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
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.
## M.Sc. I Semester (July- November)

<table>
<thead>
<tr>
<th>Code</th>
<th>Paper</th>
<th>Credits</th>
<th>MM</th>
</tr>
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<tbody>
<tr>
<td>SLS/MIC/C001</td>
<td>General Microbiology</td>
<td>3 0 0 3</td>
<td>100</td>
</tr>
<tr>
<td>SLS/MIC/C002</td>
<td>Fundamentals of Biochemistry</td>
<td>3 0 0 3</td>
<td>100</td>
</tr>
<tr>
<td>SLS/MIC/C003</td>
<td>Cell Biology</td>
<td>3 0 0 3</td>
<td>100</td>
</tr>
<tr>
<td>SLS/MIC/C004</td>
<td>Molecular Biology and Microbial Genetics</td>
<td>3 0 0 3</td>
<td>100</td>
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<tr>
<td>SLS/MIC/C005</td>
<td>Laboratory Course-I</td>
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<tr>
<td>SLS/MIC/C006</td>
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Core Credits= 18

## M.Sc. II Semester (December-April)

<table>
<thead>
<tr>
<th>Code</th>
<th>Paper</th>
<th>Credits</th>
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<tbody>
<tr>
<td>SLS/MIC/C007</td>
<td>Microbial Physiology and Metabolism</td>
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<tr>
<td>SLS/MIC/C008</td>
<td>Immunology</td>
<td>3 0 0 3</td>
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<tr>
<td>SLS/MIC/C009</td>
<td>Biological Techniques</td>
<td>3 0 0 3</td>
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<tr>
<td>SLS/MIC/C010</td>
<td>Recombinant DNA Technology</td>
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<tr>
<td>SLS/MIC/C011</td>
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<td>SLS/MIC/C012</td>
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<td><strong>Total</strong></td>
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Core Credits= 18 with additional 03 Credits of Self Study*

## M.Sc. III Semester (July- November)

<table>
<thead>
<tr>
<th>Code</th>
<th>Paper</th>
<th>Credits</th>
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<tbody>
<tr>
<td>SLS/MIC/C013</td>
<td>Medical Microbiology</td>
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<tr>
<td>SLS/MIC/C014</td>
<td>Industrial Microbiology</td>
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<td>SLS/MIC/C015</td>
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<tr>
<td>SLS/MIC/E01A</td>
<td>Food and Dairy Microbiology</td>
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<tr>
<td>SLS/MIC/E01B</td>
<td>Drug Designing and Nanobiotechnology</td>
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<tr>
<td>SLS/MIC/E01C</td>
<td>Genomics and Proteomics</td>
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<td>SLS/MIC/E01D</td>
<td>Epidemiology</td>
<td>3 0 0 3</td>
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<td>SLS/MIC/E01E</td>
<td>Bioprocess Technology</td>
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<tr>
<td>SLS/MIC/E02A</td>
<td>Agricultural Microbiology</td>
<td>3 0 0 3</td>
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<tr>
<td>SLS/MIC/E02B</td>
<td>Microbial Diversity</td>
<td>3 0 0 3</td>
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<td>SLS/MIC/E02C</td>
<td>Pharmaceutical Microbiology</td>
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<td>SLS/MIC/E02D</td>
<td>Infection and Immunity</td>
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Total Credits = 18 (Core Credits 09+ Elective Credits 09) with additional 03 Credits of Self Study*
# M.Sc. IV Semester

<table>
<thead>
<tr>
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<td>SLS/MIC/C017</td>
<td>Research Methodology</td>
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<td>SLS/MIC/C018</td>
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<td>100</td>
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<tr>
<td>SLS/MIC/E004</td>
<td>Dissertation</td>
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<tr>
<td><strong>Total</strong></td>
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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:

<table>
<thead>
<tr>
<th>Periodical Presentation</th>
<th>: 20 Marks</th>
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<tbody>
<tr>
<td>Dissertation</td>
<td>: 60 Marks</td>
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<tr>
<td>Viva Voce</td>
<td>: 20 Marks</td>
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<td>Total</td>
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</table>

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
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.
I SEMESTER
SLS/MIC/C002: FUNDAMENTALS OF BIOCHEMISTRY

Unit I: Acid-base Chemistry and Bioenergetics

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
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
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, tRNA (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**

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.
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.
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.
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.
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.

Reference Books

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.
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.
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.
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
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

Reference Books
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; Adjuvants; 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: Immunelectrophoresis, RIA, ELISA, Chemiluminescence immunooassay, 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
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

Reference Books
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

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 footprinting, 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
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$_2$S.
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*.
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.
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**
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.
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
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, 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, Ancylostomiasis, 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, Cryptococcus, Coccidiomycosis, Candidiasis, Pneumocystis, Blastomycosis, Histoplasmosis, Sporotrichosis, Aspergillosis, Mycotic keratitis, Otomycosis, Mycetoma.

Reference Books
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 griseofulvin), 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.
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.
15. Estimation of vicinal diketone in beer.
16. Improvement of strain for increased yield by U.V. mutagenesis.

Reference Books
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
III SEMESTER
SLS/MIC/E01B: DRUG DESIGNING AND NANOBIO TECHNOLOGY

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 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
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
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
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 CO2, 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
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, bAzotobacter, Rhizobium, Cyanobacteria, AM fungi, Phosphate solubilizer; Storage, shelf life, quality control and marketing of biofertilizers.

Reference Books
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, Chrysogogenetes, 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
**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**
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 immunodeficiencies; 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 (Candidosis and aspergillosis) and parasitic diseases (Malaria, leishmaniasis, schistosomiasis and filarisas).

Reference Books
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.

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
Lab exercises based on theory paper SLS/MIC/E01A
1. Microbiological examination of food.
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.
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.

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.
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 exercises 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.
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, salt pans 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**

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. 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.
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**
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.