COURSE CONTENTS & SYLLABUS

(Effective from the Academic Year 2025-2026)

UG – MICROBIOLOGY

(B.Sc. VII and VIII Semester – Honours with Research)

National Education Policy (NEP) - 2020

DEPARTMENT OF MICROBIOLOGY

HEMVATI NANDAN BAHUGUNAGARHWALUNIVERSITY
(A CENTRAL UNIVERSITY)
Srinagar, Garhwal – 246174, Uttarakhand, INDIA

DEPARTMENT OF MICROBIOLOGY

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

U.G. Microbiology (Hons. with Research)				
Sem.	**Codes**	**Credits**		**Paper name**
		T	P	
VII	DSC-1 (Core major 1)	5	0	Introduction to Microbial Life
	DSC-2 (Core major 2)	5	0	Microbial Biochemistry
	DSC-Practical-1	0	3	Practical exercises based on DSC 1-2, with equal weightage to all
	DSE-I	4 - -	2 - -	**E 1.1.** Molecular Basis of Microbial Life **E 1.2.** Microbial Functional Ecology **E 1.3.** Microbial Data Science
	MD/ID-I	2	2	Microbial Biomolecules
	Research Methodology	5	0	Research Methodology
	Total Credits	**21+7 = 28**		
VIII	DSC-4	5	0	Applied Laboratory Microbiology
	DSC-Practical-2	0	3	Practical exercises based on DSC 4
	DSE-II	4	0	**E 2.1.** Epidemiology and Disease Control **E 2.2.** Fundamentals of Immunology **E 2.3.** Biology of Viruses and Fungi
	MD/ID-II	2	2	Concepts of Immunology
	Dissertation	0	12	
	Total Credits	**11+17 = 28**		

UG -Microbiology (VII – Semester)

DSC 1- Introduction to Microbial Life (Theory)

Hours: 75 **Credits: 5**

Unit I: History and Classification (15 hours)

History and development of microorganisms; Conflicts over spontaneous generation; Golden era of microbiology; World of microorganisms; Concepts of prokaryotes and eukaryotes; 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; Techniques used in microbial classification (Morphological, chemotaxonomic and genetic methods); Tools for systematics (Phylogenetic, numerical and polyphasic taxonomy); Scope and relevance of microbiology, Future of microbiology.

Unit II: Microscopy (15 hours)

Principle of bright field microscopy, dark field microscopy, fluorescence and immuno-flourescence microscopy, phase contrast 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 (15 hours)

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, Generation time, Growth kinetics, Diauxic growth curve, Asynchronous and synchronous growth, Measurement of growth, Effect of environmental conditions (pH, temperature, aeration, etc.) on microbial growth; Control of microbial growth: Physical and chemical agents

Unit IV: General Bacteriology (15 hours)

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, ribosomes and nucleoid; Reserve food materials- PHB, phosphate granules, oil droplets, cyanophycean granules and sulphur inclusions Bacterial reproduction; Characteristic features of Archaea.

Unit V: General Virology (15 hours)

Discovery of viruses; Characteristic feature of viruses, viroids, virusoids prions and Satellite viruses; 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); 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; Application of bacteriophages.

Suggested Readings

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. Wheelis, M. Principles of modern microbiology. Jones and Bartlett Learning, Sudbury.
5. Stanier, R.Y., Ingraham, J.L., Wheelis, M.L. and Painter, P.R. General microbiology. MacMillan Press, London.
6. Sclegel, H.G. General Microbiology. Cambridge University Press, Cambridge.
7. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R. Microbiology. McGraw-Hill, New York.
8. Dubey, R.C. and Maheshwari, D K, A Textbook of Microbiology, S Chand, New Delhi
9. Hawkes, P.W., Spence, J.C.H. (2019) Springer Handbook of Microscopy, Springer Nature Switzerland
10. Dimmoc, N.J., Easton, A.J. and Leppard, K.N. Introduction to Modern Virology. Wiley-Blackwell, New Jersey.
11. Read related review articles and research papers published recently in reputed journals.

DSC 2 - Microbial Biochemistry (Theory)

Hours: 75 **Credits: 5**

Unit I – Acid–Base Chemistry (12 hours)

Bronsted and Lewis concepts; conjugate acid–base pairs; ionization of solutions; pH and pKa; physiological relevance of pH. Biological buffers; Henderson–Hasselbalch equation, buffer capacity, polyprotic acids, amphoteric salts, ionic strength in biological systems, Lab buffers; Phosphate, bicarbonate, histidine-containing peptides, Good's buffers.

Unit II Bioenergetics (12 hours)

Energy generation in biological systems: substrate-level phosphorylation, oxidative phosphorylation, photophosphorylation. Electron transport chain: organization in bacteria and mitochondria; artificial electron donors; inhibitors and uncouplers. Chemiosmotic theory of ATP synthesis; experimental evidence and modern perspectives. High-energy phosphate compounds: ATP, GTP, PEP, creatine phosphate. Phosphate group transfer potential; free energy of ATP hydrolysis under physiological conditions.

Unit III – Carbohydrates Metabolism (12 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 IV –Lipid Metabolism (10 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 V –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).

Unit VI – Enzymes: Structure, Function & Regulation (14 hours)

Mechanisms of enzyme catalysis: acid–base catalysis, covalent catalysis, metal ion catalysis. Kinetics of single-substrate and multi-substrate reactions (sequential, ping–pong mechanisms). Reversible and irreversible inhibition (competitive, non-competitive, uncompetitive, mixed). Allosteric enzymes: sigmoidal kinetics, cooperative binding, models of allostery (MWC, KNF). Regulation of enzyme activity: covalent modification, feedback inhibition. Determination of active site structure and turnover number. Applications of enzymes in biotechnology and industry.

Suggested Readings

1. Lehninger, A. L., Nelson, D. L., & Cox, M. M. (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)

DSC Practical 1

(Practical exercises based on DSC 1-2)

Hours: 90 **Credits: 3**

Introduction to Microbial Life

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

Microbial Biochemistry

1. **Preparation of Buffers and Solutions**:
   Molar, normal, and present solutions; pH adjustment and verification.
2. **Quantitative Estimation of Biomolecules**
   A. Proteins: Lowry's method or Bradford assay using BSA standard curve.
   B. Reducing Sugars: DNS method using glucose standard curve.
   C. Nucleic Acids: UV spectrophotometric method at 260 nm.

Suggested Readings

1. Cappuccino J., and Welsh C., Microbiology: A Laboratory Manual, 11th Edition, Pearson, USA
2. Dubey, R.C. and Maheshwari, D K, Practical Microbiology, S Chand, New Delhi
3. Practical Biochemistry by Pamela Jha
4. Practical Manual of Biochemistry by G. Sattanathan, S.S. Padmapriya, B. Balamuralikrishnan,

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

DSE 1.1 - Molecular Basis of Microbial Life (Theory)

Hours: 60 **Credits: 4**

Unit I: Microbial Genome and Chromosome Architecture (15 hours)

Chemical and physical properties of DNA and RNA; Structure and types of DNA: A-, B-, Z-DNA; G-quadruplexes, DNA denaturation, renaturation kinetics, and DNA topology (supercoiling, topoisomerases); C-value paradox and genome complexity; Epigenetic landscape: Chromatin remodeling, histone modifications, DNA methylation; Chromosome territories; Telomere biology and telomerase in aging and cancer.

Unit II: Replication, Transcription, and Epitranscriptomics (15 hours)

DNA replication in prokaryotes and eukaryotes: Origins, replication forks, and replisomes; Replication timing and origin licensing; Inhibitors of replication: Anticancer and antiviral drugs; RNA polymerases and transcriptional machinery; Mechanisms of transcription initiation, elongation, and termination; Transcription factors, co-activators, and silencers; Post-transcriptional modifications: Capping, polyadenylation, splicing (including alternative splicing); RNA modifications: Epitranscriptomics (m6A, m5C, pseudouridine); Structure and functions of mRNA, tRNA, rRNA, and ncRNAs..

Unit III: Translation, Proteostasis, and Gene Expression Control (15 hours)

Genetic code: Universality, degeneracy, and exceptions; Mechanism of translation in prokaryotes and eukaryotes; Ribosome structure and biogenesis; Ribosome profiling; Regulation of translation: uORFs, IRES, miRNAs, riboswitches; Post-translational modifications: Phosphorylation, ubiquitination, SUMOylation; Protein folding, misfolding, and quality control mechanisms (chaperones, proteasomes, autophagy); Regulation of gene expression: lac, trp, and arb operons; Regulatory RNAs: miRNA, siRNA, piRNA, lncRNA.

Unit IV: Recombination, Mobile Elements, Mutation and Genome Integrity (15 hours)

Homologous recombination (Holliday model, DSBR, SDSA) and non-homologous end joining (NHEJ); Proteins and complexes involved in recombination (RecA, Rad51, MRN complex); Transposons and retrotransposons: Role in genome evolution and disease; Genome editing tools: CRISPR-Cas9, base editors, prime editing; Mutations: Types, causes, and molecular consequences; Chemical and physical mutagens; Genome-wide mutagenesis screening; DNA repair pathways: BER, NER, MMR, HR, NHEJ, translesion synthesis; DNA damage signaling and cell cycle checkpoints.

Suggested Readings

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.

Practical (DSE 1.1 - Molecular Basis of Microbial Life)

Hours: 60 **Credits: 2**

1. Quantitative estimation of DNA by diphenyl amine (DPA) and spectrophotometric method.
2. Determination of quality of DNA by spectrophotometric method.
3. Isolation of genomic DNA from bacterial culture.
4. Visualization of DNA by agarose gel electrophoresis.
5. Determination of Tm of given DNA sample.
6. Study of effect of temperature and pH on denaturation of DNA.
7. Study of effect of different concentrations of urea on denaturation of DNA.
8. Mutagenesis in given bacterial culture by U.V. radiation.
9. Demonstration of photoreactivation mechanism in bacteria.
10. Isolation of antibiotic-resistant bacteria by gradient plate method.

Suggested Readings

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

DSE 1.2 - Microbial Functional Ecology (Theory)

Hours: 60 **Credits: 4**

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 II: Air and Aquatic Microbiology (15 Hours)

Aerobiology: Droplet nuclei, Aerosol, Assessment of air quality, Solid and liquid impingement methods, Brief account of air born transmission of microbes; Aquatic microbiology: Zonation and microbiota of fresh water (ponds, lake and rivers) and marine habitats (estuaries, deep sea and coral reefs), Upwelling and downwelling, Eutrophication, Food chain, Mechanism of dissolved organic matter production, Microbial assessment of water quality, Water purification.

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, Cultivation of microorganisms by animals for food and food processing.

Unit IV: Pollution and its Control (15 Hours)

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), Waste water treatment: Pretreatment, primary, secondary and tertiary treatment; Application of biofilm in waste water treatment; Environment impact assessment.

Suggested Readings

1. Reineke, W., Schlömann, M. (2023) Environmental Microbiology, Springer Nature
2. Pepper, I.L., Gerba, C.P., Gentry, T.J. (2015) Environmental Microbiology, Elsevier
3. Eldowney, S., and Waites, S. Pollution: Ecology and biotreatment. Longman, Harlow.

4. Dubey R.C. and Maheshwari D.K., A Textbook of Microbiology, S. Chand Publishing, New Delhi
5. 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
6. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
7. Chapman, J.L. and Reiss, M.J. Ecology: Principles and applications. Cambridge University Press, Cambridge.

Practical (DSE 1.2 - Microbial Functional Ecology)

Hours: 60 **Credits: 2**

1. Physical characterization of wastewater
2. Study of microbial community succession in decomposing litter.
3. Isolation of plastic-degrading microorganisms
4. Isolation of xenobiotic compound-degrading bacteria by enrichment culture technique.
5. Determination of pollution indices by measuring BOD and COD of different effluents.
6. Detection of Phenolics in effluents
7. Detection of heavy metals in water
8. Detection of the presence of detergent in the water sample
9. Detection and quantification of microorganisms in the water sample
10. Detection and quantification of H_2S as a pollution indicator
11. Assay for eutrophication
12. Bioassay for self-purification of water

Suggested Readings

1. Yates, M.V., Nakatsu, CH., Miller, R.V. Pillai, S.D., Manual of Environmental Microbiology, 4th Edition, ASM Press
2. Dubey, R.C. and Maheshwari, D K, Practical Microbiology, S Chand, New Delhi
3. Dharajiya, D., Jasani, H., Vyas, S.R. Environmental Microbiology and Biotechnology - A Practical Manual, S. D. Agricultural University, Sardarkrushinagar

DSE 1.3 - Microbial Data Science (Theory)

Hours: 60 **Credits: 4**

Unit I: Introduction to Bioinformatics & Biological Databases (15 hours)

Definition, scope, and applications of bioinformatics in microbiology. Types of biological data: sequence, structure, expression, and functional data. Overview of biological databases: primary, secondary, and specialized microbial databases (NCBI, EMBL, DDBJ, UniProt, PDB, KEGG, MG-RAST). Data retrieval techniques and database searching strategies.

Unit II: Sequence Alignment & Analysis (15 hours)

Concept of sequence similarity, identity, and homology. Pairwise sequence alignment: global (Needleman-Wunsch) and local (Smith-Waterman) algorithms. Multiple sequence alignment (MSA) – tools and applications (Clustal Omega, MUSCLE). Sequence file formats (FASTA, GenBank) and reading sequence data.

Unit III: Molecular Phylogenetics (15 hours)

Basics of phylogenetic tree construction. Distance-based methods (UPGMA, Neighbor-Joining) and character-based methods (Maximum Parsimony, Maximum Likelihood). Bootstrap analysis and tree evaluation. Application of phylogenetics in microbial taxonomy and evolutionary studies.

Unit IV: Computational Genomics and Proteomics (15 hours)

Introduction to microbial genome sequencing and annotation. Comparative genomics and functional genomics concepts. Basics of proteomics and protein structure prediction (primary to quaternary structure).

Practical (DSE 1.3 - Microbial Data Science)

Hours: 60 **Credits: 2**

1. Introduction to Biological Databases & Data Retrieval
- Navigating NCBI, EMBL, DDBJ, and UniProt databases.
- Downloading nucleotide and protein sequences in FASTA and GenBank formats.
- Searching microbial-specific databases (MG-RAST, IMG, KEGG).

2. Sequence Alignment *(10 hours)*
- Pairwise sequence alignment using BLAST (nucleotide and protein).
- Interpreting BLAST results (E-value, score, identity).
- Performing Multiple Sequence Alignment (MSA) using Clustal Omega/MUSCLE.

3. Phylogenetic Analysis
- Construction of phylogenetic trees using MEGA or PhyML.

- Bootstrap analysis for tree reliability.
- Application of phylogenetics in microbial taxonomy case study.

4. Microbial Genome and Metagenome Analysis

- Genome annotation using NCBI Genome Browser.
- Comparative genomics using online tools (IMG, PATRIC).
- Metagenomic data analysis using MG-RAST or QIIME (sample dataset).

5. Statistical Data Handling & Visualization

- Creating bar charts, scatter plots, heatmaps from microbiological datasets.
- Simple correlation and regression analysis on microbial growth or gene expression data.

6. Project-based Mini Assignment

- Retrieve sequences of a microbial gene/protein of interest.
- Perform alignment, build a phylogenetic tree, and interpret evolutionary relationships.
- Prepare a short report with data visualization.

Suggested Readings

1. Mount, D.W. (2004). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor Laboratory Press.
2. Lesk, A.M. (2019). *Introduction to Bioinformatics*. Oxford University Press.
3. Pevsner, J. (2015). *Bioinformatics and Functional Genomics*. Wiley-Blackwell.
4. Zvelebil, M., & Baum, J.O. (2020). *Understanding Bioinformatics*. Garland Science.
5. Raghava, G.P.S., & Raghava, S. (2010). *Bioinformatics for Beginners*. Alpha Science International.

Research Methodology

Hours: 75 **Credits: 5**

Unit I (20 Hours)
Research and Types of research: Meaning of Research- Objectives of Research. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical. Research Process. Criteria of good Research. Literature review – Primary and secondary sources, Critical literature review – Identifying gap areas from literature review.

Unit II (20 Hours)
Data Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection – Modeling, Mathematical Models for research, Sampling Methods- Data processing and Analysis strategies.

Unit III (20 Hours)
Designing research work. Scientific writing - characteristics. Logical format for writing thesis and papers. Essential features of abstract, introduction, review of literature, materials and methods and discussion. Effective illustration - tables and figures. Reference styles - Harvard and Vancouver systems.

Unit IV (15 Hours)
Guidelines for preparing an article - ISSN, ISBN, impact factor, citation index, downloading index, h- index, i-index, Google scholar, Scopus, Thomson & Reuters, Web of Science and Science Citation Index (SCI) of Web of Science (WOS). Plagiarism and its software.

Suggested Readings

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, EssEss Publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
5. Leedy, P.D. and Ormrod, J.E., 2004 Practical Research: Planning and Design, Prentice Hall.
6. Read Recent Research paper and review article published recently in reputed journals

PG -Microbiology (VIII – Semester)

DSC 4 - Applied Laboratory Microbiology (Theory)

Hours: 75 **Credits: 5**

Unit I: Advanced Microscopy and Biosensors (15 hours)

Microscopy: Light microscopy phase contrast, Fluorescence (Multiphoton and Total Internal Reflection Fluorescence (TIRF) microscopy), and confocal microscopy; Scanning and transmission electron microscopy (SEM, TEM, Cryo-TEM); Atomic Force Microscopy (AFM). Biosensors: Introduction to Biosensors and their evolution; Nano-biosensors and wearable biosensors; Cell-based biosensors; DNA biosensors; Pathogen detection sensors.

Unit II: Centrifugation Technologies (15 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. Special emphasis on - Density gradient ultracentrifugation in proteomics and virology; High-throughput microcentrifugation platforms; Analytical ultracentrifugation in biophysics and macromolecular interactions.

Unit II: Modern Chromatography Techniques (15 hours)

Basic Principles: Adsorption, partitioning, and separation efficiency. Techniques: Adsorption, ion-exchange, affinity, size exclusion, thin-layer, gas chromatography, High-performance liquid chromatography (HPLC). State-of-the-art techniques in chromatography - Ultra Performance Liquid Chromatography (UPLC), 2D-chromatography (2D-TLC, 2D-HPLC), Hyphenated techniques: LC-MS/MS, GC-MS, CE-MS, Metabolomic and lipidomic profiling via advanced chromatographic methods.

Unit IV: Electrophoretic Techniques (15 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). State-of-the-Art methods in electrophoresis: Capillary electrophoresis (CE) and CE-MS, Microfluidic electrophoresis and automated systems (e.g., Agilent Bioanalyzer), 2D Gel Electrophoresis (2-DE) for proteomic application.

Unit V: Spectroscopy, Mass Spectrometry, and Radiotracer Technology (15 hours)

Core Techniques: UV-Vis, IR, Fluorescence, Atomic absorption, CD, Raman, ESR, ORD spectroscopy; Basic NMR principles and applications; Radiotracers and radioactivity detection: GM counter, scintillation counters. State-of-the-Art Methods & Technologies: Mass Spectrometry (MALDI-TOF, ESI-MS, Orbitrap, Q-TOF); NMR in metabolomics and protein-ligand interaction studies.

Suggested Readings

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.

DSC Practical 2
(Practical exercises based on DSC-4)

Hours: 90 **Credits: 3**

Analytical Techniques in Microbiology

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. 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. 8. Interpretation of UV spectra.
9. Interpretation of IR spectra.
10. Interpretation of NMR spectra.
11. Interpretation of Mass spectra.

Suggested Rreadings

1. Sawhney, S.K. and Singh, R. Introductory practical biochemistry. Narosa Publishing House, New Delhi.
2. Boyer, R.F. Modern experimental biochemistry. Prentice Hall, New Jersey.
3. Wilson, K. and Walker, J.M. Principles and techniques of practical biochemistry. Cambridge University Press, Cambridge.

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

DSE 2.1 - Epidemiology and Disease Control (Theory)

Hours: 60 **Credits: 4**

Unit 1 – 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 2 – 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 3 – Public Health Microbiology & Surveillance (15 Hours)

- Structure and role of public health systems (WHO, CDC, ICMR, NCDC).
- Microbiological aspects of public health: water, food, and air quality monitoring.
- Surveillance systems: passive, active, sentinel, syndromic surveillance.
- Laboratory role in disease detection and reporting.
- AMR (antimicrobial resistance) surveillance.

Unit 4 – 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.

Suggested Readings

1. Ryan, K.J., & Ray, C.G. (2014). *Sherris Medical Microbiology*. McGraw-Hill.
2. Nelson, K.E., & Williams, C.M. (2014). *Infectious Disease Epidemiology: Theory and Practice*. Jones & Bartlett Learning.
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. WHO Technical Reports & Surveillance Guidelines – https://www.who.int

DSE 2.1 - Fundamentals of Immunology (Theory)

Hours: 60 **Credits: 4**

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; Nonspecific immune mechanisms: Surface defenses, Tissue defenses, Opsonization, Inflammatory reactions.

Unit II: Antigens and Antibodies (15 Hours)

Antigens: Structure and properties; Haptens; Adjuvents; 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: Infectious Agents (15 Hours)

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 IV: Immune Regulation of Infection (15 Hours)

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.

Suggested Readings

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.

DSE 2.3 - Biology of Viruses and Fungi (Theory)

Hours: 60 **Credits: 4**

Unit 1: Fundamentals of Virology (15 Hours)

- Historical developments and milestones in virology.
- General properties of viruses: morphology, symmetry, genome types, and replication strategies.
- Virus classification: ICTV system.
- Structure and function of viral components: capsid, envelope, viral enzymes.
- Virus–host interactions: adsorption, penetration, uncoating.

Unit 2: Viral Replication & Genetics (15 Hours)

- Replication cycles of DNA and RNA viruses (representative examples: adenoviruses, herpesviruses, retroviruses, orthomyxoviruses, picornaviruses).
- Concepts of viral latency, persistence, and oncogenesis.
- Viral genetics: mutation, recombination, reassortment, complementation, and interference.
- Molecular basis of antiviral resistance.

Unit 3: Medical & Applied Virology (15 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.
- Bacteriophages: types, life cycles (lytic and lysogenic), and applications in molecular biology and phage therapy.
- Principles of viral diagnosis: culture methods, serology, molecular techniques (PCR, RT-PCR, ELISA).

Unit 4: Fundamentals of Mycology (15 Hours)

- Introduction to fungi: general characteristics, classification (Ainsworth and Bisby, modern molecular approaches).
- 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.

MD/ID II – Concepts of Immunology (Theory)

Hours: 30 **Credits: 2**

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; Nonspecific immune mechanisms: Surface defenses, Tissue defenses, Opsonization, Inflammatory reactions.

Unit II: Antigens and Antibodies (15 Hours)

Antigens: Structure and properties; Haptens; Adjuvents; 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.

Suggested Readings

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

Practical (MD/ID II - Concepts of Immunology)

Hours: 60 **Credits: 2**

1. Separation and preservation of serum and plasma.
2. Determination of blood group and Rh factor.
3. Demonstration of agglutination reaction of bacterial cultures by slide agglutination test.
4. Quantitative estimation of antigen by radial immunodiffusion.

Suggested Readings

1. Frank C. Hay, Olwyn M. R. Westwood, Practical Immunology, Wiley-Blackwell
2. Miller, L. E., Christine, D. S. (2021) Clinical Immunology and Serology: A Laboratory, F A Davis Co.