of Epidemics
Cycle of epidemics; Emerging and re-emerging infectious diseases and pathogens; Control of transmission: Isolation, Quarantine, Threat of bioterrorism, Global travel and health considerations; Community based control by vaccination, mass vaccination and herd immunity; Public health organizations for control: Centre of Disease Control (CDC), Guidelines issued by CDC and WHO, Health standards for international epidemics.

Reference Books

1. Rothman, K.J. and Greenland, S. Modern epidemiology. Lippincott-Raven, Philadelphia.
2. Dockrell, H., Zuckerman, M., Roitt, I.M. and Chiodini, P.L. Mim's medical microbiology. Elsevier, London.
3. Gordis, L. Epidemiology. Saunders, Philadelphia.
4. Anderson, R.M. and May, R.M. Infectious diseases of humans: Dynamics and control. Oxford University Press, Oxford.
5. Giesecke, J. Modern infectious disease epidemiology. Edward Arnold, London.
6. Clayton, D. and Hills, M. Statistical models in epidemiology. Oxford University Press, Oxford.
7. Rothman K.J., Greenland, S. and Lash, T.L. Modern epidemiology. Lippincott Williams and Wilkins, Philadelphia.

8. Vynnycky, E. and White, R.G. An introduction to infectious disease modelling. Oxford University Press, Oxford.
9. Gerstman, B.B. Epidemiology kept simple: An introduction to classic and modern epidemiolgy. John Wiley and Sons, New York.
10. Vynnycky, E. and White, R. An introduction to infectious disease modelling. Oxford University Press, Oxford.
11. Kestenbaum, B. Epidemiology and biostatistics: An introduction to clinical research. Springer-Verlag, New York.

III SEMESTER

SLS/MIC/E01E: BIOPROCESS TECHNOLOGY

Unit I: Bioreactor Design

Introduction to fermentation technology; Ideal bioreactor; Types of bioreactor (Stirred tank bioreactor, airlift bioreactor, continuous stirred tank bioreactor, immobilized cell reactors, plug flow reactor, tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors and trickle flow reactors); Designing of a bioreactor: Bioreactor configuration, Design features, Parts of bioreactor; Reactor with non-ideal mixing; Sterilization reactors; Multiphase bioreactors; Animal and plant cell reactor technology.

Unit II: Fermentation Process and Kinetics

Types of fermentation; Media formulation; Sterilization (Batch and continuous); Inoculum development; Operational modes (Applications, advantages and limitations of batch, fed-batch and continuous processes); Scaling up of process; Specific growth rate; Kinetics of microbial growth in batch, continuous and fed batch culture; Kinetics of substrate utilization and product yield; Multistage system; Feedback systems and its kinetics; Biomass productivity and metabolic productivity; Basic principles of operation; Optimization and modelling of fermentation process: Single variable design, Multivariate screening designs, Critical factor analysis, Optimization designs for two or more factors, Singlet method, Metabolic and flux control analysis.

Unit III: Mass and Energy: Transfer and Balance

Aeration: Principles and methods; Oxygen requirement in industrial fermentation; Theory of oxygen transfer in bubble aeration; Oxygen transfer kinetics (Oxygen uptake rate, Oxygen transfer rate and C_{crit}); Determination of kLa; Functions of agitation; Flow patterns with different types of impellers; Fermentation broth rheology and power requirements for agitation: Concept of Newtonian and non-Newtonian fluids, Effect of broth rheology on heat, nutrient and oxygen transfer, Reynold's number, Power number, Aeration number; Conversion and balance of nutrient and biomass, Heat balance and affecting factors, Heat transfer.

Unit IV: Downstream Processing

Biomass separation by centrifugation, filtration, flocculation and other recent developments; Cell disintegration: Physical, chemical and enzymatic methods; Extraction (Solvent, two phase, liquid extraction, whole broth and aqueous multiphase extraction); Purification by different methods; Concentration by precipitation, ultra-filtration and reverse osmosis; Drying and crystallization.

Unit V: Instrumentation and Control

Methods of measuring process variability and their control: Temperature, Flow, Pressure, Dissolved oxygen and free CO_2, pH and other chemical factors; Control systems: Manual control, Automatic control systems (Two-position controllers (ON/OFF), proportional controllers, integral controllers and derivative controllers); Combinations of methods of control; Computers application in process control.

Reference Books

1. Crueger, W. and Crueger, A. Biotechnology: A textbook of industrial microbiology. Sinaeur Associates, Sunderland.

2. Stanbury, A.H., Whittaker, A. and Hall, S.J. Principles of fermentation technology. Pergamon Press, Oxford.
3. Casida, J.E. Industrial microbiology. Wiley Eastern, New Delhi.
4. Bhosh, T.K., Fiechter, A. and Blakebrough, N. Advances in biochemical engineering. Springer Verlag, New York.
5. Veith, W.F. Bioprocess engineering kinetics, mass transport, reactors and gene expressions. John Wiley and Sons, New York.
6. Pauline, D. Bioprocess engineering principles. Academic Press, New York.
7. Lydersen, B., Elia, N.A.D. and Nelson, K.M. Bioprocess engineering: Systems, equipment and facilities. John Wiley and Sons, New York.
8. Hershnergev, C.L., Queener, S.W. and Hedemen, Q. Genetics and biotechnology of industrial microorganisms. ASM Press, Washington, D.C.
9. Reed, G. Prescott and Dunn's industrial microbiology. Globe Bookservices, London.
10. Demain, A.L and Davies, J.E. Manual of industrial microbiology and biotechnology. ASM Press, Washington, D.C.
11. Patel, A.H. Industrial microbiology. MacMillan India Limited, New Delhi.
12. Richard, H., George, B., Hagemann, D. and Paul, L. Industrial microorganisms: Basic and applied molecular genetics. ASM Press, Washington, D.C.
13. Kalaichelvan, P.T. and Arulpandi, I. Bioprocess technology. MPJ Publishers, Chennai.
14. Asenjo, J.A. Separation process in biotechnology. Marcel Dekker, New York.
15. Belter, P.A. Cussler, E.L. and Hu, W.S. Bioseparation: Downstream processing for biotechnology. John Wiley and Sons, New York.
16. Peppler, H.J. and Perlman, D. Microbial technology. Academic Press, New York.

III SEMESTER

SLS/MIC/E02A: AGRICULTURAL MICROBIOLOGY

Unit I: Abiotic and Biotic Components of Soil

Types of Soil; Soil genesis; Factors involved in soil genesis; Soil profile; Physico-chemical characteristics; Suitability of soil for agriculture; Soil enzymes and significance; Soil microbes;Influence of microbial metabolism on soil chemistry and humus formation; Importance of humic and fulvic acids in soil mineralization; Organic matter dynamics in soil: Microbial decomposition of cellulose, hemicellulose and lignin, Factors affecting organic matter decomposition; Molecular markers for ecological studies of soil microorganism; Soil microbial biomass as an index of soil fertility.

Unit II: Rhizosphere and Rhizoplane Microorganisms

Rhizosphere; Rhizoplane; Composition of root exudates; Factors affecting exudation; Plant growth promoting rhizobacteria; Mycorrhiza; Rhizosphere effect; Factors affecting microbial community in soil; Biogeochemical cycle: C, N, P and S cycles; Mechanism of plant growth promotion: Mechanism of nitrogen fixation, Mechanism of phosphate solubilization and phosphate mobilization, Mechanism of iron chelation, Production of plant growth promoting hormones from bacteria and fungi, Production of antibiotics by plant growth promoting microorganisms.

Unit III: Plant Pathogens

Symptoms, casuative organisms, disease cycle and control measures of plant diseases: Blight of rice, Citrus canker, Wilt of potato, *Pythium* seed rot, Grapes downy mildew, Potato early and late blights, Fusarial wilt, Wheat-smut and rust, Tikka leaf spot in groundnut, Common viral diseases of plants (Paddy, cotton, potato, tobacco, cauliflower, tomato and sugarcane); Biochemical and genetic basis of virulence in plant pathogens.

Unit IV: Biocontrol Agents for Agriculturally Important Crop Plants

Biopesticides: Source organisms (*Bacillus thuringiensis*, *Beauveria bassiana*,*Metarhizium anisopliae*, *Trichoderma* and Baculoviruses); Mechanism of biocontrol; Other means of pathogen control: Application of viral proteins in controlling viral diseases, Antisense RNA technology in disease control, RNAi in controlling plant pathogens, Mycoviruses acting against fungal plant pathogens.

Unit V: Biofertilizers

Isolation, purification, mass multiplication, inoculum production and method of application of biofertilizers: *Azospirillum*, b*Azotobacte*r, *Rhizobium*, Cyanobacteria, AM fungi, Phosphate solubilizer; Storage, shelf life, quality control and marketing of biofertilizers.

Reference Books

1. Subba Rao, N.S. Soil microorganisms and plant growth. Oxford and IBH Publishing Company, New Delhi.
2. Alexander, M. Introduction to soil microbiology. John Wiley and Sons, New York.
3. Kononova, M.M. Soil organic matter: Nature, its role in soil formation and in soil fertility. Pergamon, Oxford.
4. Burges, A. and Raw, F. Soil biology. Academic Press, London.

5. Rangasami G. and Bagyarai, D.J. Agricultural microbiology. Prentice-Hall, New Delhi.
6. Agrios, G.N. Plant pathology. Academic Press, San Diego.
7. Mathews, R.E. Functionals of plant virology. Academic Press, San Diego.
8. Adrian, G. and Harrison, B. Plant virology: The principles. Edward Arnold, London.
9. Board, N. The complete technology book on biofertilizer and organic farming. National Institute of Industrial Research, India.
10. Sharma, A.K. Biofertilizers for sustainable agriculture. ABD Publishers, Jaipur.
11. Goel, P.K. and Pathade, G.R. Biotechnological applications in environment and agriculture. ABD Publishers, Jaipur.
12. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.
13. Tilak, K.V.B.R. Bacterial biofertilizers. IARI Publications, New Delhi.
14. Venkataraman, G.S. Algal biofertilizers and rice cultivation. Today and Tomorrow's Printers and Publishers, New Delhi.

III SEMESTER

SLS/MIC/E02B: MICROBIAL DIVERSITY

Unit I: Microbial Evolution and Biodiversity

Evolution of earth and early life forms; Genetic basis for evolution; Stromatolites; Evolution of microbes and eukaryotes; Evolution of physiological diversity; Prokaryote-eukaryote evolutionary relationship; Methods for determining evolutionary relationships: Evolutionary chronometers, Ribosomal RNA analyses, Signature sequences, Phylogenetic probes; Search for life on Mars: Biology box, gas exchange, label release and pyrolytic release experiments, Alterations in load of microbial flora of astronauts; Microbial diversity: Tools used for studying culturable and non culturable microbial diversity, Indices (Diversity, dominance and species richness indices).

Unit II: Bacterial Diversity I

Classification of bacteria into different phylums; General characteristics, ecology, physiology and metabolism of bacterial phylums: Acidobacteria,Actinobacteria, Aquificae, Bacteroidetes, Chlamydiae, Chlorobi, Chloroflexi, Chrysiogenetes, Deferribacteres, Deinococcus-Thermus, Dictyoglomi, Fibrobacteres, Fusobacteria.

Unit III: Bacterial Diversity II

General characteristics, ecology, physiology and metabolism of bacterial phylums: Nitrospira, Planctomycetes, Proteobacteria, Spirochaetes, Synergistetes, Thermodesulfobacteria, Thermotogae, Verrucomicrobia.

Unit IV: Archaea Diversity

Phylum Euryarchaeota: Halobacteria, Methanogens, Thermoplasms, Thermococcales; Phylum Crenarchaeota: Desulfurococcales, Thermoproteales, Sulfolobales; Phylum Korarchaeota; Phylum Nanoarchaeota: Nanoarchaeum.

Unit V: Physiology and molecular adaptations of extremophiles

Characteristic features, classification, physiology, molecular adaptations and applications of acidophiles, alkalophiles, psychrophiles, thermophiles, barophiles, halophiles, oligotrophs, osmophiles, radiophiles, metallophiles and xerophiles.

Reference Books

1. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
2. Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's microbiology. McGraw-Hill, New York.
3. Colwd, D. Microbial diversity. Academic Press, New York.
4. Holt, J.S., Krieg, N.R., Sneath, P.H.A. and Williams, S.S.T. Bergey's manual of determinative bacteriology. Lippincott Williams and Wilkins, Philadelphia.
5. Satynarayana, T. and Johri, B.N. Microbial diversity: Current perspectives and potential applications. I.K. International (P) Limited, New Delhi.
6. Antranikian, G. Biotechnology of extremophiles. Springer- Verlag, New York.
7. Johri B.N. Extremophiles. Springer Verlag, New York.
8. Kushner, D.J. Microbial life in extreme environments. Academic Press, New York.

9. Edward, C. Microbiology of extreme environments. McGraw-Hill, New York. .
10. Heinrich, M.R. Extreme environment: Mechanism of microbial adaptation. Academic Press, New York.
11. da Costa, M.S., Duarate, J.C. and Williams, R.A.D. Microbiology of extreme environments and its potential for biotechnology. Elsevier Applied Science, London.
12. Horikoshi, K. and Grant, W.D. Extremophiles: Microbial life in extreme environments. Wiley-Liss, New York.

III SEMESTER

SLS/MIC/E02C: PHARMACEUTICAL MICROBIOLOGY

Unit I: Drug Discovery

Introduction to pharmacogenomics; High throughput screening; Phases of drug discovery: Bioprospecting, Principles of extraction, purification and characterization of bioactive molecules from natural resources, Candidate drug selection, Preclinical trials, Clinical trial phase I/II/III; Toxicological evaluation of drug; Drug interactions; Drug metabolism (Activation / inhibition of drug *in vivo*); Adverse drug reactions; FDA guidelines for approval of new drugs and their use; Drug distribution in body; Bio-availability and pharmacokinetic studies; Bioequivalence studies.

Unit II: Development of Antimicrobial Agent

Screening and development strategies for new antimicrobial agents; Bioassay of antimicrobial agents using standard guidelines; Factors affecting bioassay; Laboratory methods to assess activity of antimicrobial combinations (Antagonism, synergism and additive effect).

Unit III: Microbial Production and Spoilage of Pharmaceutical Products

Manufacturing procedures and in process control of pharmaceuticals; Pharmaceuticals produced by microbial fermentations (Streptokinase and streptodornase); Vaccines: Multivalent subunit vaccines, Purified macromolecules, Synthetic peptide vaccines, Immuno-adhesions, Recombinant antigen vaccines, Vector vaccines, Anti-idiotype vaccines, Targeted immune stimulants, New generation vaccines; Microbial contamination and spoilage of pharmaceutical products (Sterile injectibles, non-injectibles, ophthalmic preparations and implants) and their sterilization.

Unit IV: Quality Assurance and Validation

Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry; Basic principles of quality control (QA) and quality assurance (QC); Regulatory aspects of quality control; Quality assurance and quality management in pharmaceuticals: Guidelines for QA and QC (Raw materials, sterilization, media, stock cultures and products), ISO, WHO and US certification; Sterilization control and sterility testing: Heat sterilization, D value, z value, Survival curve, Radiation, gaseous and filter sterilization, Chemical and biological indicators, Validation study; LAL test; Sterility testing and bioassay; Biosensors in pharmaceuticals; Design and layout of sterile product manufacturing unit.

Unit V: Regulatory practices and applications in pharmaceuticals

Financing R&D capital and market outlook; IP, BP and USP; Government regulatory practices and policies; FDA perspective; Reimbursement of drugs and biological; Legislative perspective; Introduction to pharmacopoeia; Immobilization procedures for pharmaceutical applications; Macromolecular, cellular and synthetic drug carriers; Application of microbial enzymes in pharmaceuticals.

Reference Books

1. Hugo, W.B. and Russell, A.D. Pharmaceutical microbiology. Blackwell Science, London.
2. Cooper, M.S. Quality control in the pharmaceutical industry. Academic Press, New York.
3. Vyas, S.P. and Dixit, V.K. Pharmaceutical biotechnology. CBS Publishers, New Delhi.
4. Willig, S.H., Tuckerman, M.M. and Hitchings, W.S. Good manufacturing practices for pharmaceuticals. Marcel Dekker, New York.

5. Gregoriadis, G. Drug carriers in biology and medicine. Academic Press, New York.
6. Bhatia, R. and Ihhpunjani, R.L. Quality assurance in microbiology. CBS Publishers and Distributors, New Delhi.
7. Burn, J.H. Principles of therapeutics. Blackwell Scientific Publications Limited, Oxford.
8. Chatwal, G.P. Biopharmaceutics and pharmacokinetics. Himalaya Publishing House, Mumbai.
9. Chorghade, M.S. Drug discovery and development. John Wiley and Sons, New York.
10. Dewick, P.M. Medicinal natural products: A biosynthetic approach. John Wiley and Sons, New York.
11. Gale E.F., Cundliffe, E., Reynolds, P.E., Richmond, M.H. and Waring, M.J. The molecular basis of antibiotic action. John Wiley and Sons, New York.
12. Graly, J.O. and Joubert, P.H. Handbook of phase I / II clinical drug trials. CRC Press, Boca Raton.
13. Satoskar, R.S. and Bhandarkar, S.D. Pharmacology and pharmacotherapeutics. Popular Prakashan, Mumbai.

III SEMESTER

SLS/MIC/E02D: INFECTION AND IMMUNITY

Unit I: Infectious Agents

Infection and its types; Infectious agents: Viruses, Bacteria, Fungi, Protozoa, Helminthes (worms), Parasites, Prions; Pathogens and immunity; Immunogenicity of pathogens; Virulence and susceptibility; Pathogen associated molecular patterns.

Unit II: Immune Regulation of Infection

Barriers preventing establishment of infection; Mechanism of establishment of infection: Invasion, Survival in intracellular and cytoplasmic space, Role of molecular factors in establishment of infection, Role of cells and molecules of immune system in infection, Adoptive immunity to infection, Immune elimination of infection, Mechanisms of escape from immune-mediated destruction, Infection in immuno-compromised host.

Unit III: Immune Responses to Infection

Immune alteration during early and late phases of infection; Immunological basis of infection; Infection and antigen presentation; Recognition of molecular pattern of pathogen; Phagocytosis and killing of infectious agents; Humoral and cell-mediated immunity against infection; Infection associated immunosuppression; Immunodeficiency and infection; Acquired immuno-deficiencies; Nosocomial and community acquired infections; Co-infections; Immunity in local and systemic infection (bacterimia and viremia); Septic infection and immunity; Immunological memory against infection and secondary responses; Immunization: Active and passive; Vaccination.

Unit IV: Immunity against Bacterial, Viral and Prions Infections

Immune responses and immunological control of bacterial infection (*Staphylococcus* and *Mycobacterium*), viral diseases (Influenza and hepatitis) and prion infections.

Unit V: Immunity against Fungal and Parasite Infections

Immune responses and immunological control of fungal infection (Candidiosis and aspergillosis) and parasitic diseases (Malaria, leishmaniasis, schistisomasis and filarisas).

Reference Books

1. Kindt, T.J., Goldsby, R.A., Osborne, B.A. and Kuby, J. Kuby immunology. W.H. Freeman and Company, New York.
2. Abbas, A.K., Lichtman, A.H.H. and Pillai, S. Cellular and molecular immunology. Saunders, Philadelphia.
3. Delves, P.J., Martin, S.J., Burton, D.R. and Roitt, I.M. Roitt's essential immunology. Wiley-Blackwell, New Jersey.
4. Palyfair, J.H.L. and Chain, B.M. Immunology at a glance. Wiley- Blackwell, New Jersey.
5. Coico, R. and Sunshine, G. Immunology: A short course. Wiley- Blackwell, New Jersey.
6. Rao, C.V. Immunology. Alpha Science International Limited, New Delhi.
7. Gooi, H.C. and Chapel, H. Clinical immunology: A practical approach. Oxford University Press, Oxford.
8. Pathak, S. and Palan, U. Immunology: Essential and fundamental. Science Publishers, New Hampshire.

9. Playfair, J.H.L and Bancroft, G.J. Infection and immunity. Oxford University Press, Oxford.
10. Pier, G.B., Lyczak, J.B. and Wetzler, L.M. Immunology, infection and immunity. ASM Press, Washington, D.C.

III SEMESTER

SLS/MIC/E02E: INTELLECTUAL PROPERTY RIGHTS

Unit I: Basic Aspects of Intellectual Property Rights
Introduction to IPR; Intellectual property; WIPO; Types of Intellectual Property Rights: Copyrights, Trademarks (Collective marks, certification marks and well-known marks),Industrial designs, Geographical indications, Patents, Plant breeder's rights; Importance and business interest of IPR for industry and academia; Relationship of IPRs with biotechnology; Trade secrets; Non-disclosure agreements.

Unit II: International Treaties for Protection of Intellectual Property
Brief background of different treaties: WIPO copyright treaty, Berne convention, Rome convention, TRIPS agreement, WIPO performances and phonograms treaty, Madrid agreement, Madrid protocol, Paris convention, Lisbon agreement, Hague agreement, Patent Cooperation Treaty; Relationship between IPR and trade: WTO, TRIPS Agreement, GATT, Enforcement and dispute settlement under the TRIPS agreement, Implication of TRIPS for developing countries in the overall WTO system.

Unit III: Patents
Patent Terminology; Patent claims; Patent life and geographical boundaries; Utilization of intellectual patents; Licensing of patents; Elements of patentability; Procedure for grant of patent in India, USA and Europe; PCT application; Patent search invention in context of "prior art"; Patent search methods; Patent databases and libraries; Country-wise patent searches (USPTO, EPO, ARIPO and India); Patent mapping; Patent harmonization; Case studies of patents in biotechnology.

Unit III: Patent Acts, Issues in Pharmaceuticals and Patent Infringement
Patent acts and latest amendments of Indian, European and US patent systems; Patent issues in drugs and pharmaceuticals: Generics, Compulsory licensing, Exclusive marketing rights, Bolar provision, Bayh-Dole act, Second medical use; Patent infringement (Case studies, defenses to infringement including experimental use, patent misuse, legal considerations, enforcement measures, patent valuations, competition and confidentiality issues); Assignment of Intellectual Property Rights; Technology Transfer Agreements.

Unit IV: Protection of Plant Varieties
Interface between technology and IPRs in the context of plants; Key features of UPOV 1978, UPOV 1991 and TRIPS with respect to IPRs on plants; Indian law on protection of plant varieties; DUS criteria; Sui generis system for protection; Patenting of genetically modified plants; Significance of IPRs in agricultural biotechnology: Case studies.

Unit V: Traditional Knowledge and Intellectual Property Rights
Importance and relevance of traditional knowledge for developing nations; Various approaches for protecting traditional knowledge; Local, national and global dimensions of the issues in traditional knowledge and IPR; Traditional medicine and IP protection; Folklore; Case studies of patenting of health foods.

Reference Books

1. Subbaram N. Patents. Pharma Book Syndicate, Hyderabad.
2. Ganguli, P. Intellectual property rights. Tata Mc-Graw Hill, New Delhi.
3. Shippey, K.C. A short course in international intellectual property rights: Protecting your brands, marks, copyrights, patents, designs and related rights worldwide. World Trade Press, Petaluma.
4. Bently, L. and Sherman, B. Intellectual property law. Oxford University Press, Oxford.
5. Parulekar, A. and D'Souza, S. Indian patent law: Legal and business implications. MacMillan Press, London.
6. Grubb, P.W. Patents for chemicals, pharmaceuticals and biotechnology: Fundamentals of global law, practice and strategy. Oxford University Press, Oxford.
7. Knight, H.J. Patent strategy: For researchers and research managers. John Wiley and Sons, New York.
8. Bryant, J.L. Protecting your ideas: The inventor's guide to patents. Academic Press, New York.
9. Durham, A.L. Patent law essentials: A concise guide. Quorum books, Westport.
10. Gordon, T.T. and Cookfair, A.S. Patent fundamentals for scientists and engineers. CRC Press, Boca Raton.
11. Halpern, S. Fundamentals of United States intellectual property law: Copyright, patent and trademark. Springer-Verlag, New York.
12. Santaniello, V., Evenson, R.E., Zilberman, D. and Carlson, G.A. Agriculture and Intellectual Property Rights: Economic, institutional and implementation issues in biotechnology. CABI Publications, New York.

III SEMESTER

SLS/MIC/E003: LAB COURSE-II
(Based on Theory Papers SLS/MIC/E01 and SLS/MIC/E02)

Lab exercises based on theory paper SLS/MIC/E01A

1. Microbiological examination of food.
2. Assay of quality of milk sample using MBRT test.
3. Adulteration tests for milk.
4. Microbial production of curd.
5. Isolation and identification of *Lactobacillus* from fermented dairy products.
6. Isolation and biochemical identification of microorganisms from contaminated food and dairy samples.
7. Determination of D value in heat treatment of foods.
8. Effect of freezing temperatures on microorganisms in food
9. Production of sauerkraut.
10. Estimation of lactic acid production in sauerkraut.
11. Effect of salt concentration on lactic acid production in sauerkraut.
12. Estimation of acidity of vinegar.

Lab exercises based on theory paper SLS/MIC/E01B

1. Testing of presence of drug in the given biological sample.
2. Structure analysis of different medicinal compounds using software.
3. Computational approach for sequence design of DNA nanostructures.

Lab exercises based on theory paper SLS/MIC/E01C

1. Data mining using NCBI, SWISSPROT, EBI, PDB and MBGD.
2. Database search.
3. Determination of protein structure.
4. Genome sequence analysis.
5. Determining homology between different microorganisms based on their rDNA sequence in database.
6. Pairwise sequence alignment and multiple sequence alignment.

Lab exercises based on theory paper SLS/MIC/E01D

1. Universal precautions and recommendations from CDC for personnel employed in clinical laboratories.
2. Study of morbidity and mortality weekly reports (MMWR) issued by CDC.
3. Calculation of mortality, morbidity and prevalence rate in data procured from websites of health organisations.

Lab exercises based on theory paper SLS/MIC/E01E

1. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microorganisms for design of a sterilizer.
2. Inoculum preparation for bioreactor.
3. Media formulation for enhanced enzyme production by microbial culture *via* batch fermentation.
4. Extraction of intracellular and extracellular enzyme produced by microbial culture *via* batch fermentation.

5. Optimization of culture conditions for enhanced enzyme production by microbial culture *via* batch fermentation.
6. Determination of oxygen transfer rate.
7. Determination of substrate degradation profile.
8. Immobilization of microbial cells and enzyme.

Lab exercises based on theory paper SLS/MIC/E02A

1. Isolation and biochemical identification of *Azotobacter* from soil.
2. Isolation and biochemical identification of *Rhizobium* from root nodule of leguminous plant.
3. Isolation of phosphate solubilizers from soil.
4. Isolation and biochemical identification of PGPR from plant rhizosphere.
5. Determination of siderophore production by PGPR.
6. Determination of phosphorus solubilization by PGPR.
7. Determination of rhamnolipid production by PGPR.
8. Study of symptoms of bacterial, fungal and viral diseases of plants.
9. Isolation and identification of pathogenic microorganisms from diseased plant sample.

Lab exercises based on theory paper SLS/MIC/E02B

1. Determination of diversity of microbial community in different habitats.
2. Determination of species richness and evenness in microbial community in different habitats.
3. Isolation and characterization of thermophilic microorganisms.
4. Isolation and characterization of acidophilic and alkalophilic microorganisms.

Lab exercises based on theory paper SLS/MIC/E02C

1. Screening of plant extracts for antimicrobial potential.
2. Evaluation of synergistic antimicrobial potential of antibiotics and plant extracts.
3. Determination of MIC and MBC concentration of plant extracts by broth dilution test.
4. Sterility testing of pharmaceutical products.

Lab exercises based on theory paper SLS/MIC/E02D

1. Determination of antibody synthesis after vaccination in mouse.
2. Determination of infection induced alteration in TLC and DLC.
3. Isolation of macrophages from mouse peritoneal cavity.
4. *In vitro* activation of macrophages by bacterial cell wall components.
5. Phagocytosis of bacterial and yeast cells by macrophages.
6. Determination of effect of infection on cytokine level in blood.
7. Determination of alteration in cytokine production by infected macrophages.

Lab exercises based on theory paper SLS/MIC/E02E

1. Online search for patents in WIPO site.
2. Case studies of different patents: Basmati, Neem, Turmeric, Oncomouse, Bald mouse, Novartis gleevec, Cre-lox, Diamond versus Chakrabarty, Round up ready crops.
3. Theoretical exrercises for identifying the protection of different elements of a common discovery under different types of IPR.

Reference Books

1. McLandsborough, L. Food microbiology laboratory. CRC Press, Boca Raton.

2. Harrigan, W.F. Laboratory methods in food microbiology. Gulf Professional Publishing, Houston.
3. Leboffe, M.J. and Pierce, B.E. Microbiology: Laboratory theory and application. Morton Publishing Company, Englewood.
4. Gunasekaran, P. Laboratory manual in microbiology. New Age International, New Delhi.
5. Graly, J.O. and Joubert, P.H. Handbook of phase I / II clinical drug trials. CRC Press, Boca Raton.
6. Higginns, D. and Taylor, W. Bioinformatics: Sequence, structure and databanks – A Practical approach. Oxford University Press, Oxford.
7. Baxevanis A.D and Ouellette, B.F.F. Bioinformatics – A practical guide to the analysis of genes and proteins. Wiley – Interscience, New York.
8. Ausubel, F.M., Breut, R., Kingston, R.E. and Moore, D.D., Siedman, J.G., Smith, J.A. and Struhl, K. Short protocols in molecular biology. Wiley, New York.
9. Clayton, D. and Hills, M. Statistical models in epidemiology. Oxford University Press, Oxford.
10. Kestenbaum, B. Epidemiology and biostatistics: An introduction to clinical research. Springer-Verlag, New York.
11. Baltz, R.H., Demain, A.L and Davies, J.E. Manual of industrial microbiology and biotechnology. ASM Press, Washington, D.C.
12. Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. William C. Brown, Dubuque.
13. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.
14. Holt, J.G. and Krieg, N.R. Bergey's manual of determinative bacteriology. Lippincott Williams and Wilkin, Philadelphia.
15. Chorghade, M.S. Drug discovery and development. John Wiley and Sons, New York.
16. Dewick, P.M. Medicinal natural products: A biosynthetic approach. John Wiley and Sons, New York.
17. Rose, N.R., Hamilton, R.G. and Detrick, B. Manual of clinical laboratory immunology. ASM Press, Washington, D.C.
18. Weir, D.M. Handbook of experimental immunology. Blackwell Scientific Publications, New Jersey.
19. Stafseth, H.J., Stockton, J.J. and Newman, J.P. A laboratory manual for immunology. Burgess Publishing Company, Stockland.
20. Burrell, R.G. and Mascoli, C.C. Experimental immunology. Burgess Publishing Company, Stockland.
21. Grubb, P.W. Patents for chemicals, pharmaceuticals and biotechnology: Fundamentals of global law, practice and strategy. Oxford University Press, Oxford.

IV SEMESTER

SLS/MIC/C016: ENVIRONMENTAL MICROBIOLOGY

Unit I: Fundamentals of Microbial Ecology

Ecosystem; Biotic and abiotic components; Habitat and Niche; Population and guilds; Concepts of community and continuum; Community coefficient; Community stability; Stability hypothesis; Intermediate-disturbance hypothesis; Concept of ecological niche; Ecosystem organization: Structure and functions, Primary production, Energy dynamics (Trophic organization, energy flow pathways and ecological efficiencies); Microbial community dynamics: r and k strategies of population selection within communities, Community succession.

Unit II: Air and Aquatic Microbiology

Aerobiology: Droplet nuclei, Aerosol, Assessment of air quality, Solid and liquid impingement methods, Brief account of air born transmission of microbes (viruses, bacteria and fungi), Aeroallergy and aeroallergens; Aquatic microbiology: Zonation and microbiota of fresh water (ponds, lake and rivers) and marine habitats (estuaries, mangroves, deep sea, hydrothermal vents, saltpans and coral reefs), Upwelling and downwelling, Eutrophication, Food chain, Mechanism of dissolved organic matter production, Strategies of organic matter utilization in sea, Microbial assessment of water quality, Water purification, Heavy metal tolerance in microbes.

Unit III: Microbial Interactions

Positive and negative interactions amongst microbial populations: Cooperation, Neutralism, Commensalism, Synergism, Mutualism, Competition (Gause hypothesis), Amensalism, Parasitism, Predation; Interactions between microorganisms and plants: Rhizobacteria, Mycorrhiza, Epiphytic and endophytic microorganisms; Interactions between microorganisms and animals: Predation on microorganisms by animals, Cultivation of microorganisms by animals for food and food processing.

Unit IV: Pollution and its Control

Air pollution and its control: Sources, Major pollutants, Adverse effect on living organisms: Acid rain and its impact on ecosystem, Greenhouse effect, Global warming, Ozone layer depletion and its effect, Smog, Control through biotechnology (deodorization, reduction in CO_2 emission, bioscrubbers, biobeds and biofilters); Water pollution and its control: Sources, Ground water contamination, Wastes: Characterization of solid and liquid wastes, Solid waste treatment (Landfills, incineration, composting, anaerobic digestion and pyrolysis),Utilization of solid wastes (Food, fuel and fertilizers), Waste water treatment: Pretreatment, primary, secondary (activated sludge, surface aerated basins, fluidized bed reactors, trickling filter, biotower, rotating biological contactors, membrane bioreactors and secondary sedimentation) and tertiary treatment, disinfection and odor control; Application of biofilm in waste water treatment; Environment impact assessment.

Unit V: Impact of Microbes on Environment

Biodegradation of recalcitrant compounds: Pesticides, Petroleum, Organopollutants; Bioremediation: *In situ* & *Ex situ* remediation, Concept of bioremediation technologies, Microbial consortium, Bioremediation of oil spills, paper and pulp mill effluents and textile effluents; Bioaugmentation; Biomagnification; Biomineralization; Biomining; Metal corrosion: Mode of deterioration, Microorganisms involved, Disadvantages, Mode of prevention;

Bioleaching of ore; Bioaccumulation of metals and detoxification; GMO and their impact; Microbial plastics; Biodiesel.

Reference Books

1. Alexander, M. Microbial ecology. John Wiley and Sons, New York.
2. Eldowney, S., and Waites, S. Pollution: Ecology and biotreatment. Longman, Harlow.
3. Baker, K.H. and Herson, D.S. Bioremediation. McGraw- Hill, New York.
4. Marshal, K.C. Advances of microbial ecology. Plenum Press, New York.
5. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
6. Chapman, J.L. and Reiss, M.J. Ecology: Principles and applications. Cambridge University Press, Cambridge.
7. Heywood, V.H. and Watson, R.T. Global biodiversity assessment. Cambridge University Press, Cambridge.
8. Kormondy, E.J. Concepts of ecology. Prentice-Hall, New Delhi.
9. Odum, E.P. Basic ecology. Saunders, Philadelphia.
10. Mitchell, R. and Gu, J.D. Environmental microbiology. Wiley-Blackwell, New Jersey.
11. Maier, R., Pepper, I. and Gerba, C. Environmental microbiology. Academic Press, San Diego.
12. Evans, G.M. and John, J.C.F. Environmental biotechnology: Theory and applications. John Wiley and Sons, New York.
13. Satyanarayana, T., Littlechild, J. and Kawarabayasi, Y. Thermophilic microbes in environmental and industrial biotechnology. Springer Science and Business Media, Dordrecht.
14. Satyanarayana, T., Johri, B.N. and Prakash, A. Microorganisms in environmental management: Microbes and environment. Springer Verlag, New York.

IV SEMESTER

SLS/MIC/C017: RESEARCH METHODOLOGY

Unit I: Formulating Research Problem and Experimental Planning

Selection of an area for research; Importance and need of research in that field; Literature survey; Planning of experimental work: Importance and designing of the problem to be undertaken, Defining the aim and objectives of the research work planned, Importance of prior collection of protocols, Time bound frame of work plan, Designing of experimental protocol; Description of strategies to meet the objectives using state-of-the-art techniques and proper citation of standard procedures.

Unit II: Data Collection and Analysis

Types of data: Qualitative and quantitative data, Primary and secondary data; Site selection for sample collection; Source selection for data acquisition; Sampling techniques: Simple and random sampling, Systematic sampling, Stratified sampling, Multistage sampling, Cluster sampling, Multiphase sampling; Sample size; Recording of data and data summarization; Significance of triplicate readings; Measures of dispersion: Range, Quartile deviation, Mean deviation, Standard deviation, Coefficient of variation; Probability: Random experiment, Events, Sample space, Mutually exclusive events, Independent and dependent events, Statement of addition and multiplication theorems of probability, Random variables (Discrete and continuous), Probability density functions and its properties.

Unit III: Statistical Basis of Biological Assay

Response-Dose metameler; Delusion assay; Direct and indirect assays; Quantal responses Probit and logit; LD_{50}, ED_{50} and PD_{50}; Standard line interpolation assay; Parallel line assay (4 point and 6 point assays); Slope ratio assay; Count data: Examples of count data (Bacterial cell count, radioactivity count, colony counts and plaque counts); Statistical treatment to count data: Poison distribution, Skewness and kurtosis, Standard error, Confidence limits of counts; Statistical treatment to proportion data(MPN, sterility testing of medicines, therapeutic trial of drugs and vaccines); Properties and uses of tests of significance (T-test, z-test and chi-square tests of heterogeneity and independence of attributes, F-test); Concept of standard error; Goodness of fit.

Unit IV: Analysis of Variance

Principles of experimental designs; Randomized block and latin square designs; One- way and two-way classifications with single observation per cell; Standard curves: Correlation, Linear regression (fitting of best line through a series of points), MLR, Multiple collinearity, Standard curves and interpolation of unknown Y-values.

Unit V: Basics of Bioinformatics and Technical Writing

Bioinformatics: Introduction to various biological databases (Primary, secondary and composite databases); Introduction to biological information system: SRS, ENTREZ; Sequence comparison and alignment: Sequence similarity searching tools (FASTA and BLAST), Multiple sequence alignment and applications; Introduction of data mining: Classification, Clustering, Data collection, Data warehousing, Data preprocessing, Applications of data mining and genomes mining; Databases: Nucleotide sequence information sources (GenBank, EMBL, EBI, DBJ and UCSC), Protein sequence information sources (PIR, ExPASY, UniProt KB, SwissProt and TrEMBL); Phylogenetic analysis: Phenetic and cladistic approach; Phylogenetic tree construction (Rooted and unrooted method); Prediction of protein structure and modelling:

Introduction to various methods for prediction of primary and secondary structure, Homology and threading methods for tertiary structure prediction; Technical writing: Selection of appropriate title, Abstract, Introduction, Aims and objectives, Review of literature, Methodology, Results, Discussion, Summary and Conclusions, Bibliography.

Reference Books

1. Bhattacharyya, D.K. Research methodology. Excel Books, New Delhi.
2. Kumar, R. Research methodology: A step-by-step guide for beginners. SAGE Publications, California.
3. Singh, Y.K. Research methodology. APH Publishing Corporation, New Delhi.
4. Khan, J.A. Research methodology. APH Publishing Corporation, New Delhi.
5. Gupta, S. Research methodology and statistical techniques. Deep and Deep Publications, New Delhi.
6. Khanzode, V.V. Research methodology. APH Publishing Corporation, New Delhi.
7. Goddard, W. and Melville, S. Research methodology: An introduction. Juta and Company Limited, Landsdown.
8. Dawson, C. Practical research methods: A user-friendly guide to mastering research techniques and projects. How to Books Limited, London.
9. Daniel, P.S. and Sam, A.G. Research methodology. Gyan Publishing House, New Delhi.
10. Murray, R. How to write a thesis. McGraw-Hill, New York.
11. Glantz, S.A. Primer of biostatistics. McGraw-Hill, New York.
12. Dawson, B., Trapp, R.G., Dawson, B. and Trapp, R. Basic and clinical biostatistics. McGraw-Hill, New York.
13. Bliss, C.I.K. Statistics in biology. McGraw-Hill, New York.
14. Campbell R.C. Statistics for biologists. Cambridge University Press, Cambridge.
15. Wardlaw, A.C. Practical statistics for experimental biologists. John Wiley and Sons, New York.
16. Claverie J.M. and Notredame, C. Bioinformatics for dummies. Wiley, New York.
17. Mount, D.W. Bioinformatics: Sequence and genome analysis. Cold Spring Harbor Laboratory Press, New York.
18. Higginns, D. and Taylor, W. Bioinformatics: Sequence, structure and databanks – A practical approach. Oxford University Press, Oxford.
19. Baxevanis A.D and Ouellette, B.F.F. Bioinformatics – A practical guide to the analysis of genes and proteins. Wiley – Interscience, New York.
20. Gibson, G. and Muse, S.V. A primer of genome science. Sinauer Associates, Sunderlands.
21. Attwood, T.K. and Smith, D.J.P. Introduction to bioinformatics. Pearson Education Asia, Singapore.

IV SEMESTER

SLS/MIC/C018: LAB COURSE-I
(Based on Theory Papers SLS/MIC/C016 and SLS/MIC/C017)

1. Isolation of antibiotic producing microbes from soil sample.
2. Isolation and identification of symbiotic bacteroids of *Rhizobium* sp. from root nodules of leguminous plants.
3. Study of microbial community succession in decomposing litter.
4. Isolation of xenobiotic compound degrading bacteria by enrichment culture technique.
5. Determination of indices of pollution by measuring BOD and COD of different effluents.
6. Literature survey on selected problem and its proper citation.
7. Defining aim and objectives of the problem.
8. Writing a review article for a journal.
9. Statistical and graphical representation of data.
10. Calculation of mean, median and mode.
11. Linear equation analysis (Regression analysis).
12. Exponential equation analysis (Survival curve).
13. Chi square test.
14. Normal distribution.
15. Data mining using NCBI, SWISSPROT, EBI, PDB and MBGD.
16. Database search- Working on various BLAST programs.
17. Pairwise sequence alignment and multiple sequence alignment.
18. Phylogenetic analysis.

Reference Books

1. Pepper, I.L., Gerba, C.P. and Brendecke, J.W. Environmental microbiology: A laboratory manual. Academic Press, San Diego.
2. Hurst, C.J., Crawford, R.L., Garland, J.L., Lipson, D.A., Mills, A.L. and Stetzenbach, L.D. Manual of environmental microbiology. ASM Press, Washington, D.C.
3. Singer, S. Experiments in applied microbiology. Academic Press, New York.
4. Cappucino, J. and Sherman, N. Microbiology: A laboratory manual. Benjamin Cummings Publishing Company, San Francisco.
5. Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. McGraw-Hill, New York.
6. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.
7. Atlas, R.M., Brown, A.E. and Parks, L.C. Laboratory manual of experimental microbiology. Mosby College Publishing Company, St. Louis.
8. Kannan, K. Laboratory manual in general microbiology. Panima, New Delhi.
9. Dawson, C. Practical research methods: A user-friendly guide to mastering research techniques and projects. How to Books Limited, London.
10. Wardlaw, A.C. Practical statistics for experimental biologists. John Wiley and Sons, New York.
11. Mount, D.W. Bioinformatics: Sequence and genome analysis. Cold Spring Harbor Laboratory Press, New York.
12. Baxevanis A.D and Ouellette, B.F.F. Bioinformatics – A practical guide to the analysis of genes and proteins. Wiley – Interscience, New York.

IV SEMESTER

SLS/MIC/E004: DISSERTATION

Topics for Dissertation

1. Drug Discovery
2. Drug Resistance
3. Infection and Immunity
4. Plant- Microbes Interaction
5. Microbial Diversity
6. Bioremediation
7. Prevalence and Characterization of Pathogenic Microorganisms
8. Food Adulteration and Food borne Pathogens
9. Fermented Foods
10. Strain Improvement
11. Enzyme Production
12. Microbial Biotechnology
13. Biomass and Bioenergy Production

Any other topic suggested by departmental committee may also be considered for the dissertation/project work.