COURSE CONTENTS & SYLLABUS

(Effective from the Academic Year 2025-2026)

PG - MICROBIOLOGY

National Education Policy (NEP) - 2020

DEPARTMENT OF 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. - Microbiology				
Sem.	**Codes**	**Credits**		**Paper name**
		T	P	
I	DSC-1	5	0	Introduction to Microbial World
	DSC-2	5	0	Fundamentals of Microbial Biochemistry
	DSC-3	5	0	Microbial Cell Biology
	DSC-Practical-1	0	3	(Practical exercises based on DSC 1-3, with equal weightage to all)
	DSE-I	4 - -	2 - -	(**Any one of the following in semester-I**) **E 1.1.** Microbial Molecular Biology **E 1.2.** Environmental Microbiology **E 1.3.** Bioinformatics in Microbiology
	Total credits	**19+5=24**		
II	DSC-4	5	0	Analytical techniques in Microbiology
	DSC-5	5	0	Microbial Physiology and Metabolism
	DSC-6	5	0	Recombinant DNA Technology
	DSC-Practical-2	0	3	(Practical exercises based on DSC 4-6, with equal weightage to all)
	DSE-II	4	2	**(Any one of the following in semester-II)** **E 2.1.** Epidemiology **E 2.2.** Infection Immunology **E 2.3.** Virology & Mycology
	Total credits	**19+5=24**		

Note for both first and second semester:

1. In lieu of Discipline Specific Elective (Theory and Practical=4+2 credits) the departments may offer any one course i.e. dissertation/project work of 6 credits.

2. In lieu of only Discipline Elective Practical (2 credits) the departments may offer 2 credit additional course (Field work/Project/ SWAYAM Course).

PG -Microbiology (I – Semester)

DSC 1- Introduction to Microbial World (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 - Fundamentals of 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 3 – Microbial Cell Biology (Theory)

Hours: 75 **Credits: 5**

Unit I: Intracellular Compartmentalization of the Cell (15 Hours)

- **Ultrastructure and Functions** of nucleus, mitochondria, chloroplast, endoplasmic reticulum, Golgi apparatus, peroxisomes, lysosomes, and endosomes.
- **Cytoskeleton:** Actin filaments, microtubules, intermediate filaments – organization, dynamics, and role in intracellular transport and cell motility.
- **Molecular Motors:** Kinesins, dyneins, and myosins in vesicular transport and organelle positioning.
- **Cellular Integration in Tissues:** Cell junctions (tight, adherens, gap, desmosomes, hemidesmosomes), cell-cell adhesion (cadherins), and cell–extracellular matrix adhesion (integrins, focal adhesions).
- **Vesicular Trafficking:** SNARE proteins, Rab GTPases, COPI/COPII vesicles, clathrin-coated vesicles, exosomes, and endocytosis pathways.

Unit II: Plasma Membrane Architecture and Solute Transport (15 Hours)

- **Plasma Membrane:** Composition, structural organization (fluid mosaic model), membrane microdomains (lipid rafts), and dynamics (lateral diffusion, flip-flop, membrane fusion).
- **Membrane Biophysics:** Techniques to study membrane structure and dynamics (FRAP, FRET, Cryo-EM).
- **Solute Transport Mechanisms:**
  - Passive transport – simple and facilitated diffusion.
  - Active transport – primary and secondary.
  - Pumps and transporters (Na+/K+ ATPase, Ca2+ ATPase, ABC transporters).
  - Ion channels – ligand-gated, voltage-gated, mechanosensitive, and aquaporins.
- **Trans-epithelial transport** and intracellular ion homeostasis.

Unit III: Cell Signaling and Communication (15 Hours)

- **Modes of Signaling:** Paracrine, endocrine, autocrine, juxtacrine, and synaptic signaling.
- **Signaling Pathways:**
  - Cell surface receptors – G protein-coupled receptors (GPCRs), receptor tyrosine kinases (RTKs), enzyme-linked and ion-channel-linked receptors.
  - Second messengers – cAMP, IP3, DAG, Ca2+, NO, cGMP – synthesis and roles.
  - MAPK, PI3K-Akt, JAK-STAT, Wnt, Hedgehog, and Notch pathways – mechanisms and regulation.
- **Signal Integration & Amplification:** Crosstalk between pathways and feedback loops.

Unit IV: Cell Cycle Regulation and Cell Division (15 Hours)

- **Cell Cycle:** Molecular events of G1, S, G2, M phases; roles of cyclins, CDKs, and checkpoint proteins (p53, ATM, ATR).
- **Cell Cycle Control Mechanisms:** DNA damage response, spindle assembly checkpoint, and cell cycle arrest.
- **Abnormalities & Disease:** Dysregulation in cancer, proto-oncogenes, tumor suppressor genes, oncogenic mutations, and therapeutic targets (CDK inhibitors).

- **Cell Division:** Molecular mechanisms of mitosis and meiosis; cytokinesis; chromosomal segregation; role of microtubules and kinetochores.

Unit V: Cell Death Pathways and Aging (15 Hours)

- **Necrosis, Autophagy, Senescence, and Apoptosis** – morphological and molecular features.
- **Mechanisms of Apoptosis:** Intrinsic (mitochondrial) and extrinsic (death receptor) pathways; caspase cascade; role of Bcl-2 family proteins.
- **Apoptosis in Disease:** Cancer, neurodegenerative disorders, immune regulation, and organ transplantation.
- **Autophagy:** Role in homeostasis and disease; selective autophagy pathways (mitophagy, xenophagy).
- **Aging and Cell Death:** Telomere biology, senescence-associated secretory phenotype (SASP), and therapeutic interventions.
- **Emerging Concepts:** Pyroptosis, ferroptosis, necroptosis, and immunogenic cell death.

Suggested Readings

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

DSC Practical 1

(Practical exercises based on DSC 1-3, 1 credit from each)

Hours: 90 **Credits: 3**

Introduction to Microbial World

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.

Fundamentals of 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.

Microbial Cell Biology

Wet Lab Experiments

1. Study of different stages of mitosis.
2. Study of different stages of meiosis.
3. Study of mechanism of diffusion.
4. Study of mechanism of exosmosis and endosmosis.
5. Effect of isotonic, hypotonic and hypertonic solutions on cell.
6. Preparation of splenocytes.

Bioinformatics & Virtual Lab Modules *(Essential where wet lab access is limited)*

Virtual Microscopy & Live-Cell Imaging

Online platforms (e.g., https://www.swissbiopics.org/, https://www.swissbiopics.org/ and https://idr.openmicroscopy.org/) to study subcellular structures

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

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

DSE 1.1 - Microbial Molecular Biology (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 - Microbial Molecular Biology)

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. 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 - Environmental Microbiology (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 CO2 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.
8. Heywood, V.H. and Watson, R.T. Global biodiversity assessment. Cambridge University Press, Cambridge.
9. Evans, G.M. and John, J.C.F. Environmental biotechnology: Theory and applications. John Wiley and Sons, New York.
10. Satyanarayana, T., Johri, B.N. and Prakash, A. Microorganisms in environmental management: Microbes and environment. Springer Verlag, New York.
11. Read related review articles and research papers published recently in reputed journals.

Practical (DSE 1.2 - Environmental Microbiology)

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

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 - Bioinformatics in Microbiology (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 (15hours)

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 4: 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 - Bioinformatics in Microbiology)

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.

PG -Microbiology (II – Semester)

DSC 4 - Analytical techniques in 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 5 - Microbial Physiology and Metabolism (Theory)

Hours: 75 **Credits: 5**

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.

Unit IV – Microbial Transport Systems (15 hours)
Principles of membrane transport, Donnan equilibrium, thermodynamics of transport. Passive and facilitated diffusion, primary and secondary active transport. Group translocation: phosphoenolpyruvate-dependent phosphotransferase system (PEP–PTS) and its role in catabolite repression. ABC transporters: structure, function, and regulation. Protein secretion pathways in bacteria (Sec, Tat, Type I–VI secretion systems).

Unit V: Communication in prokaryotes (15 hours)
Intercellular signaling: pheromone-mediated communication, quorum sensing (AHLs, oligopeptides, AI-2 signaling), biofilm formation. Intracellular signaling: two-component regulatory systems, phosphorelays, secondary messengers (c-di-GMP, ppGpp, cAMP). Cross-kingdom signaling between microbes and hosts/plants.

Suggested Readings

1. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
2. Foster, J.W. and Spector, M.P. Microbial physiology. John Wiley and Sons, New York.
3. Rose, A.H. Advances in microbial physiology. Academic Press, New York.
4. David, W., Drummond, J.T. and Fuqua, C. Physiology and biochemistry of prokaryotes. Oxford University Press, New York.
5. Caldwell, D. R. Microbial physiology and metabolism. Star Publishers, California.

DSC 6 - Recombinant DNA Technology (Theory)

Hours: 75 **Credits: 5**

Unit I: Principles and Tools of Gene Cloning (15 Hours)

- Isolation of nucleic acids: DNA (Genomic, plasmid, bacteriophage) and RNA – traditional and modern extraction techniques.
- Enzymes used in genetic engineering: Restriction endonucleases, ligases, polymerases (Taq, Pfu, Phusion), kinases, alkaline phosphatases, terminal transferases, recombinases, and CRISPR-associated nucleases (Cas9, Cas12, Cas13).
- Cloning vectors: Characteristics and applications of plasmid-based vectors (E. coli and yeast), bacteriophage (λ, M13), cosmids, phasmids, BAC, YAC, PAC, shuttle vectors, plant vectors (Ti and Ri plasmids), animal viral vectors (SV40, Adenovirus, Lentivirus, AAV).
- Recent developments: CRISPR-based cloning tools, and synthetic biology vectors, self-replicating plasmids.

Unit II: Strategies of Gene Cloning (15 Hours)

- General steps of gene cloning and design of recombinant DNA constructs.
- DNA fragment generation: Linkers, adaptors, homopolymer tailing, Gateway cloning, Gibson assembly, Golden Gate cloning.
- DNA delivery methods: Transformation (chemical and electroporation), transfection (liposome-mediated, electroporation, viral vectors), microinjection, biolistics, and CRISPR-based gene integration.
- Library construction: cDNA and genomic libraries; next-generation sequencing (NGS)–based library approaches.
- Selection and screening: Blue-white selection, antibiotic resistance, fluorescence-based screening, colony PCR, immunoscreening, and functional complementation.

Unit III: Expression of Cloned Genes in Prokaryotic and Eukaryotic Systems (15 Hours)

- Architecture and components of expression vectors: Promoters, enhancers, terminators, selection markers, reporter genes, signal peptides, affinity tags.
- Expression systems: Prokaryotic (pET, pBAD), Eukaryotic (pcDNA3, CMV, baculovirus vectors).
- Host systems: E. coli, Bacillus, yeast, fungi, insect cells, mammalian cell lines, transgenic plants and animals.
- Expression of fusion proteins, codon optimization, and post-translational modifications in heterologous hosts.
- Screening and characterization of recombinant proteins: HRT, HART, ELISA, immunoblotting, and mass spectrometry.
- Emerging expression platforms: Cell-free protein synthesis, synthetic biology chassis, and CRISPR-activated gene expression.

Unit IV: Sequence Detection, Amplification and Modification Techniques (15 Hours)

- Blotting techniques: Southern, Northern, Western, and advanced methods (Dot blot, Slot blot, Far-Western).
- Probe labelling (radioactive and non-radioactive), hybridization techniques, and high-throughput detection.

- DNA sequencing: Sanger, Maxam–Gilbert, Next-Generation Sequencing (NGS), Single-Molecule Real-Time (SMRT), Nanopore sequencing.
- PCR: Principle, design, and applications; Types – Degenerate, Multiplex, Hot-start, Nested, Touchdown, Q-PCR, RT-PCR, RACE, Digital PCR, Isothermal amplification methods (LAMP, RPA).
- Site-directed mutagenesis: Oligonucleotide-directed, PCR-based, CRISPR/Cas base editing, and prime editing technologies.

Unit V: Genome Analysis and Applications of Recombinant DNA Technology (15 Hours)

- Genome analysis techniques: Exon trapping, R-loop mapping, S1 mapping, chromosome walking, ribonuclease protection assay, DNA footprinting, gel shift assay, DNA fingerprinting, ChIP-based assays.
- Functional genomics tools: Antisense technology, ribozyme technology, RNA interference (RNAi), CRISPR/Cas9 genome editing, dCas9 for transcriptional regulation.
- Applications of RDT:
    - Forensics: DNA profiling, STR analysis, ancestry tracing.
    - Therapeutics: Recombinant vaccines, monoclonal antibodies, gene therapy, CRISPR-based therapies.
    - Agriculture: Transgenic plants, genome-edited crops, resistance to pests, pathogens, and abiotic stresses.
    - Industrial biotechnology: Enzyme engineering, metabolic engineering, synthetic biology-based biomanufacturing.

Suggested Reading

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. Kingsman, S.M. and Kingsman, A.J. Genetic engineering: An introduction to gene analysis and exploitation in eukaryotes. Blackwell Science, Oxford.
10. Greene, J.J. and Rao, V.B. Recombinant DNA principles and methodologies. Marcel Dekker, New York.
11. Brown, T.A. Genomes. Wiley-Liss, Oxford.
12. Pevsner, J. Bioinformatics and functional genomics. Wiley-Blackwell, New Jersey.
13. Sambrook, J. and Russell, D.W. Molecular Cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.
14. Reece R.J. Analysis of genes and genomes. John Wiley and Sons, New York.
15. Recombinant DNA safety guidelines. Department of Biotechnology, Ministry of

Science and Technology, Government of India, New Delhi.

16. Students are advised to read the recent and comprehensive reviews published in high quality, indexed scientific journals.

DSC Practical 2
(Practical exercises based on DSC 4-6)

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. Determination of molecular weight of DNA by agarose gel electrophoresis.
6. Separation and determination of molecular weight of proteins by SDS-PAGE.
7. Visualization of enzyme activity by NATIVE-PAGE.
8. Interpretation of UV spectra.
9. Interpretation of IR spectra.
10. Interpretation of NMR spectra.
11. Interpretation of Mass spectra.

Microbial Physiology and Metabolism

1. Respiration and Fermentation Studies
- Gas production in fermentation (Durham tube method).
- Determination of fermentation end-products by titration (e.g., lactic acid).

2. Nitrogen and Sulfur Metabolism
- Detection of nitrate reduction.
- H_2S production from sulfur-containing amino acids.

Recombinant DNA Technology

Wet Lab Experiments
1. Isolation of genomic and plasmid DNA from bacteria.
2. Restriction digestion and analysis by agarose gel electrophoresis.
3. Ligation of DNA fragments and preparation of recombinant plasmid.
4. Transformation of competent *E. coli* cells and selection of transformants.
5. PCR amplification of target gene and analysis.
6. Expression of recombinant protein in *E. coli* and SDS-PAGE analysis.
7. Western blotting for detection of recombinant protein.

Bioinformatics-Based Practicals
1. Retrieval of gene sequences from NCBI and sequence analysis.
2. Designing primers for PCR and mutagenesis using online tools.
3. Predicting expression and solubility of recombinant proteins using bioinformatics tools.
4. Phylogenetic analysis of gene sequences.

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.
4. Sambrook, J. and Russell, D.W. Molecular cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.
5. Rhodes, P.M. and Stanbury, P.F. Applied microbial physiology: A practical approach. IRL Press, Oxford.
6. Microbiology: a laboratory manual by Cappuccino, James G
7. Practical Microbiology by RC Dubey, Maheshwari DK
8. Sambrook, J. and Russell, D.W. Molecular cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.
9. Miller, J.H. Experiments in molecular genetics. Cold Spring Harbor Lab Press, New York.
10. Wilson, K. and Walker, J.M. Principles and techniques of practical biochemistry. Cambridge University Press, Cambridge.
11. Chaitanya, K.V. Cell and molecular biology: A lab manual. PHI Learning, New Delhi.
12. Celis, J.E. Cell biology: A laboratory handbook. Elsevier, Amsterdam.

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

DSE 2.1 - Epidemiology (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

Practical (DSE 2.1 - Epidemiology)

Hours: 60 **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

1. Epidemiological Studies: A Practical Guide: A Practical Guide by Tatiana, Alan and Gary

DSE 2.1 - Infection 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.

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. Read related review articles and research papers published recently in reputed journals.

Practical (DSE 2.2 - Infection 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.
5. Determination of the presence of specific antibody for its antigen by Dot-ELISA method.
6. Determination of concentration of antigen by sandwich ELISA.

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

DSE 2.3 - Virology and Mycology (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.

Practical (DSE 2.3 - Virology and Mycology)

Hours: 60 **Credits: 2**

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.
3. One-step growth curve of bacteriophages.
4. Detection of viral antigens using ELISA.
5. Case study analysis of recent viral outbreaks (HIV, SARS-CoV-2, influenza).

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*).
6. Determination of spore germination rate in selected fungi.
7. Detection of mycotoxins (demonstration).

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.