Approved by BoS (12 August, 2026)

COURSE CONTENTS & SYLLABUS

(Effective from the Academic Year 2026-2027)

PG (Two years) - MICROBIOLOGY

National Education Policy (NEP) - 2020

DEPARTMENT OF BOTANY AND MICROBIOLOGY
HEMVATI NANDAN BAHUGUNA GARHWAL UNIVERSITY
(A CENTRAL UNIVERSITY)
Srinagar, Garhwal – 246174, Uttarakhand, INDIA

DEPARTMENT OF MICROBIOLOGY

Hemvati Nandan Bahuguna Garhwal
University (A Central University)
Srinagar, Garhwal – 246174, Uttarakhand, INDIA

P.G (2 years). - Microbiology				
Sem.	**Codes**	**Credits**		**Paper name**
		T	P	
I	DSC-1	3	2	Introduction to Microbial World
	DSC-2	3	2	Fundamentals of Microbial Biochemistry
	DSC-3	3	2	Microbial Cell Biology
	SEC-I/Vocational	3	2	Bioinformatics in Microbiology
	DSE-I	3	1	(**Any one of the following)** **E 1.1.** Microbial Molecular Biology **E 1.2.** Virology and Mycology
	AEC (Non-CGPA Course)	1	-	AEC-Indian Knowledge System
	Total credits	**15+9=24**		
II	DSC-4	3	2	Analytical techniques in Microbiology
	DSC-5	3	2	Microbial Physiology and Metabolism
	DSC-6	3	2	Recombinant DNA Technology
	SEC -II/Vocational	3	2	Epidemiology
	DSE-II	3	1	(**Any one of the following)** **E 2.1.** Immunology **E 2.2.** Drug Designing and Nanobiotechnology
	VAC (Non-CGPA Course)	1	-	VAC-Constitutional, Ethical, and Moral Values
	Total credits	**15+9=24**		

Note:

1. AEC-Indian Knowledge System (IKS)

   IKS- Department will adopt the IKS course prescribed by the University

2. VAC (Non-CGPA Course)

   The department will adopt the "Constitution, Ethical and Moral Values" course prescribed by the University

P.G (2 years). - Microbiology				
Sem.	**Codes**	**Credits**		**Paper name**
		T	P	
III	DSC-7	3	2	Medical Microbiology
	DSC-8	3	2	Industrial Microbiology
	DSC-9	3	2	Genomics and Proteomics
	DSC-10	3	2	Food Microbiology
	DSE-III	3	1	(**Any one of the following**) **E 3.1.** Bioprocess Technology **E 3.2.** Environmental Microbiology
	SEC (Non-CGPA Course)	1	-	SEC- Academic Library Systems and Services or Entrepreneurship & Startup Awareness
	Total credits	**15+9=24**		
IV	DSC-11	3	2	Pharmaceutical Microbiology
	DSC-12	3	2	Agriculture Microbiology
	DSC-13	- 10 -		**Option-II major** Dissertation/project work (in lieu of two DSC)
	DSC-14			
	DSE-IV	3	1	(**Any one of the following**) **E 4.1.** Research Methodology **E 4.2.** Intellectual Property Rights
	SEC (Non-CGPA Course)	1	-	SEC- Community outreach activities
	Total credits	**9+5+10 =24**		
	NHEQF Level-6.5	Student on successfully completing two-year PG programme (i.e., securing minimum required 96 credits will be awarded "Postgraduate Degree", in related field/discipline/subject.		

Note: **SEC**

1. The University shall provide a common syllabus for the course titled "**Academic Library Systems and Services**"
2. **Entrepreneurship & Startup Awareness** - Departments will adopt the 'Entrepreneurship & Startup Awareness' course prescribed by the University. Departments shall offer this course to familiarize students with entrepreneurial mindset, startup ecosystem, innovation, and self-employment opportunities. The course may include basic business planning, case studies, interaction with entrepreneurs, and awareness of government startup schemes, with assessment based on participation and practical exercises. The course aims to promote creativity, leadership, and employment generation in alignment with NEP 2020.

3. **SEC- Community outreach activities-** Departments will offer a community outreach–based non-CGPA course focusing on societal engagement, local needs, and institutional social responsibility. The course may include activities such as field visits, awareness programmes, surveys, or collaboration with local bodies/NGOs, with evaluation based on participation, field reports, and reflective learning. This course aims to inculcate social sensitivity, ethical values, and experiential learning in alignment with NEP 2020.

PG -Microbiology (I – Semester)

I SEMESTER/SLS/MIC/DSC 1- INTRODUCTION TO MICROBIAL WORLD (THEORY)

Hours: 45 **Credits: 3**

Unit I: History and Classification (10 hours)

History and development of microorganisms; Conflicts over spontaneous generation; Golden era of microbiology; Concepts of prokaryotes and eukaryotes; Classification of microorganisms: Haeckel's three kingdom concept, Whittaker's five kingdom concept, Eight kingdom classification, Techniques used in microbial classification (Morphological, chemotaxonomic and genetic methods); Future of microbiology.

Unit II: Microscopy (10 hours)

Principle of bright field microscopy, dark field microscopy, fluorescence and electron (transmission and scanning) microscopy and their applications in microbiology, Staining of microorganisms, simple staining, negative staining, Gram staining and endospore staining.

Unit III: Basics of Microbiology (10 hours)

Microbial nutrition; Culture media; Culture techniques for isolation of pure culture; Cultivation of aerobic and anaerobic bacteria; Preservation methods; Microbial growth; Generation time, Diauxic growth curve; Effect of environmental conditions (pH, temperature, aeration, etc.) on microbial growth.

Unit IV: General Bacteriology and Virology (15 hours)

Ultrastructure of bacterial cell: Morphology of bacteria, Structure and properties of cell wall and cell membrane, Capsule (Types, composition and function), Ultrastructure and functions of flagella, pili, ribosomes and nucleoid; Characteristic feature of viruses, viroids, virusoids prions and Satellite viruses; Morphology and ultrastructure: Capsids and their arrangements, Types and composition of envelopes, Viral genome (Types and structures); Multiplication of viruses; Bacteriophage: Structural organization, Replication, Application of bacteriophages.

I SEMESTER/SLS/MIC/DSC 1- INTRODUCTION TO MICROBIAL WORLD (PRACTICAL)

Hours: 60 **Credits: 2**

1. Safety rules of working in the microbiology lab, disposal of cultures, calibration, validation and maintenance of instruments.
2. Principles and working of instruments used in the microbiology lab.
3. Media preparation and its sterilization.
4. Isolation and enumeration of bacteria and fungi from the given sample.
5. Isolation and maintenance of pure culture of bacteria and fungi.
6. Staining of bacterial cells (Simple staining, Gram staining and Negative staining).
7. Measurement of bacterial cell size using a micrometre.
8. Staining of endospore and capsule.
9. Staining of fungal cell.
10. Isolation and enumeration of bacteriophage from sewage water.

Suggested Readings (Theory and Practical)

1. Willey, J., Sandman, K., and Wood, D., (2023) Prescott's Microbiology (12th Edition), McGraw-Hill, New York.
2. Madigan, M.T., Bender, K.S., Buckley, D.S., Sattley, W.M., Stahl, D.A. (2020) Brock Biology of Microorganisms, (16th Edition), Pearson Publisher, USA
3. Pommerville, J.C. Alcamo's fundamentals of microbiology. Jones and Bartlett Learning, Sudbury.
4. Stanier, R.Y., Ingraham, J.L., Wheelis, M.L. and Painter, P.R. General microbiology. MacMillan Press, London.
5. Sclegel, H.G. General Microbiology. Cambridge University Press, Cambridge.
6. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R. Microbiology. McGraw-Hill, New York.
7. Dubey, R.C. and Maheshwari, D K, A Textbook of Microbiology, S Chand, New Delhi
8. Hawkes, P.W., Spence, J.C.H. (2019) Springer Handbook of Microscopy, Springer Nature Switzerland
9. Dimmoc, N.J., Easton, A.J. and Leppard, K.N. Introduction to Modern Virology. Wiley-Blackwell, New Jersey.
10. Cappuccino J., and Welsh C., Microbiology: A Laboratory Manual, 11th Edition, Pearson, USA
11. Dubey, R.C. and Maheshwari, D K, Practical Microbiology, S Chand, New Delhi
12. Read review articles and research papers related to this syllabus published recently in reputed journals.

I SEMESTER/SLS/MIC/DSC 2 - FUNDAMENTALS OF MICROBIAL BIOCHEMISTRY (THEORY)

Hours: 45 **Credits: 3**

Unit I – Carbohydrates Metabolism (15 Hours)

Glycolysis and its regulation. TCA cycle and amphibolic role. Glyoxylate shunt and its significance in microbes. Pentose phosphate pathway: oxidative and non-oxidative phases. Anaplerotic reactions and gluconeogenesis. Fermentation pathways: lactic acid, ethanol, mixed acid, butanediol, propionic acid.

Unit II –Lipid Metabolism (15 Hours)

Biosynthesis of fatty acids, triacylglycerols, phospholipids, cholesterol, steroids, isoprenoids. Regulation of cholesterol biosynthesis (HMG-CoA reductase). B-oxidation, α-oxidation, ω-oxidation of fatty acids. Ketogenesis and ketolysis. Integration of lipid metabolism with carbohydrate metabolism.

Unit III –Amino Acids & Nucleotides (15 Hours)

Biosynthesis of Amino acids and its regulation. Deamination and transamination reactions. Biosynthesis of purines and pyrimidines (de novo and salvage pathways). Regulation of nucleotide biosynthesis. Degradation pathways of purines (uric acid) and pyrimidines. Role of nucleotides in cellular energy and signaling (ATP, GTP, cAMP, cGMP).

I SEMESTER/SLS/MIC/DSC 2 - FUNDAMENTALS OF MICROBIAL BIOCHEMISTRY (PRACTICAL)

Hours: 60 **Credits: 2**

1. Quantitative Estimation of Proteins using Lowry's method and Bradford assay
2. Quantitative Estimation of Reducing Sugars using the DNS method.
3. Quantitative Estimation of Nucleic Acids using spectrophotometry.
4. Quantitative Estimation of Lipid using the Anthrone method.

Suggested Readings (Theory and Practical)

1. Nelson, D. L., Cox, M. M., & Hoskins, A. (2021). Lehninger Principles of Biochemistry. Macmillan. (8th edition)
2. Rodwell, V., Bender, D., Botham, K. M., Weil, P. A., & Kennelly, P. J. (2022). Harper's Illustrated Biochemistry. 28. Citeseer, New York, United States. (32nd edition)
3. Voet, D., Voet, J G., Pratt, C W. (2018). Voets Principles of Biochemistry, 235. John Wiley. (5th edition)
4. Berg, J., Stryer, L. (2023). Biochemistry. 1120. Springer Verlag. (10th edition)
5. Jayaraman J (2011). Laboratory manual in Biochemistry. New age international publishers, New Delhi.
6. Sadasivam S, Manickam A, (2008). Biochemical methods. New age international publishers, New Delhi.

I SEMESTER/SLS/MIC/DSC 3 – MICROBIAL CELL BIOLOGY (THEORY)

Hours: 45 **Credits: 3**

UNIT I: Cellular Architecture and Membrane Organization (08 hours)

Comparative cellular organization of Bacteria, Archaea and microbial Eukarya; Plasma membrane composition, structure and fluid mosaic model; membrane asymmetry and microdomains. Membrane transport: simple and facilitated diffusion, osmosis, primary and secondary active transport; ion channels, pumps and ABC transporters.

UNIT II: Cytoskeleton, Intracellular Organization and Cellular Dynamics (10 hours)

Prokaryotic cytoskeletal elements (FtsZ, MreB, crescentin/CreS, DivIVA, Par proteins and bactofilins) and their roles in cell shape, polarity, chromosome positioning and cell division. Eukaryotic cytoskeleton: actin filaments, microtubules and intermediate filaments. Structure and functions of major eukaryotic organelles. Cell polarity, cellular motility and molecular motors. Vesicular trafficking, endocytosis and exocytosis; basic roles of Rab and SNARE proteins.

UNIT III: Chromosome Organization, Cell Cycle and Cell Division (10 hours)

Organization of bacterial and archaeal chromosomes; nucleoid-associated proteins, chromosome condensation, partitioning and segregation. Plasmid inheritance and Par systems. Eukaryotic chromosome organization: chromatin, nucleosomes, centromeres and telomeres. Microbial cell cycle, chromosome replication and segregation; divisome assembly; FtsZ-ring/Z-ring formation and bacterial cytokinesis. Eukaryotic cell cycle, cyclins and CDKs, checkpoints, mitosis, meiosis and cytokinesis.

UNIT IV: Protein Targeting, Secretion and Cellular Communication (10 hours)

Signal peptides and protein targeting. Bacterial Sec and Tat pathways. Eukaryotic protein targeting through the endoplasmic reticulum and secretory pathway; ER-Golgi trafficking and protein sorting. Overview of bacterial secretion systems and extracellular vesicles. Microbial communication: quorum sensing, two-component systems, chemotaxis and contact-dependent signaling. Basic eukaryotic cellular signaling through cell-surface receptors, GPCRs, receptor tyrosine kinases and second messengers.

UNIT V: Cellular Stress, Survival and Cell Death (07 hours)

Cellular stress and adaptation in microorganisms, including oxidative, osmotic, thermal, envelope and protein stress. Stress-response systems, proteostasis and stringent response. Microbial survival strategies: dormancy, persistence, persister cells and viable-but-nonculturable states. Microbial programmed cell death, toxin–antitoxin systems and apoptosis-like cell death. Eukaryotic apoptosis, necrosis, autophagy (involved proteins and pathways).

I SEMESTER/SLS/MIC/DSC-3: MICROBIAL CELL BIOLOGY (PRACTICAL)

Hours: 60 **Credits: 2**

1. Study of bacterial cell morphology, cellular dimensions and organization using appropriate staining and microscopic techniques; determination of cell dimensions using ocular micrometry or calibrated digital imaging.
2. Demonstration of bacterial capsule/glycocalyx using appropriate capsule-staining techniques and microscopic interpretation of extracellular structures.
3. Study of bacterial membrane permeability and the effects of selected physical or chemical factors

using suitable indicator-based assays.

4. Study of bacterial growth kinetics and changes in cellular morphology during different phases of growth; correlation of growth phase with cellular organization and cell division.
5. Bioinformatics analysis of bacterial cytoskeletal proteins, including FtsZ, MreB and crescentin, using sequence databases, multiple-sequence alignment and conserved-domain analysis.
6. Comparative sequence and structural analysis of prokaryotic and eukaryotic cytoskeletal proteins, with emphasis on FtsZ/tubulin and MreB/actin relationships.
7. Analysis of bacterial chromosome-partitioning and cell-division proteins using sequence and protein-structure databases.
8. Prediction and analysis of bacterial protein-targeting signals and cellular localization with reference to Sec and Tat pathways; basic bioinformatics analysis of selected secretion-system proteins.
9. Study of bacterial quorum-sensing systems using a suitable biosensor/indicator system, where available, or through database-based analysis of quorum-sensing components.
10. Experimental study of bacterial stress responses by investigating the effects of selected environmental stresses on bacterial growth and survival.
11. Bioinformatics analysis of bacterial toxin–antitoxin systems and comparative analysis of selected molecular components involved in microbial programmed cell death and eukaryotic apoptosis/autophagy.
12. Analysis, interpretation and presentation of experimental and bioinformatics datasets related to microbial cellular organization, membrane function, growth, cytoskeleton, chromosome organization, protein targeting, stress response and cell division.

Suggested Readings (Theory and Practical)

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. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M. & Stahl, D. A. Brock Biology of Microorganisms. 16th ed. Pearson.
4. Cooper, G.M. and Hausman, R.E. Cell: Molecular approach. ASM Press, Washington, D.C.
5. de Robertis, E. D. P. and de Robertis, E.M.F. Cellular and molecular biology. Saunders, Philadelphia.
6. Snyder, L., Peters, J. E., Henkin, T. M. & Champness, W. Molecular Genetics of Bacteria. ASM Press.
7. Pollard, T.D., Earnshaw, W.C. and Schwartz, J.L. Cell biology. Saunders, Philadelphia.
8. Karp, G. Cell and molecular biology- Concepts and experiments. John Wiley and Sons, New York.
9. Slonczewski, J. L., Foster, J. W. & Zinser, E. R. Microbiology: An Evolving Science. 5th ed. W. W. Norton, 2020.
10. Key Review Articles & Recent Literature
11. Read review articles published in reputed and Indexed Scientific journals.
12. Recommended online resources

I SEMESTER/SLS/MIC/SEC-I/Vocational: BIOINFORMATICS IN MICROBIOLOGY (THEORY)

Hours: 45 **Credits: 03**

Unit I – Bioinformatics and Biological Data Resources (10 hours)

Scope and applications of bioinformatics in microbiology; types of biological data and major biological databases. Primary, secondary and integrated databases, with emphasis on NCBI, ENA/DDBJ, UniProt, PDB and KEGG. Microbial genome and metagenome resources; accession numbers and sequence identifiers; basic sequence formats and database searching. Retrieval, organization and interpretation of biological data.

Unit II – Sequence Analysis and Phylogenetics (13 hours)

Sequence similarity, identity, homology and orthology; pairwise alignment and global/local alignment. BLAST-based similarity searching. Multiple sequence alignment using Clustal Omega/MUSCLE; conserved regions and functional inference. Principles of phylogenetic analysis, including UPGMA, Neighbor-Joining and Maximum Likelihood; bootstrap analysis and tree interpretation. Applications in microbial identification, taxonomy, functional annotation and evolutionary studies.

Unit III – Microbial Genomics, Proteomics and Metagenomics (12 hours)

Introduction to next-generation sequencing; sequence reads, quality assessment and genome assembly. Genome and functional annotation; comparative genomics, orthologs and pangenome concepts. Introduction to transcriptomics and proteomics; protein sequence and structure analysis. Principles of metagenomics and microbiome analysis; amplicon and shotgun metagenomics; basic concepts of microbial diversity analysis and interpretation.

Unit IV – Biological Data Analysis, Visualization and Emerging Approaches (10 hours)

Basic statistics for biological data: descriptive statistics, correlation, regression and hypothesis testing. Data normalization and transformation. Biological data visualization using graphs, heatmaps and clustering. Protein sequence analysis: identification of conserved domains, motifs and functional sites; protein family and functional annotation. Introduction to structural bioinformatics: protein structure databases, structure prediction and visualization, and basic structure–function relationships. Basic concepts of biological networks, pathway analysis and machine learning applications in bioinformatics. Reproducible data analysis, interpretation of bioinformatics results, limitations and scientific reporting.

I SEMESTER/SLS/MIC/SEC-I/Vocational: BIOINFORMATICS IN MICROBIOLOGY (PRACTICAL)

Hours: 60 **Credits: 02**

1. Biological Databases and Sequence Retrieval

- Exploration of NCBI, ENA/DDBJ, UniProt, PDB and KEGG.
- Retrieval of microbial nucleotide and protein sequences using accession numbers and keywords.
- Downloading sequences in FASTA and GenBank formats.
- Retrieval and interpretation of basic sequence metadata.

2. Sequence Similarity and BLAST Analysis

- Nucleotide and protein sequence similarity searching using BLAST.
- Selection of appropriate BLAST programs.
- Interpretation of E-value, bit score, percentage identity and query coverage.
- Identification of homologous sequences and functional inference.

3. Multiple Sequence Alignment and Phylogenetic Analysis

- Multiple sequence alignment using Clustal Omega/MUSCLE.
- Identification of conserved and variable regions.
- Construction of phylogenetic trees using suitable software.

- Comparison of UPGMA, Neighbor-Joining and Maximum Likelihood approaches.
- Bootstrap analysis and interpretation of phylogenetic relationships.
- Application to microbial identification and taxonomy.

4. Microbial Genome Analysis and Annotation

- Retrieval and exploration of microbial genome sequences.
- Identification and interpretation of genomic features.
- Basic genome and functional annotation.
- Identification of selected antimicrobial-resistance and virulence-associated genes.
- Comparative analysis of selected microbial genomes.

5. Protein Sequence, Domain and Structural Analysis

- Analysis of microbial protein sequences using UniProt and other suitable resources.
- Identification of conserved domains, motifs and functional sites.
- Protein family and functional annotation.
- Exploration of protein structures using PDB and suitable structure-visualization/prediction resources.
- Basic interpretation of structure–function relationships.

6. Metagenomics and Microbiome Analysis

- Introduction to amplicon and shotgun metagenomic datasets.
- Basic analysis of representative metagenomic datasets using suitable online tools.
- Taxonomic classification and microbial community profiling.
- Basic concepts of alpha and beta diversity.
- Interpretation and visualization of microbial community data.

7. Statistical Analysis and Biological Data Visualization

- Organization and basic analysis of biological datasets.
- Descriptive statistics and graphical representation.
- Preparation of bar graphs, scatter plots and heatmaps.
- Correlation and simple regression analysis.
- Interpretation and presentation of results.

8. Integrated Bioinformatics Mini-Project

Analysis of a selected microbial gene/protein through an integrated workflow:
Sequence retrieval → BLAST → multiple sequence alignment → domain/motif analysis → phylogenetic analysis → biological interpretation

Suggested Readings (Theory and Practical)

1. Lesk, A.M. Introduction to Bioinformatics. Oxford University Press.
2. Raghava, G.P.S., & Raghava, S. (2010). Bioinformatics for Beginners. Alpha Science International.
2. Pevsner, J. Bioinformatics and Functional Genomics. Wiley-Blackwell.
3. Zvelebil, M. & Baum, J.O. Understanding Bioinformatics. Garland Science.
4. Mount, D.W. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
5. NCBI/BLAST official documentation and NCBI Handbook.
6. UniProt Knowledgebase and current analysis tools.
7. EMBL-EBI/ENA resources; PDB; KEGG.
8. QIIME 2 current amplicon/microbiome documentation.
9. Current official database/software documentation should supersede older interface-specific instructions.

DSE – I (Any one of the following in semester I)

I SEMESTER/SLS/MIC/DSE 1.1 - MICROBIAL MOLECULAR BIOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I: Microbial Genome (9 Hours)

Structure and chemical properties of DNA and RNA; Types of DNA (A-, B-, and Z-DNA) and DNA topology DNA denaturation and renaturation; Special DNA structures (G-quadruplexes); Telomeres and their biological importance

Unit II: Genome Replication (9 Hours)

DNA replication models and mechanisms in prokaryotes and eukaryotes. Replication initiation, elongation, and termination mechanisms.

Unit III: Transcription (9 Hours)

Types and functions of RNA (mRNA, tRNA, rRNA, and non-coding RNAs). Transcription initiation, elongation, and termination; Role of transcription factors and regulatory proteins; RNA processing: capping, polyadenylation, and splicing;

Unit IV: Translation and Gene Expression (9 Hours)

Genetic code; Protein synthesis (translation) in prokaryotes and eukaryotes; Structure and function of ribosomes; Post-translational modifications of proteins; Regulation of gene expression: lac, trp, and arabinose (ara) operons; Regulatory RNAs: miRNA, siRNA, piRNA, and lncRNA.

Unit V: Genome Recombination, Mobile Elements, and Mutation (9 Hours)

DNA recombination: homologous and non-homologous recombination; Major proteins involved in DNA repair and recombination; Transposons and retrotransposons; Types and causes of mutations; Chemical and physical mutagens and their effects on microbial genomes.

I SEMESTER/SLS/MIC/DSE 1.1 - MICROBIAL MOLECULAR BIOLOGY (PRACTICAL)

Hours: 30 **Credits: 1**

1. Determination of quality of DNA by spectrophotometric method.
2. Isolation of genomic DNA from bacterial culture.
3. Visualization of DNA by agarose gel electrophoresis.
4. Determination of Tm of given DNA sample.
5. Study of effect of temperature and pH on denaturation of DNA.
6. Study of effect of different concentrations of urea on denaturation of DNA.
7. Isolation of antibiotic-resistant bacteria by gradient plate method.

Suggested Readings (Theory and Practical)

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. Sambrook, J. and Russell, D.W. Molecular cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.
12. Murray, R.G.F., Wood, W.A. and Krieg, N.B. Methods for general and molecular bacteriology. ASM Press, Washington, D.C.
13. Chaitanya, K.V. Cell and molecular biology: A lab manual. PHI Learning, New Delhi.
14. Celis, J.E. Cell biology: A laboratory handbook. Elsevier, Amsterdam.

I SEMESTER/SLS/MIC/DSE 1.2. VIROLOGY AND MYCOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit 1: Fundamentals of Virology (10 Hours)

- Historical developments and milestones in virology.
- General properties of viruses: morphology, symmetry, genome types, and replication strategies.
- Virus–host interactions: adsorption, penetration, uncoating.

Unit 2: Viral Replication (10 Hours)

- Replication cycles of DNA and RNA viruses (representative examples: adenoviruses, herpesviruses, retroviruses, orthomyxoviruses, picornaviruses).
- Concepts of viral latency, persistence, and oncogenesis.

Unit 3: Medical & Applied Virology (10 Hours)

- Pathogenesis and epidemiology of major human viral diseases (e.g., influenza, hepatitis, HIV/AIDS, COVID-19, rabies, polio).
- Plant viruses: economic importance, examples, and control measures.

Unit 4: Fundamentals of Mycology (15 Hours)

- Introduction to fungi: general characteristics and classification.
- Structure and reproduction in fungi: hyphae, mycelium, spores (sexual and asexual).
- Growth and nutrition of fungi: environmental factors affecting growth, fungal metabolism.
- Mycotoxins: types, producers, and health impacts.

I SEMESTER/SLS/MIC/DSE 1.2. VIROLOGY AND MYCOLOGY (PRACTICAL)

Hours: 30 **Credits: 1**

Section A – Virology

1. Biosafety practices in a virology laboratory (BSL-2 & BSL-3 basics).
2. Bacteriophage assay – plaque assay using *E. coli* and T4 phage.

Section B – Mycology

1. Isolation of fungi from soil, air, and water samples by plating methods.
2. Microscopic examination of fungi – Lactophenol cotton blue mount.
3. Slide culture technique for studying fungal morphology.
4. Identification of common moulds (*Aspergillus*, *Penicillium*, *Rhizopus*).
5. Identification of yeasts (*Candida albicans*, *Saccharomyces cerevisiae*).

Suggested Readings (Theory and Practical)

1. Flint, S.J., Enquist, L.W., Racaniello, V.R., & Skalka, A.M. (2020). *Principles of Virology*. ASM Press.
2. Knipe, D.M., & Howley, P.M. (2013). *Fields Virology*. Lippincott Williams & Wilkins.
3. Carter, J., & Saunders, V. (2013). *Virology: Principles and Applications*. Wiley-Blackwell.
4. Deacon, J.W. (2013). *Fungal Biology*. Wiley-Blackwell.
5. Alexopoulos, C.J., Mims, C.W., & Blackwell, M. (2018). *Introductory Mycology*. Wiley.
6. Dhingra, O.D., & Sinclair, J.B. (2017). *Basic Plant Pathology Methods*. CRC Press.

PG -Microbiology (II – Semester)

II SEMESTER/SLS/MIC/DSC 4 - ANALYTICAL TECHNIQUES IN MICROBIOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I: Advanced Microscopy and Biosensors (9 hours)

Microscopy: *Light microscopy*: Phase contrast microscopy, Fluorescence microscopy, Total Internal Reflection Fluorescence (TIRF) microscopy, and confocal microscopy; Scanning and transmission electron microscopy; Atomic Force Microscopy (AFM). Biosensors: Introduction to Biosensors and their evolution; Cell-based biosensors; DNA-based biosensors.

Unit II: Centrifugation Technologies (9 hours)

Basic Principles: Centrifugal force, sedimentation rate, sedimentation coefficient. Types and Applications: Clinical, micro, high-speed, ultracentrifuges, industrial centrifuges; Fixed-angle, swinging bucket, zonal, and continuous flow rotors. Density gradient ultracentrifugation.

Unit III: Modern Chromatography Techniques (9 hours)

Basic Principles: Adsorption, partitioning, and separation efficiency. Techniques: Adsorption, ion-exchange, affinity, size exclusion, thin-layer, gas chromatography (GC), High-performance liquid chromatography (HPLC) and Ultra High-Performance Liquid Chromatography (UHPLC).

Unit IV: Electrophoretic Techniques (9 hours)

Core Concepts: Charge-based separation and gel systems. Types: Paper, moving boundary, isoelectric focusing, SDS-PAGE, native PAGE, reducing PAGE, Disc electrophoresis, Pulse Field Gel Electrophoresis (PFGE).

Unit V: Spectroscopy, Mass Spectrometry, and Radiotracer Technology (9 hours)

Core Techniques: UV-Vis, IR, Fluorescence spectroscopy. Principles and applications of NMR, Mass Spectrometry, Radiotracers and radioactivity detection: GM counter & scintillation counters.

II SEMESTER/SLS/MIC/DSC 4 - ANALYTICAL TECHNIQUES IN MICROBIOLOGY (PRACTICAL)

Hours: 60 **Credits: 2**

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. Separation and determination of molecular weight of proteins by SDS-PAGE.
6. Interpretation of UV spectra.
7. Interpretation of IR spectra.
8. Interpretation of NMR spectra.
9. Interpretation of Mass spectra

Suggested Readings (Theory and Practical)

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. Chatwal, G. and Anand, S. Instrumental methods of chemical analysis. Himalaya Publishing House, Mumbai.
4. Hamilton, R.J. and Sewell, P.A. Introduction to high performance liquid chromatography. Chapman and Hall Limited, London.
5. Sharma, V.K. Techniques in microscopy and cell biology. Tata McGraw-Hill, New Delhi.
6. Hames, B.D. Gel electrophoresis of proteins: A practical approach. Oxford University Press, Oxford.
7. Wilson, Keith, Andreas Hofmann, John M. Walker, and Samuel Clokie, eds. *Wilson and Walker's principles and techniques of biochemistry and molecular biology*. Cambridge university press, 2018.Keeler, J. Understanding NMR spectroscopy. John Wiley and Sons, New York.
8. Davies, A.M.C. and Creaser, C.S. Analytical applications of spectroscopy. Royal Society of Chemistry, California.
9. Wang, C.H. and Willis, D.L. Radiotracer methodology in biological science. Prentice Hall, New Jersey.
10. Sambrook, J. and Russell, D.W. Molecular cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.

II SEMESTER/SLS/MIC/DSC 5 - MICROBIAL PHYSIOLOGY AND METABOLISM (THEORY)

Hours: 45 **Credits: 3**

Unit I – Phototrophy and Chemotrophy (15 hours)

Cyclic and non-cyclic photophosphorylation, proton motive force generation, CO_2 fixation pathways. Chemolithotrophy: ecological role and energy yield, Sulphur, iron, hydrogen, and nitrogen oxidation pathways, Methylotrophy: C1 metabolism, methanotrophy, energetics, Methanogenesis in archaea: biochemistry, coenzymes (F_{420}, coenzyme M), and regulation.

Unit II – Nitrogen and Sulphur metabolism (15 Hours)

Genetics of nitrogen fixation: nif and fix gene clusters, regulation (NifA, NifL, and environmental control), Symbiotic nitrogen fixation: Rhizobium–legume interaction, nodule formation, leghaemoglobin function. Nitrate/nitrite assimilation and dissimilation, ammonium assimilation (GS-GOGAT pathway, GDH pathway), Regulation of nitrogen metabolism (ntr system, PII proteins). Assimilatory and dissimilatory sulphate reduction pathways, Biosynthesis of cysteine and methionine, Glutathione biosynthesis and function in oxidative stress and sulphur homeostasis.

Unit III: Respiration and Fermentation (15 Hours)

Anaerobic respiration: alternative electron acceptors (nitrate, fumarate, sulphate, CO_2, metals), ecological significance. Mechanism of oxygen toxicity and microbial defences (superoxide dismutase, catalase, peroxidases). Biochemistry of lactic acid, alcoholic, mixed acid, butanediol, propionic acid, butyric acid fermentations, Fermentation of amino acids (Stickland reactions), Industrial relevance of fermentative pathways.

II SEMESTER/SLS/MIC/DSC 5 - MICROBIAL PHYSIOLOGY AND METABOLISM (THEORY)

Hours: 60 **Credits: 2**

1. Gas production in fermentation (Durham tube method).
2. Determination of fermentation end-products by titration (e.g., lactic acid).
3. Detection of nitrate reduction.
4. H_2S production from sulfur-containing amino acids.

Suggested Readings (Theory and Practical)

1. Madigan, M.T., Bender K.S., Buckley D.H, Sattley W.M, Stahl D.A (2021) Brock biology of microorganisms. Pearson, London, United Kingdom.
2. Moat, A. G., Foster, J. W., & Spector, M. P. (Eds.). (2002). *Microbial physiology*. John Wiley & Sons.
3. Poole, R. K. (2019). *Advances in microbial physiology* (Vol. 74). Academic Press.
4. White, D., Drummond, J. T., Fuqua, C., White, D., & Drummond, J. T. (2007). *The physiology and biochemistry of prokaryotes* (Vol. 4). New York: Oxford University Press.
5. Bruggeman, F. J., Planqué, R., Molenaar, D., & Teusink, B. (2020). Searching for principles of microbial physiology. *FEMS microbiology reviews*, *44*(6), 821-844.
6. Aneja K. R. (2005). Experiments In Microbiology, Plant Pathology And Biotechnology. New Age International Publishers, New Delhi.

II SEMESTER/SLS/MIC/DSC 6 - RECOMBINANT DNA TECHNOLOGY (THEORY)

Hours: 45 **Credits: 03**

UNIT I: Principles and Tools of Gene Cloning (9 Hours)

DNA and RNA isolation and basic assessment of purity and integrity. DNA-modifying enzymes: Restriction endonucleases, DNA ligase, DNA polymerases, kinases and phosphatases. Cloning vectors: essential features and applications of plasmids, bacteriophage-derived vectors, cosmids, BACs, YACs and shuttle vectors. Specialized vectors for plant and animal systems. Overview of contemporary cloning approaches, including Gibson assembly, Golden Gate and Gateway cloning.

UNIT II: Gene Cloning Strategies, Libraries and Screening (9 Hours)

General workflow of recombinant DNA cloning: target selection, vector and insert preparation, DNA assembly, host transformation, selection, screening and validation. DNA fragment generation by restriction digestion and PCR. Bacterial transformation by chemical and electroporation methods; basic principles of eukaryotic transfection. Genomic and cDNA libraries: construction, screening and applications. Selection and screening of recombinant clones using antibiotic selection, reporter-based screening, colony PCR and restriction analysis.

UNIT III: Recombinant Gene Expression and Protein Production (9 Hours)

Expression-vector architecture: promoters, regulatory elements, terminators, selectable markers, reporter genes, signal peptides and affinity tags. Prokaryotic expression systems, with emphasis on inducible pET/T7-based systems. Overview of yeast, insect and mammalian expression systems. Selection of expression hosts according to protein folding, localization and post-translational modification requirements. Recombinant protein production, fusion proteins and affinity tags; codon optimization, inclusion bodies and protein solubility. Basic characterization and purification of recombinant proteins using SDS-PAGE and affinity-based methods.

UNIT IV: PCR, DNA Sequencing and Genome Editing (9 Hours)

PCR: principle, components, primer design, specificity, optimization and troubleshooting. Major PCR variants, including multiplex PCR, nested PCR, RT-PCR and qPCR; controls and interpretation of results. DNA sequencing: Sanger sequencing and overview of next-generation sequencing and long-read sequencing technologies. Site-directed mutagenesis and strategies for generating targeted mutations. CRISPR-Cas genome editing: guide RNA, Cas systems, gene knockout, knock-in and targeted modification; basic concepts of base and prime editing.

UNIT V: Functional Genomics and Applications (9 Hours)

Principles of functional genomics; gene-expression and regulatory analysis using reporter assays and DNA–protein interaction approaches. Gene knockdown and knockout using RNA interference and CRISPR/Cas systems. Gene targeting and validation in bacterial and eukaryotic systems. Applications of recombinant DNA technology in medicine, agriculture, environmental and industrial biotechnology, including recombinant proteins, vaccines, molecular diagnostics and metabolic engineering. Ethical, biosafety and regulatory considerations.

II SEMESTER/SLS/MIC/DSC 6 - RECOMBINANT DNA TECHNOLOGY (PRACTICAL)

Hours: 60 **Credits: 02**

1. **Isolation and Characterization of Nucleic Acids**
   Isolation of bacterial genomic and plasmid DNA; determination of concentration and purity; agarose-gel electrophoresis for assessment of DNA integrity.
2. **Restriction Digestion and DNA Fragment Analysis**
   Restriction digestion of plasmid DNA; agarose-gel electrophoresis; estimation of fragment sizes and interpretation of restriction patterns. Basic principles of restriction mapping.
3. **DNA Ligation and Recombinant DNA Construction**
   Design of insert–vector cloning strategy; preparation of compatible DNA fragments; DNA ligation; calculation of appropriate insert-to-vector ratios; prediction and interpretation of expected recombinant products.
4. **Bacterial Transformation and Selection**
   Preparation/use of competent *E. coli*; transformation with recombinant plasmid DNA; antibiotic selection; appropriate positive and negative controls; calculation and interpretation of transformation efficiency.
5. **Screening and Confirmation of Recombinant Clones**
   Screening of transformants using blue-white screening and/or colony PCR; restriction analysis of selected clones; confirmation of recombinant versus non-recombinant colonies; interpretation of cloning results.
6. **PCR and Primer Design**
   Design of primers for amplification of a selected target gene; PCR amplification; use of positive, negative and no-template controls; agarose-gel analysis; optimization and troubleshooting of PCR reactions.
7. **Recombinant Protein Expression and Analysis**
   Induction of recombinant protein expression in *E. coli*; comparison of induced and uninduced cultures; analysis of recombinant proteins by SDS-PAGE; assessment of expression and solubility.
8. **Gene Expression and Sequencing Data Analysis**
   Interpretation of RT-PCR/qPCR datasets, including controls, Ct values and relative expression. Interpretation of Sanger sequencing chromatograms and basic sequence-quality assessment. Confirmation of recombinant clones using sequence information.
9. **In-silico Analysis for Recombinant DNA Experiments**
   Retrieval of a target gene sequence; basic BLAST analysis; identification of ORFs and conserved domains; primer-design considerations; prediction of expected recombinant sequences.
10. **Integrated Recombinant DNA Project**
    Design of an end-to-end recombinant DNA experiment involving target-gene selection, vector choice, primer design, cloning strategy, transformation, screening, expression and validation. Preparation and presentation of a concise experimental workflow and expected results.

Suggested Readings (Theory and Practical)

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. Clark, D.P., & Pazdernik, N.J. (2021). *Molecular Biology: Understanding the Genetic Revolution* (4th ed.). Academic Press.
7. Old, R.W. and Primrose, S.B. Principles of gene manipulations. Blackwell Science, Oxford.
8. Winnacker, E.L. From genes to clones: Introduction to gene technology. Wiley-VCH, Germany.
9. Brown, T.A. Genomes. Wiley-Liss, Oxford.
10. Pevsner, J. Bioinformatics and functional genomics. Wiley-Blackwell, New Jersey.
11. Sambrook, J. and Russell, D.W. Molecular Cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.
12. Reece R.J. Analysis of genes and genomes. John Wiley and Sons, New York.
13. Recombinant DNA safety guidelines. Department of Biotechnology, Government of India, New Delhi.
14. Students are advised to read the recent and comprehensive reviews published in high quality, indexed scientific journals.

II SEMESTER/SLS/MIC/SEC-II/VOCATIONAL - EPIDEMIOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I – Introduction to Epidemiology (15 Hours)

- Definition, scope, and history of epidemiology.
- Basic concepts: incidence, prevalence, morbidity, mortality, case fatality rate.
- Types of epidemiological studies: descriptive, analytical, and experimental.
- Epidemiological triad (agent–host–environment).
- Emerging and re-emerging infectious diseases – global perspective.

Unit II – Disease Transmission & Dynamics (15 Hours)

- Modes of transmission: direct, indirect, airborne, vector-borne, zoonotic.
- Chain of infection and breaking the chain.
- Reservoirs of infection in humans, animals, and the environment.
- Dynamics of disease occurrence: endemic, epidemic, pandemic, sporadic.
- Mathematical models in epidemiology (basic reproduction number R_0, herd immunity concept).

Unit III – Outbreak Investigation & Control Measures (15 Hours)

- Steps of outbreak investigation.
- Case definition and contact tracing.
- Laboratory support in outbreak investigations (sample collection, transport, analysis).
- Vaccination programs and immunization schedules.
- Public health interventions: quarantine, isolation, chemoprophylaxis, sanitation.

II SEMESTER/SLS/MIC/SEC-II/VOCATIONAL - EPIDEMIOLOGY (PRACTICAL)

Hours: 30 **Credits: 2**

1. Epidemiological Data Analysis
   - Calculation of incidence, prevalence, morbidity, and mortality rates using sample datasets.
   - Epidemic curve plotting and interpretation.
2. Food Microbiology for Public Health
   - Isolation of foodborne pathogens (e.g., *E. coli*, *Salmonella*) from food samples.
   - Detection of contamination by standard microbiological methods.
3. Bioinformatics in Epidemiology
   - Using online databases for disease tracking (e.g., WHO, CDC).
   - Data visualization using spreadsheet tools.

Suggested Readings (Theory and Practical)

1. Nelson, K.E., & Williams, C.M. (2014). *Infectious Disease Epidemiology: Theory and Practice*. Jones & Bartlett Learning.
2. Ryan, K., & Ahmad, N. (2018). *Sherris Medical Microbiology*. McGraw-Hill.
3. Park, K. (2021). *Preventive and Social Medicine*. Banarsidas Bhanot Publishers.
4. Jawetz, E., Melnick, J.L., & Adelberg, E.A. (2022). *Medical Microbiology*. McGraw-Hill.
5. Alan J. Silman, Gary J. Macfarlane (2002). *Epidemiological Studies: A Practical Guide: A Practical Guide* . Cambridge University Press.

DSE – II (Any one of the following in semester-II)

II SEMESTER/SLS/MIC DSE 2.1 - IMMUNOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I: Immune System and Immunity (15 Hours)

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.

Unit II: Antigens and Antibodies (10 Hours)

Antigens: Structure and properties; Haptens; Adjuvants; Immunogenicity; Immunoglobulin: Structures, Heterogeneity, Types and subtypes, Properties (Physiochemical and biological), Antibody effector mechanism, Antibody receptors, Antibody diversity, Theories of antibody production, Effect of somatic mutations on the antibody diversity, Recombinant antibodies, Hybridoma technology.

Unit III: Complement system and Cytokines (10 Hours)

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.

Unit IV: Immunopathology and Transplantations (10 Hours)

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); Transplantation: Graft vs. host reaction and rejection.

II SEMESTER/SLS/MIC DSE 2.1 - IMMUNOLOGY (PRACTICAL)

Hours: 30 **Credits: 1**

1. Separation and preservation of serum and plasma.
2. Determination of blood group and Rh factor.
3. Quantitative estimation of antigen by radial immunodiffusion.
4. Determination of concentration of antigen by sandwich ELISA/Dot-ELISA method.

Suggested Readings (Theory and Practical)

1. Punt, P., Stranford, S., Jones, P., Owen, J.A. Kuby Immunology. W.H. Freeman and Company, New York.
2. Male, D.K. Immunology: An illustrated outline. Elsevier Health Sciences, Philadelphia.
3. Spec, A., Escota, G., Davies, B, O'Halloran, J., (2025), Comprehensive Review of Infectious Diseases, 2nd Edition. Elsevier
4. Abbas, A.K., Lichtman, A.H.H. and Pillai, S. Cellular and molecular immunology. Saunders, Philadelphia.
5. Delves, P.J., Martin, S.J., Burton, D.R. and Roitt, I.M. Roitt's essential immunology. Wiley-Blackwell, New Jersey.
6. Tizard, I.R. Immunology: An introduction. Saunders, Philadelphia.
7. Playfair, J.H.L. Immunology at a glance. Blackwell Scientific Publications, Oxford.
8. Abbas, A.K. and Lichtman, A.H.H. Basic immunology: Functions and disorders of the immune system. Saunders, Philadelphia.
9. Chapel, H., Haeney, M., Misbah, S. and Snowden, N. Essentials of clinical immunology. Wiley, New Jersey.
10. Coico, R. and Sunshine, G. Immunology: A short course. Wiley- Blackwell, New Jersey.
11. Gerald B. Pier, Jeffrey B. Lyczak, Lee M. Wetzler, Immunology, Infection, and Immunity, ASM Press
12. Frank C. Hay, Olwyn M. R. Westwood, Practical Immunology, Wiley-Blackwell
13. Miller, L. E., Christine, D. S. (2021) Clinical Immunology and Serology: A Laboratory, F A Davis Co
14. Read review articles and research papers related to this syllabus published recently in reputed journals.

II SEMESTER/SLS/MIC DSE 2.1 DRUG DESIGNING AND NANOBIOTECHNOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I: Drug Receptor Interactions (15 Hours)

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 (15 Hours)

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: Nanobiotechnology (15 Hours)

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.

II SEMESTER/SLS/MIC DSE 2.1 DRUG DESIGNING AND NANOBIOTECHNOLOGY (PRACTICAL)

Hours: 30 **Credits: 1**

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.

Suggested Readings (Theory and Practical)

1. Chorghade, M.S. Drug discovery and development. John Wiley and Sons, New York.
2. Dewick, P.M. Medicinal natural products: A biosynthetic approach. John Wiley and Sons, New York.
3. Graly, J.O. and Joubert, P.H. Handbook of phase I / II clinical drug trials. CRC Press, Boca Raton.
4. Silverman, R. Organic chemistry of drug design and drug action. Elsevier, London.
5. Gorden, E.M. and Kerwin, J.F. Combinatorial chemistry and molecular diversity in drug discovery. Wiley-Liss, Oxford.
6. Pirrung, M.C. Molecular diversity and combinatorial chemistry: Principles and applications. Elsevier, London.
7. Larsen, P.K. and Stromgaard, K. Textbook of drug design and discovery. CRC Press, Boca Raton.
8. Patrick, G.L. An introduction to medicinal chemistry. Oxford University Press, Oxford.
9. Gregoriadis, G. Drug carriers in biology and medicine. Academic Press, New York.
10. Niemeyer, C.M. and Mirkin, A. Nanobiotechnology: Concepts, applications and perspectives. Wiley, New York.
11. Donald, M. Nanobiotechnology of biomimetic membranes. Springer Verlag, New York.
12. deVilliers, M.M., Aramwit, P. and Kwon, G.S. Nanotechnology in drug delivery. Springer-Science, New York.
13. Kulkarni, S.S. Nanotechnology: Principles and practices. Capital Publishing Company, New Delhi.
14. Goosell, D.S. Bionanotechnology: Lessons from nature. John Wiley and Sons, New York.
15. Read review articles and research papers related to this syllabus published recently in reputed journals.

III SEMESTER

III SEMESTER/SLS/MIC DSC-7: MEDICAL MICROBIOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I: Pathogenesis and Antimicrobial Chemotherapy (15 Hours)

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; Emergence of drug resistance in bacteria (MRSA, ESBL and MDR TB); Resistance mechanism; Various types of vaccines for prevention of infectious diseases.

Unit II: Bacterial and Viral Diseases (15 Hours)

Clinical features, transmission, characteristics of causative organism, pathogenesis, laboratory diagnosis, prevention and control of bacterial diseases and clinical syndromes: Cholera, Leprosy, Meningitis; Clinical features, transmission, characteristics of causative organism, pathogenesis, laboratory diagnosis, prevention and control of viral diseases: Hepatitis, HIV, Viral cancer.

Unit III: Protozoal and Fungal Diseases (15 Hours)

Clinical features, transmission, pathogenesis, laboratory diagnosis, prevention and control of protozoal diseases: Amoebiasis, Giardiasis, Leishmaniasis, Malaria; Clinical features, transmission, pathogenesis, laboratory diagnosis, prevention and control of fungal diseases: Aspergillosis, Cryptococcosis, Candidiasis, Blastomycosis.

III SEMESTER SLS/MIC/DSC-7: MEDICAL MICROBIOLOGY (PRACTICAL)

Hours: 60 **Credits: 2**

1. Biosafety guidelines and biosafety levels.
2. Collection, transportation and processing of clinical samples.
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.

Suggested Readings (Theory and Practical)

1. Murray, P. R., Rosenthal, K. S., & Pfaller, M. A. (2015). *Medical microbiology e-book: Medical microbiology e-book*. Elsevier Health Sciences.
2. Mahon, C. R., & Lehman, D. C. (2022). *Textbook of diagnostic microbiology-E-Book: Textbook of diagnostic microbiology-E-Book*. Elsevier Health Sciences.
3. Ananthanarayan, R. (2006). *Ananthanarayan and Paniker's textbook of microbiology*. Orient Blackswan.
4. Goering, R., Dockrell, H., Zuckerman, M., Roitt, I., & Chiodini, P. L. (2012). *Mims' medical microbiology*. Elsevier Health Sciences.
5. McCartney, J. E., Collee, J. G., & Mackie, T. J. (1989). *Practical medical microbiology*. Charchil Livingstone.

III SEMESTER/SLS/MIC DSC-8: INDUSTRIAL MICROBIOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I: Introduction to Industrial Microbiology (9 Hours)

Primary and secondary metabolites; Structure of fermentor/bioreactor; Types of fermentor/bioreactors; Scale up and scale down processes; Types of fermentation (Solid state, surface and submerged fermentation).

Unit II: Basic Aspects of Fermentation (9 Hours)

Media formulation; Sterilization; Inoculum development; Effect of temperature, pH and high nutrient concentration on fermentation; Operational modes of fermentation (Batch, fed- batch and continuous); Downstream processing.

Unit III: Microbial Strain Improvement (9 Hours)

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);

Unit IV: Industrial Production Aspects I (9 Hours)

Production of antibiotics (penicillin, D-cycloserine, streptomycin, tetracycline, bacitracin and grieseofulvin), amino acid (glutamic acid and lysine), biopolymers (dextran, alginate, xanthan and pullulan).

Unit V: Industrial Production Aspects II (9 Hours)

Production of enzymes (pectinase, amylase, lipase, protease, cellulase and xylanase), alcohol and alcoholic beverages, vitamins (B12 and riboflavin), and bioplastics (PHB and PHA).

III SEMESTER/SLS/MIC DSC-8: INDUSTRIAL MICROBIOLOGY (PRACTICAL)

Hours: 60 **Credits: 2**

1. Isolation and screening of bacterial and fungal cultures for enzyme production.
2. Estimation of enzyme production by microbial culture *via* liquid state fermentation.
3. Estimation of enzyme production by microbial culture *via* solid state fermentation.
4. Media formulation for enhanced enzyme production by microbial culture *via* liquid and solid state fermentation.
5. Production of wine from fruit juice.

Suggested Readings (Theory and Practical)

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/DSC-9: GENOMICS AND PROTEOMICS (THEORY)

Hours: 45 **Credits: 03**

UNIT I: Genome Organization, Mapping and Epigenomics (9 Hours)

Organization of prokaryotic and eukaryotic genomes; genome size and complexity, coding and non-coding DNA, repetitive sequences, transposable elements and organellar genomes. Gene organization, operons, gene families and regulatory regions. Structural, comparative and functional genomics and their applications in microbiology. Genetic mapping, linkage and recombination; bacterial genetic mapping. Molecular markers, including RFLP, VNTR, microsatellites and SNPs, and their applications. Physical mapping: restriction mapping, FISH and contig organization. Introduction to epigenomics: DNA methylation, histone modifications and chromatin remodeling.

UNIT II: Genome Sequencing, Assembly and Comparative Genomics (10 Hours)

Principles and strategies of whole-genome sequencing; Sanger and next-generation sequencing (NGS). Basic NGS workflow, read generation and quality assessment. Overview of long-read sequencing, including single-molecule and nanopore technologies. Genome assembly: quality control, de novo and reference-guided assembly, contigs and scaffolds. Genome annotation: coding sequences, non-coding RNAs and functional elements. Comparative genomics: orthologs, paralogs, synteny, conserved regions and pangenomes. Genome variation, including SNPs, indels and structural variation. Major genome projects and their significance.

UNIT III: Transcriptomics and Functional Genomics (9 Hours)

Principles of transcriptome organization and global gene-expression analysis. Conventional gene-expression approaches and reporter assays. Microarray technology: principles, experimental design and interpretation. RNA sequencing (RNA-seq): basic workflow, read mapping, transcript quantification and differential gene-expression analysis. Introduction to single-cell transcriptomics. Functional genomics approaches, including gene knockdown/knockout, RNA interference, CRISPR-based perturbation and transposon mutagenesis. Loss- and gain-of-function approaches for determining gene function.

UNIT IV: Proteomics and Protein Identification (9 Hours)

Scope and applications of structural, functional, comparative and quantitative proteomics. Protein extraction, separation and analysis; SDS-PAGE and two-dimensional gel electrophoresis. Principles of peptide mass fingerprinting and MS/MS-based protein identification. Bottom-up proteomics and database-assisted protein identification. Basic concepts of quantitative proteomics, including label-free and isotope-based approaches. Protein post-translational modifications and their identification. Applications of proteomics in microbial pathogenesis, diagnostics, biomarker discovery and biotechnology.

UNIT V: Protein Interactions and Integrative Omics (8 Hours)

Principles of protein–protein interaction analysis; yeast two-hybrid, co-immunoprecipitation and affinity-based approaches. Protein interaction networks and their biological interpretation. Introduction to ChIP and ChIP-seq for studying DNA–protein interactions and gene regulation. Proteogenomics and integration of genome, transcriptome and proteome data. Multi-omics approaches and pathway- and network-level interpretation. Major omics databases, including NCBI, UniProt, GEO/SRA and PRIDE, and retrieval of genomic, transcriptomic and proteomic data. Applications of integrated omics in antimicrobial resistance, microbial biotechnology and systems biology. Emerging concepts in single-cell and spatial omics.

III SEMESTER SLS/MIC/DSC 9: GENOMICS AND PROTEOMICS (PRACTICAL)

Hours: 60 **Credits: 2**

1. **Genomic DNA Isolation and Quality Assessment**
   Isolation of bacterial genomic DNA; determination of DNA concentration and purity; agarose-gel electrophoresis and assessment of DNA integrity.
2. **Restriction Analysis and Molecular Marker Data**
   Restriction digestion and agarose-gel analysis; fragment-size estimation and interpretation of restriction patterns. Analysis and interpretation of RFLP, SSR or SNP datasets for studying genetic variation.
3. **Genome Database Exploration**
   Retrieval of complete or draft microbial genomes from NCBI; analysis of genome size, GC content, coding sequences and basic genome annotation.
4. **Genome Sequence Quality, Assembly and Annotation**
   Analysis of prepared sequencing-read datasets; assessment of basic sequence quality; interpretation of contigs, scaffolds and assembly statistics. Identification of genes/ORFs and interpretation of genome annotation.
5. **Comparative Genomics**
   Comparison of selected microbial genomes; identification of homologous genes/proteins; interpretation of orthologs, paralogs, conserved regions and genome organization. Basic analysis of genomic variation.
6. **Transcriptomics and Gene-Expression Analysis**
   Analysis of representative RNA-seq or microarray datasets; read-count/expression data interpretation, normalization, fold change and differential expression. Biological interpretation of differentially expressed genes and pathway-level patterns.
7. **Protein Separation and 2-D Gel Analysis**
   Protein extraction and separation; SDS-PAGE analysis; molecular-weight estimation and interpretation of differential protein expression. Demonstration/interpretation of 2-D PAGE data, including isoelectric point and molecular-weight-based separation.
8. **Mass-Spectrometry-Based Protein Identification**
   Interpretation of MALDI-TOF/ESI-MS and MS/MS datasets; peptide mass fingerprinting; database-assisted protein identification; interpretation of peptide/protein identification results.
9. **Protein Database, Domain and Interaction Analysis**
   Retrieval and analysis of protein information using UniProt and other appropriate resources; identification of domains, motifs and functional annotations. Interpretation of protein–protein interaction data and construction/interpretation of basic interaction networks.
10. **Integrated Genomics–Proteomics Mini-Project**
    Integration of genome, transcriptome and/or proteome datasets to investigate a selected microbial gene/protein or biological process. Preparation of a concise workflow, data interpretation and scientific report.

Suggested Readings (Theory and Practical)

1. Brown, T.A. Genomes. Wiley-Blackwell.
2. Pevsner, J. Bioinformatics and Functional Genomics. Wiley-Blackwell.
3. Reece, R.J. Analysis of Genes and Genomes. Wiley.
4. Gibson, G. and Muse, S.V. A Primer of Genome Science. Sinauer Associates/Oxford University Press.
5. Campbell, A.M. and Heyer, L.J. Discovering Genomics, Proteomics and Bioinformatics. Pearson.
6. Primrose, S.B. and Twyman, R. Principles of Gene Manipulation and Genomics. Wiley-Blackwell.
7. Alberts, B. et al. Molecular Biology of the Cell. Garland Science.

8. Liebler, D.C. Introduction to Proteomics: Tools for the New Biology. Humana Press.
9. Twyman, R.M. Principles of Proteomics. Garland Science.
10. Baxevanis, A.D. and Bader, G.D. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Wiley.
11. Relevant and recent review, research articles published in reputed journals on sequencing, transcriptomics, proteomics, single-cell and multi-omics.
12. Wilson, K. and Walker, J.M. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
13. Sambrook, J. and Russell, D.W. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press.
14. Pevsner, J. Bioinformatics and Functional Genomics. Wiley-Blackwell.
15. Liebler, D.C. Introduction to Proteomics: Tools for the New Biology. Humana Press.
16. Current protocols and public datasets from NCBI, GEO, SRA, UniProt and PRIDE.

III SEMESTER SLS/MIC/DSC 10: FOOD MICROBIOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I: Principles of Food Preservation (15 hours)

Food as substrate for microorganisms; Factors influencing microbial growth in food; 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).

Unit II: Contamination and Spoilage (15 hours)

Characterization of contamination and spoilage of cereals, vegetables, fruits, meat and meat products, milk and milk products, fish and sea foods, beer and wines; Spoilage of fermented foods and canned foods.

Unit III: Production of Fermented Foods (15 hours)

Beneficial Microorganism in Food; Industrial production methods of bread, fermented vegetables (olives and cucumber), fermented dairy products (acidophilus milk, cheese and yoghurt), single cell proteins, sauerkraut, meat (sausages); Production of oriental foods (mycoprotein, soya sauce, idli, and poi) and beverages (vinegar, cider, and palm wines); Alcoholic beverages of Himalayan region.

III SEMESTER SLS/MIC/DSC-10: FOOD MICROBIOLOGY (PRACTICAL)

Hours: 60 **Credits: 2**

1. Microbiological examination of food.
2. Assay of the quality of the milk sample using the MBRT test.
3. Adulteration tests for milk.
4. Microbial production of curd.
5. Determination of D value in heat treatment of foods.
6. Effect of freezing temperatures on microorganisms in food
7. Production of sauerkraut.
8. Estimation of lactic acid production in sauerkraut.
9. Effect of salt concentration on lactic acid production in sauerkraut.
10. Estimation of the acidity of vinegar.

Suggested Readings (Theory and Practical)

1. Matthews K.R., Kniel K.E., and Montville T.J. (2017) Food Microbiology: An introduction.4th edition, ASM Press.
2. Doyle, M.P and Beuchat, L.R. (2007) Food Microbiology: Fundamentals and Frontiers, Third Edition, ASM Press
3. Adams, M.R., and Moss, M.O. Food microbiology. Royal Society of Chemistry Publication, Cambridge.
4. Frazier, W.C. and Westhoff, D.C. Food microbiology. Tata McGraw Hill, New Delhi.
5. Erkmen, O., Bozoglu T.F. Food Microbiology: Principles into Practice, John Wiley & Sons, Ltd
6. Banwart, G.J. Basic food microbiology. CBS Publishers and Distributors, New Delhi.
7. Robinson, R.K. Dairy microbiology. Elsevier Applied Sciences, London.
8. James M.J. Modern food microbiology. CBS Publishers and Distributors, New Delhi.
9. Wood, B.J. Microbiology of fermented foods. Elsevier Applied Sciences, London.
10. Roberts, D., Greenwood, M., Practical Food Microbiology, John Wiley and Sons Ltd
11. Shen, C., Zhang, Y. (2023) Food Microbiology Laboratory for the Food Science Student: A Practical Approach, Springer
12. Aneja, K.R. Experiments in Microbiology, Plant Pathology, Tissue Culture and Microbial Biotechnology, New Age International Private, Limited
13. Read review articles and research papers related to this syllabus published recently in reputed journals.

(DSE -**Any one of the following**)

III SEMESTER-DSE 3.1: BIOPROCESS TECHNOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I: Bioreactor Design (15 Hours)

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)

Unit II: Fermentation Process and Kinetics (15 Hours)

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.

Unit III: Downstream Processing (15 Hours)

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.

III SEMESTER- DSE 3.1: BIOPROCESS TECHNOLOGY (PRACTICAL)

Hours: 30 **Credits: 1**

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. Optimization of culture conditions for enhanced enzyme production by microbial culture *via* batch fermentation.
5. Immobilization of microbial cells and enzyme.

Suggested Readings (Theory and Practical)

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. Demain, A.L and Davies, J.E. Manual of industrial microbiology and biotechnology. ASM Press, Washington, D.C.
10. Patel, A.H. Industrial microbiology. MacMillan India Limited, New Delhi.
11. Richard, H., George, B., Hagemann, D. and Paul, L. Industrial microorganisms: Basic and applied molecular genetics. ASM Press, Washington, D.C.
12. Asenjo, J.A. Separation process in biotechnology. Marcel Dekker, New York.
13. Belter, P.A. Cussler, E.L. and Hu, W.S. Bioseparation: Downstream processing for biotechnology. John Wiley and Sons, New York.
14. Peppler, H.J. and Perlman, D. Microbial technology. Academic Press, New York.

III SEMESTER SLS/MIC/DSE 3.3: ENVIRONMENTAL MICROBIOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I: Fundamentals of Microbial Ecology (15 Hours)

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

Unit III: Microbial Interactions (15 Hours)

Positive and negative interactions amongst microbial populations: Cooperation, Neutralism, Commensalism, Synergism, Mutualism, Competition, Amensalism, Parasitism, Predation; Interactions between microorganisms and plants: Rhizobacteria, Mycorrhiza, Epiphytic and endophytic microorganisms; Interactions between microorganisms and animals: Predation on microorganisms by animals.

Unit V: Impact of Microbes on the Environment (15 Hours)

Biodegradation of recalcitrant compounds: Pesticides and Petroleum; Bioremediation: *In situ* & *Ex situ* remediation, Bioremediation of oil spills; Bioaugmentation; Biomagnification; Biomineralization; Metal corrosion: Mode of deterioration, Microorganisms involved, Mode of prevention; Bioleaching of ore; Microbial plastics; Biodegradation of microplastics and nanoplastics; Biodiesel.

III SEMESTER SLS/MIC/DSE 3.3: ENVIRONMENTAL MICROBIOLOGY (PRACTICAL)

Hours: 30 **Credits: 1**

1. Isolation of xenobiotic compound-degrading microorganisms by the enrichment culture technique.
2. Determination of indices of pollution by measuring BOD and COD of different effluents.
3. Isolation of microplastic/nanoplastics degrading microbes from environmental sample.

Suggested Readings (Theory and Practical)

1. Alexander, M. Microbial ecology. John Wiley and Sons, New York.
2. Eldowney, S., and Waites, S. Pollution: Ecology and biotreatment. Longman, Harlow.
3. Marshal, K.C. Advances of microbial ecology. Plenum Press, New York.
4. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
5. Chapman, J.L. and Reiss, M.J. Ecology: Principles and applications. Cambridge University Press, Cambridge.
6. Odum, E.P. Basic ecology. Saunders, Philadelphia.
7. Mitchell, R. and Gu, J.D. Environmental microbiology. Wiley-Blackwell, New Jersey.
8. Maier, R., Pepper, I. and Gerba, C. Environmental microbiology. Academic Press, San Diego.
9. Satyanarayana, T., Johri, B.N. and Prakash, A. Microorganisms in environmental management: Microbes and environment. Springer Verlag, New York.
10. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.
11. Dubey, R.C. and Maheshwari, D K, Practical Microbiology, S Chand, New Delhi
12. Read review articles and research papers related to this syllabus published recently in reputed journals.

IV SEMESTER

IV SEMESTER SLS/MIC/DSC-11: PHARMACEUTICAL MICROBIOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I: Drug Discovery (10 hours)

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*).

Unit II: Development of Antimicrobial Agent (10 hours)

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 (10 hours)

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.

Unit IV: Quality Assurance and Validation (15 hours)

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.

IV SEMESTER SLS/MIC/DSC-11: PHARMACEUTICAL MICROBIOLOGY (Practical)

Hours: 60 **Credits: 2**

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.

Suggested Readings (Theory and Practical)

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. Dubey, R.C. and Maheshwari, D K, A text book of Microbiology, S Chand, New Delhi
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.

IV SEMESTER SLS/MIC/DSC-12: AGRICULTURAL MICROBIOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I: Abiotic and Biotic Components of Soil (11 hours)

Physico-chemical characteristics of soil; Soil enzymes and significance; Soil microbes; Soil microbial ecology, Influence of microbial metabolism on soil chemistry and humus formation; Factors affecting organic matter decomposition, Unculturable soil biota.

Unit II: Rhizosphere and Rhizoplane Microorganisms (11 hours)

Rhizosphere; Rhizoplane; Composition of root exudates; Factors affecting exudation; Mechanism of plant growth promotion: Mechanism of nitrogen fixation, Mechanism of phosphate solubilization and phosphate mobilization, Mechanism of iron chelation.

Unit III: Biocontrol Agents for Agriculturally Important Crop Plants (11 hours)

Biopesticides: Source organisms (*Bacillus thuringiensis*, *Beauveria bassiana*, *Trichoderma* and Baculoviruses); Biodegradation of pesticides; Mechanism of biocontrol; Other means of pathogen control.

Unit IV: Biofertilizer (12 hours)

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

IV SEMESTER SLS/MIC/DSC-12: AGRICULTURAL MICROBIOLOGY (PRACTICAL)

Hours: 60 **Credits: 2**

1. Isolation and biochemical identification of *Rhizobium* from the root nodules of leguminous plants.
2. Isolation of phosphate-solubilising microorganisms from soil.
3. Isolation and biochemical identification of IAA-producing microorganisms from rhizospheric soil.
4. Isolation of HCN-producing microorganisms from rhizospheric soil.
5. Isolation of bacteria as biocontrol agents from agricultural soil.

Suggested Readings (Theory and Practical)

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. Molina, G., Usmani, Z., Sharma, M., Yasri, A., Gupta, V.K. (2023). Microbes in Agri-Forestry Biotechnology. Taylor and Francis group.
4. Dubey, R.C. and Kumar, P. (2022). Rhizosphere Engineering, Elsevier, USA
5. Kononova, M.M. Soil organic matter: Nature, its role in soil formation and in soil fertility. Pergamon, Oxford.

6. Burges, A. and Raw, F. Soil biology. Academic Press, London.
7. Rangasami G. and Bagyarai, D.J. Agricultural microbiology. Prentice-Hall, New Delhi.
8. Dubey R.C. and Maheshwari D.K., A Textbook of Microbiology, S. Chand Publishing, New Delhi
9. Aneja, K.R., Fundamentals of Agricultural Microbiology, New Age International Private Limited, India
10. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.
11. Dubey, R.C. and Maheshwari, D K, Practical Microbiology, S Chand, New Delhi
12. Read review articles and research papers related to this syllabus published recently in reputed journals.

IV SEMESTER SLS/MIC/DSE 4.1: RESEARCH METHODOLOGY (THEORY)

Hours: 45 **Credits: 3**

Unit I: Data Collection and Hypothesis Testing (15 Hours)

Data, types of data: Sampling techniques: Sample size; Recording of data and data summarisation; 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; Hypothesis; Hypothesis-Testing Procedure; Sample Size, Tests for Differences between Means: Test for Differences between Proportions;

Unit II: Analysis of Variance (15 hours)

Analysis of Variance; One- way and two-way ANOVA, Inferences about Population Variance; 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; Chi-Square Test; The Sign Test for Paired Data; Rank Sum Tests: The Mann-Whitney U Test and the Kruskal-Wallis Test; The One-Sample Runs Test; Rank Correlation; The KolmogorovSmirnov Test.

Unit III: Basics of Bioinformatics (15 hours)

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; Phylogenetic analysis: Phenetic and cladistic approach; Phylogenetic tree construction (Rooted and unrooted method).

IV SEMESTER SLS/MIC/DSE 4.1: RESEARCH METHODOLOGY (PRACTICAL)

Hours: 30 **Credits: 1**

1. Statistical and graphical representation of data.
2. Calculation of mean, median and mode.
3. Linear equation analysis (Regression analysis).
4. Exponential equation analysis (Survival curve).
5. Chi square test.
6. Normal distribution.
7. One-way ANOVA.
8. Two-way ANOVA.

Suggested Readings (Theory and Practical)

1. Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.
2. Singh, Y. K. (2006). *Fundamental of research methodology and statistics*. New Age International.
3. Thomas, C. G., & Thomas, C. G. (2021). *Research methodology and scientific writing* (pp. 135-151). Thrissur: Springer.
4. Dawson, C. (2002). *Practical research methods: A user-friendly guide to mastering research*. How to books.
5. Daniel, P. S., & Sam, A. G. (2011). *Research methodology*. Gyan Publishing House.

6. Campbell, R. C. (1989). *Statistics for biologists*. Cambridge University Press.
7. Mount, D. W., & Mount, D. W. (2001). *Bioinformatics: sequence and genome analysis* (Vol. 564). Cold Spring Harbor, NY: Cold spring harbor laboratory press.
8. Higgins, D., & Taylor, W. (2000). *Bioinformatics: Sequence, Structure and Databanks: A Practical Approach* (Vol. 236). OUP Oxford.
9. Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.
10. Higgins, D., & Taylor, W. (2000). *Bioinformatics: Sequence, Structure and Databanks: A Practical Approach* (Vol. 236). OUP Oxford

IV SEMESTER SLS/MIC/DSE 4.2: INTELLECTUAL PROPERTY RIGHTS (THEORY)

Hours: 45 **Credits: 03**

UNIT I: Fundamentals of Intellectual Property Rights (9 Hours)

Concept, scope and importance of Intellectual Property Rights (IPR); role of WIPO and major forms of intellectual property, including patents, copyright, trademarks, industrial designs, geographical indications and plant breeders' rights. Relevance of IPR to microbiology, biotechnology and academic research. Intellectual property generated through research and innovation. Concepts of ownership, inventorship, confidentiality and trade secrets. Non-disclosure agreements and responsible disclosure. Basic principles of intellectual property management in academic and industrial research.

UNIT II: International Framework of Intellectual Property (9 Hours)

International framework for intellectual property protection; roles of WIPO and WTO. Overview and significance of major international agreements, including the Paris Convention, Berne Convention, Patent Cooperation Treaty (PCT) and TRIPS Agreement. Principles of national treatment and minimum standards of IP protection. International patenting routes and protection of intellectual property across countries. Relationship between IPR, international trade, technological development and access to health and biotechnology-related technologies.

UNIT III: Patents and Patent Searching (10 Hours)

Concept, scope and significance of patents; basic patent terminology, including inventor, applicant, assignee, priority, specification and claims. Patentability requirements: novelty, inventive step/non-obviousness, industrial applicability and enabling disclosure. Patentable and non-patentable subject matter with emphasis on microbiology and biotechnology. Overview of the Indian patent system and international patenting through the PCT. Prior art and patent-search strategies. Use of major patent databases, including IP India, WIPO PATENTSCOPE and Espacenet. Patent mapping and technology landscapes. Case studies of patents in microbiology, biotechnology and pharmaceuticals.

UNIT IV: Patent Law, Licensing and Technology Transfer (9 Hours)

Basic provisions of Indian patent law relevant to biotechnology and pharmaceuticals. Patent rights and limitations; patent infringement and basic principles of enforcement. Compulsory licensing, research/experimental use and Bolar provision. Intellectual property ownership in academic research. Patent assignment, licensing and technology-transfer agreements. Commercialization and valuation of intellectual property. Confidentiality and ethical considerations in technology transfer. Role of patents and licensing in development and commercialization of drugs, vaccines, diagnostics and biotechnology products. Selected case studies.

UNIT V: Plant Variety Protection, Traditional Knowledge and Bioprospecting (8 Hours)

Intellectual property protection of plant varieties and agricultural biotechnology. Protection of Plant Varieties and Farmers' Rights (PPV&FR) framework in India; breeders' rights, farmers' rights and researchers' rights; DUS criteria. Overview of TRIPS and international approaches to plant variety protection. Protection of genetically modified crops and agricultural innovations. Traditional knowledge and its significance for biotechnology and developing countries. Biopiracy, access and benefit-sharing, and protection of traditional knowledge and biological resources. Case studies involving traditional medicines, biological resources and agricultural biotechnology.

IV SEMESTER SLS/MIC/DSE 4.2: INTELLECTUAL PROPERTY RIGHTS (PRACTICAL)

Hours: 30 **Credits: 1**

1. IP-right identification: classify real research outputs into patent, copyright, trademark, design, GI, trade secret or plant-variety protection.
2. Patent-document anatomy: retrieve a patent and annotate title, abstract, priority, applicants, inventors, claims, description and citations.
3. Create keyword/synonym sets for a selected microbiology or biotechnology invention.
4. Perform a basic keyword and Boolean search in WIPO PATENTSCOPE.
5. Perform a classification-based and citation-based search; compare results.
6. Search Indian patent records and retrieve bibliographic and legal-status information.
7. Compare the same technology across WIPO, Espacenet, USPTO and IP India.
8. Patent family exercise: identify related applications and jurisdictions.
9. Patentability exercise: identify novelty and inventive-step issues from supplied prior art.
10. Patent landscape: collect and categorize patents around an assigned topic such as microbial enzymes, probiotics, diagnostics or natural products.
11. Technology mapping: group retrieved patents by applicant/assignee, year, jurisdiction and technological theme.
12. Biotechnology case study: vaccine, diagnostic, recombinant product or microbial process patent.
13. Plant variety case study: DUS, breeders' rights, farmers' rights and researchers' rights.
14. Traditional-knowledge case study: identify claims of biopiracy and benefit-sharing issues.
15. Case studies of different patents: Basmati, Neem, Turmeric, Oncomouse, Bald mouse, Novartis gleevec, Cre-lox, Diamond versus Chakrabarty, Round up ready crops.
16. Prepare a one-page invention disclosure for a hypothetical microbiological invention.
17. Draft a simplified patent abstract and 2–3 illustrative claims for the hypothetical invention.
18. Mini-project: prepare a 3–5 page patent landscape and oral presentation on a selected microbiology/biotechnology technology.

Practical Record / Outputs (At least 03 of the following are mandatory)

1. At least 4 documented patent-search exercises.
2. One patentability/prior-art analysis.
3. One claim-analysis exercise.
4. One mini patent landscape/technology map.
5. One invention-disclosure exercise.
6. One case-study presentation.

Suggested Readings (Theory and Practical)

1. Subbaram, N. Patents. Pharma Book Syndicate, Hyderabad.
2. Ganguli, P. Intellectual Property Rights. Tata McGraw-Hill, New Delhi.
3. Shippey, K.C. A Short Course in International Intellectual Property Rights. World Trade Press.
4. Bently, L. and Sherman, B. Intellectual Property Law. Oxford University Press.
5. Parulekar, A. and D'Souza, S. Indian Patent Law: Legal and Business Implications. Macmillan Press.
6. Grubb, P.W. Patents for Chemicals, Pharmaceuticals and Biotechnology: Fundamentals of Global Law, Practice and Strategy. Oxford University Press.
7. Knight, H.J. Patent Strategy: For Researchers and Research Managers. Wiley.
8. Gordon, T.T. and Cookfair, A.S. Patent Fundamentals for Scientists and Engineers. CRC Press.
9. WIPO resources on intellectual property, patents and international treaties.
10. Government of India, Intellectual Property India resources.
11. PPV&FR Authority, Government of India, for plant variety protection.

Note: *IP laws, rules, examination guidelines and database interfaces are periodically amended or updated. Current official notifications and guidance from WIPO, Intellectual Property India, the PPV&FR Authority and other relevant authorities should therefore be consulted while teaching procedural or legal details.*