Approved by BOS (12 August, 2026)

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 (I and II semesters)				
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)
	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)
	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).

DEPARTMENT OF MICROBIOLOGY

HEMVATI NANDAN BAHUGUNA GARHWAL UNIVERSITY
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P.G. – Microbiology (III and IV semesters)				
Sem.	**Codes**	**Credits**		**Paper name**
		T	P	
III	DSC-7	5	0	Medical Microbiology
	DSC-8	5	0	Industrial Microbiology
	DSC-9	5	0	Genomics and Proteomics
	DSC-Practical-3	0	3	(Practical exercises based on DSC 7-9)
	DSE-III	4 - -	2 - -	(**Any one of the following)** **E 3.1.** Food Microbiology **E 3.2.** Bioprocess Technology
	Total credits	**19+5=24**		
IV	DSC-10	5	0	Agricultural Microbiology
	DSC-11	5	0	Pharmaceutical Microbiology
	DSC-12	5	0	Research Methodology
	DSC-Practical-4	0	3	(Practical exercises based on DSC 10-12)
	DSE-IV	4	2	**(Any one of the following)** **E 4.1.** Intellectual Property Rights **E 4.2** Drug Designing and Nanobiotechnology
	Total credits	**19+5=24**		
	NHEQF Level-6.5			Student on successfully completing 2-Year PG Programme (i.e., securing minimum required 96 credits will be awarded "Postgraduate Degree", in related field/ discipline/subject.

Note for both first and second semester:

3. 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.

4. 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 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.
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 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 - 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 III: 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. Glick, B.R., Pasternak, J.J. and Patten, C.L. Molecular biotechnology: Principles and applications of recombinant DNA. ASM Press, Washington, D.C.
4. Hartwell, L. Genetics: From genes to genome. McGraw-Hill, New York.
5. Clark, D.P., & Pazdernik, N.J. (2021). *Molecular Biology: Understanding the Genetic Revolution* (4th ed.). Academic Press.
6. Old, R.W. and Primrose, S.B. Principles of gene manipulations. Blackwell Science, Oxford.
7. Winnacker, E.L. From genes to clones: Introduction to gene technology. Wiley-VCH, Germany.
8. Greene, J.J. and Rao, V.B. Recombinant DNA principles and methodologies. Marcel Dekker, New York.
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. Recombinant DNA safety guidelines. Department of Biotechnology, Ministry of Science and Technology, Government of India, New Delhi.
13. 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 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 – 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 IV – 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 I: 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 II: 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 III: 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 IV: 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.

2nd Year

III SEMESTER SLS/MIC/DSC-7: MEDICAL MICROBIOLOGY

Hours: 75 **Credits: 5**

Unit I: Basics of Medical Microbiology (15 Hours)

Normal microbiota of human body; Transient and resident flora; Gut microflora and Human Health. Opportunistic and obligate pathogens; Epidemiological triad; Routes of transmission of pathogens; Infection and types of infections; Pathogenicity islands; Mechanism of pathogenesis: Mechanism of bacterial adhesion, colonization and invasion, Protein toxins (Classification and mode of action), Cytoskeletal modulation of host cell.

Unit II: Antimicrobial Chemotherapy (15 Hours)

Mechanism of action of antimicrobial agents; Methods of drug susceptibility testing: Kirby-Bauer's disc diffusion method, Stokes method, Agar dilution method, Broth dilution method, E-strip method; Emergence of drug resistance in bacteria (MRSA, ESBL and MDR TB); Resistance mechanism; Various types of vaccines for prevention of infectious diseases; National immunization program and immunization schedule.

Unit III: Bacterial Diseases (15 Hours)

Clinical features, transmission, characteristics of causative organism, pathogenesis, laboratory diagnosis, prevention and control of bacterial diseases and clinical syndromes: Cholera, Leprosy, Diphtheria, Tetanus, Meningitis, Conjunctivitis, Pneumonia and Gastroenteritis.

Unit IV: Viral Diseases (15 Hours)

Clinical features, transmission, characteristics of causative organism, pathogenesis, laboratory diagnosis, prevention and control of viral diseases: Herpes, Chikungunya, Influenza, Measles, Mumps, Hepatitis, HIV, Viral cancer.

Unit V: 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.

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

Hours: 75 **Credits: 5**

Unit I: Introduction to Industrial Microbiology (15 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 (15 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 (15 hours)

Strategies for isolation and cultivation of desired microorganisms; Screening for the desired product; Strategies for strain improvement: Mutation, Protoplast fusion, Recombinant DNA technology, Metabolic engineering.

Unit IV: Industrial Production Aspects I (15 hours)

Production aspects (Microbial strains, substrate, product optimisation, and applications) of antibiotics, amino acids and biopolymers.

Unit V: Industrial Production Aspects II (15 hours)

Production of enzymes (pectinase, amylase, lipase, protease, cellulase and xylanase), alcohol and alcoholic beverages, vitamins (B12 and riboflavin), organic acids (citric acid, acetic acid and lactic acid).

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

Hours: 75 **Credits: 5**

UNIT I: Genome Organization, Mapping and Epigenomics (15 Hours)

Structural, comparative and functional genomics; applications of genomics in biology, medicine, agriculture and microbiology;

Organization of prokaryotic and eukaryotic genomes; genome size, C-value, genome complexity, coding and non-coding DNA, repetitive DNA, transposable elements and organellar genomes.

Gene organization in prokaryotes and eukaryotes; operons, gene families, pseudogenes, regulatory regions and genome architecture.

Genetic mapping: linkage analysis, recombination frequency, pedigree analysis and mapping functions; bacterial genetic mapping.

Molecular markers: RFLP, VNTR/SSLP, SNPs and microsatellites; applications in genotyping, linkage mapping and population studies.

Physical mapping: restriction mapping, FISH, sequence-tagged sites, contig construction and chromosome-level genome organization.

Epigenomics: DNA methylation, histone modifications, chromatin remodeling, genomic imprinting and X-chromosome inactivation.

Methods for DNA methylation analysis: methylation-sensitive PCR, bisulfite sequencing and quantitative methylation assays.

Chromatin organization and epigenetic regulation of gene expression; relationship between epigenetic states, genome stability and disease.

UNIT II: Genome Sequencing, Assembly, Annotation and Comparative Genomics (15 Hours)

Principles and strategies of whole-genome sequencing: clone-by-clone and whole-genome shotgun approaches.

Sanger sequencing and next-generation sequencing: sequencing-by-synthesis and high-throughput sequencing workflows; read generation and quality assessment.

Third-generation sequencing: single-molecule real-time sequencing and nanopore sequencing; advantages, limitations and applications.

Genome assembly: quality control, de novo and reference-guided assembly, contigs, scaffolds, genome finishing and assembly-quality metrics.

Genome annotation: identification of coding sequences, ORFs, regulatory elements, non-coding RNAs and functional annotation.

Comparative genomics: orthologs, paralogs, synteny, conserved regions, gene families and pan-genomes.

Genome variation: SNPs, indels and structural variation; variant detection and biological interpretation.

Human Genome Project and major genome projects; outcomes, applications, limitations, ethical and societal issues.

Metagenomics: shotgun metagenomics, marker-gene approaches, taxonomic profiling, functional profiling and applications in microbial ecology and human health.

UNIT III: Transcriptomics, Gene Expression and Functional Genomics (15 Hours)

Transcriptome organization and principles of global gene-expression analysis.

Conventional approaches: Northern hybridization, cDNA analysis, RACE and reporter-gene assays.

Microarray technology: DNA chips, oligonucleotide arrays, tiling arrays, experimental design, normalization and interpretation.

SAGE and MPSS: principles, applications and limitations.

RNA sequencing: library preparation, sequencing, read quality control, mapping/assembly, transcript quantification and differential gene-expression analysis.

Alternative splicing, isoform analysis, non-coding RNAs and transcriptome complexity.

Comparative transcriptomics, co-expression analysis and pathway-level interpretation.

Single-cell transcriptomics: basic principles, workflow, clustering and applications; comparison with bulk RNA-seq.

Functional genomics: gene knockdown/knockout, RNA interference, CRISPR-based perturbation, transposon mutagenesis and genome-wide screening.

Determining gene function: homology analysis, gene targeting, gene trapping, overexpression, loss-of-function and gain-of-function approaches.

Integrative analysis of gene-expression data and functional enrichment.

UNIT IV: Proteomics and Protein Identification (15 Hours)

Proteome organization and scope of structural, functional, comparative and quantitative proteomics.

Protein extraction, separation and analysis; SDS-PAGE, isoelectric focusing and two-dimensional gel electrophoresis.

Mass spectrometry principles: ionization, mass-to-charge ratio, mass analyzers and tandem mass spectrometry.

MALDI-TOF and electrospray ionization; peptide mass fingerprinting and tandem MS/MS-based protein identification.

Bottom-up and top-down proteomics; enzymatic digestion, peptide separation and database-assisted identification.

Quantitative proteomics: label-free analysis, stable-isotope labeling and isobaric tagging; differential proteomics.

Protein post-translational modifications: phosphorylation, glycosylation, acetylation, ubiquitination and strategies for PTM identification.

Protein sequencing by mass spectrometry; interpretation of peptide spectra, sequence coverage, false-discovery rate and confidence in identification.

Targeted proteomics: selected/multiple reaction monitoring and applications.

Proteomic biomarkers, clinical proteomics, microbial proteomics, drug discovery and systems biology.

Proteogenomics and integration of proteomic data with genome and transcriptome information.

UNIT V: Protein Interactions, Proteogenomics, Bioinformatics and Integrative Omics (15 Hours)

Protein-protein interaction analysis: yeast two-hybrid, co-immunoprecipitation, affinity purification-mass spectrometry and interaction mapping.

Phage-display libraries and protein microarrays; principles, applications and limitations.

Chromatin immunoprecipitation and ChIP-seq for analysis of DNA-protein interactions and chromatin regulation.

Proteogenomics: integration of genome, transcriptome and proteome data for improved genome annotation and functional interpretation.

Multi-omics integration: genomics, transcriptomics, proteomics and metabolomics; pathway, network and systems-level analysis.

Bioinformatics resources and databases: NCBI, Ensembl, UniProt, PDB, GEO, SRA and PRIDE; principles of sequence and protein-data retrieval.

Sequence analysis: BLAST, pairwise and multiple sequence alignment, phylogenetic interpretation, conserved motifs and domains.

Protein analysis: primary/secondary/tertiary structure, domain architecture, molecular weight/pI, subcellular localization and functional annotation.

Suggested readings (Theory and Practicals)

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. Altelaar, A.F.M., Munoz, J. and Heck, A.J.R. Next-generation proteomics: towards an integrative view of proteome dynamics. Nature Reviews Genetics.
11. Baxevanis, A.D. and Bader, G.D. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Wiley.
12. Recent research and review articles published in indexed journals on genome sequencing, RNA-seq, quantitative proteomics, single-cell and multi-omics.
13. Wilson, K. and Walker, J.M. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
14. Sambrook, J. and Russell, D.W. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press.
15. Pevsner, J. Bioinformatics and Functional Genomics. Wiley-Blackwell.
16. Liebler, D.C. Introduction to Proteomics: Tools for the New Biology. Humana Press.
17. Current protocols and public datasets from NCBI, GEO, SRA, UniProt and PRIDE

DSC-Practical-3 (Practical exercises based on DSC 7-9)

Hours: 90 **Credits: 3**

MEDICAL MICROBIOLOGY

1. Isolation and biochemical characterization of pathogenic bacteria and fungi from clinical specimens.
2. Determination of antimicrobial susceptibility of pathogens by Kirby-Bauer's disc diffusion method.
3. Determination of MIC and MBC concentration of antibiotics by broth dilution test.

INDUSTRIAL MICROBIOLOGY

1. Isolation and screening of bacterial and fungal cultures for enzyme production.
2. Media formulation for enhanced enzyme production by microbial culture via liquid and solid-state fermentation.
3. Optimization of culture conditions for enhanced enzyme production by microbial culture via liquid and solid-state fermentation.
4. Production of wine from fruit juice.
5. Monitoring of sugar reduction during wine production.
6. Estimation of alcohol concentration in wine.

GENOMICS AND PROTEOMICS

1. **Genomic DNA isolation and quality assessment:** Isolation of genomic DNA; concentration/purity assessment and agarose-gel evaluation of integrity.
2. **Restriction digestion and DNA analysis:** Restriction digestion, agarose gel electrophoresis and fragment-size estimation; interpretation of a simple restriction map.
3. **PCR-based genotyping:** Primer selection/design, amplification of a target locus, controls and interpretation of PCR products.
4. **DNA methylation analysis:** Analysis of a methylation-sensitive PCR or bisulfite-conversion dataset and interpretation of methylation status.
5. **Genome database and sequence analysis:** NCBI/ENA retrieval of a genome; analysis of genome size, GC content, genes and annotated features.
6. **BLAST and comparative sequence analysis:** BLAST search, homolog identification, multiple sequence alignment and interpretation of conserved regions.
7. **RNA-seq/transcriptomics data analysis:** Interpretation of read counts, normalization, fold change and differential-expression results from a prepared dataset.
8. **Protein separation and 2-D PAGE data interpretation:** SDS-PAGE/2-D PAGE analysis, molecular-weight estimation and interpretation of differential protein abundance.
9. **Mass-spectrometry-based protein identification:** Interpretation of MALDI-TOF/ESI-MS data or supplied peptide mass fingerprinting results; database-based protein identification.
10. **Protein database/domain analysis:** UniProt retrieval; domain/motif identification; molecular weight/pI and subcellular-localization analysis.
11. **Protein-protein interaction analysis:** Interpretation of yeast two-hybrid or affinity-purification data and construction/interpretation of an interaction network.
12. **Integrated omics mini-exercise:** Integration of a genome, transcriptome or proteome dataset to identify a candidate gene/protein and infer its function.

III SEMESTER SLS/MIC/DSE 3.1: FOOD MICROBIOLOGY

Hours: 60 **Credits: 4**

Unit I: Principles of Food Preservation (12 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 (12 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: Foodborne Infections and Intoxications (12 hours)

Bacterial and nonbacterial infections and intoxications of *Brucella*, *Bacillus*, *Clostridium*, *Escherichia*, *Salmonella*, *Staphylococcus*, *Vibrio*, *Yersinia*, nematodes, algae, fungi and viruses; Structure and functions of aflatoxins.

Unit IV: Food Safety and Quality Assurance (12 hours)

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

Unit V: Production of Fermented Foods (12 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.

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. Ayres, J.C., Mundt, O. and Sandinee, W.E. Microbiology of foods. W.H. Freeman and Company, New York.
11. Hobbs, B.C. and Roberts, D. Food poisoning and food hygiene. Edward Arnold, London.
12. Roberts, D., Greenwood, M., Practical Food Microbiology, John Wiley and Sons Ltd
13. Shen, C., Zhang, Y. (2023) Food Microbiology Laboratory for the Food Science Student: A Practical Approach, Springer
14. Aneja, K.R. Experiments in Microbiology, Plant Pathology, Tissue Culture and Microbial Biotechnology, New Age International Private, Limited
15. Read related review articles and research papers published recently in reputed journals.

III SEMESTER SLS/MIC/DSE 3.1P: FOOD MICROBIOLOGY-Practical

Hours: 60 **Credits: 2**

1. Microbiological examination of food.
2. Assay of quality of milk sample using MBRT test.
3. Adulteration tests for milk.
4. Microbial production of curd.
5. 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 acidity of vinegar.

III SEMESTER SLS/MIC/DSE 3.2: BIOPROCESS TECHNOLOGY

Hours: 60 **Credits: 4**

Unit I: Bioreactor Design (12 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); Designing of a bioreactor: Bioreactor configuration, Design features, Parts of bioreactor; Reactor with non-ideal mixing; Sterilization reactors; Multiphase bioreactors; Animal and plant cell reactor technology.

Unit II: Fermentation Process and Kinetics (12 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; Biomass productivity and metabolic productivity; Basic principles of operation; Optimization and modelling of fermentation process: Single variable design, Multivariate screening designs, Critical factor analysis, Optimization designs for two or more factors, Singlet method, Metabolic and flux control analysis.

Unit III: Mass and Energy: Transfer and Balance (12 hours)

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

Unit IV: Downstream Processing (12 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.

Unit V: Instrumentation and Control (12 hours)

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

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. Hershnergev, C.L., Queener, S.W. and Hedemen, Q. Genetics and biotechnology of industrial microorganisms. ASM Press, Washington, D.C.
8. Reed, G. Prescott and Dunn's industrial microbiology. Globe Bookservices, London.
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. Kalaichelvan, P.T. and Arulpandi, I. Bioprocess technology. MPJ Publishers, Chennai.
13. Asenjo, J.A. Separation process in biotechnology. Marcel Dekker, New York.
14. Belter, P.A. Cussler, E.L. and Hu, W.S. Bioseparation: Downstream processing for biotechnology. John Wiley and Sons, New York.
15. Peppler, H.J. and Perlman, D. Microbial technology. Academic Press, New York.

III SEMESTER SLS/MIC/DSE 3.2P: BIOPROCESS TECHNOLOGY- Practical

Hours: 60 **Credits: 2**

1. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microorganisms for design of a sterilizer.
2. Inoculum preparation for bioreactor.
3. Media formulation for enhanced enzyme production by microbial culture *via* batch fermentation.
4. Extraction of intracellular and extracellular enzyme produced by microbial culture *via* batch fermentation.
5. Optimization of culture conditions for enhanced enzyme production by microbial culture *via* batch fermentation.
6. Determination of oxygen transfer rate.
7. Determination of substrate degradation profile.
8. Immobilization of microbial cells and enzyme.

IV SEMESTER

SLS/MIC/DSC-10: AGRICULTURAL MICROBIOLOGY

Hours: 75 **Credits: 5**

Unit I: Abiotic and Biotic Components of Soil (15 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; Organic matter dynamics in soil: Microbial decomposition of cellulose, hemicellulose and lignin, Factors affecting organic matter decomposition, Unculturable soil biota.

Unit II: Rhizosphere and Rhizoplane Microorganisms (15 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, Production of plant growth promoting hormones from bacteria and fungi, Production of antibiotics by plant growth promoting microorganisms.

Unit III: Biocontrol Agents for Agriculturally Important Crop Plants (15 hours)

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

Unit IV: Biofertilizers (15 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.

Unit V: BIS and GMO (15 hours)

BIS standards recommendation for biofertilizers (nitrogenous/phosphatic biofertilizers), production and its economics; methods of biofertilizer inoculation and microbial communities in the soil/on seeds; Use of genetically-engineered microorganisms in biotechnology, bioinsecticides, biofertilizers

Reference Books

1. Subba Rao, N.S. Soil microorganisms and plant growth. Oxford and IBH Publishing Company, New Delhi.
2. Alexander, M. Introduction to soil microbiology. John Wiley and Sons, New York.
3. 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., Fundamental Agricultural Microbiology, New Age International Private Limited, India
10. Read related review articles and research papers published recently in reputed journals.

IV SEMESTER SLS/MIC/DSC-11: PHARMACEUTICAL MICROBIOLOGY

Hours: 75 **Credits: 5**

Unit I: Drug Discovery (15 hours)

Introduction to pharmacogenomics; High throughput screening; 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 (15 hours)

Screening and development strategies for new antimicrobial agents; Bioassay of antimicrobial agents using standard guidelines; Factors affecting bioassay;

Unit III: Microbial Production and Spoilage of Pharmaceutical Products (15 hours)

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)

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.

Unit V: Regulatory practices and applications in pharmaceuticals (15 hours)

Financing R&D capital and market outlook; IP, BP and USP; Government regulatory practices and policies; FDA perspective; Reimbursement of drugs and biological; Legislative perspective.

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. Gale E.F., Cundliffe, E., Reynolds, P.E., Richmond, M.H. and Waring, M.J. The molecular

basis of antibiotic action. John Wiley and Sons, New York.
12. Graly, J.O. and Joubert, P.H. Handbook of phase I / II clinical drug trials. CRC Press, Boca Raton.
13. Satoskar, R.S. and Bhandarkar, S.D. Pharmacology and pharmacotherapeutics. Popular Prakashan, Mumbai.

IV SEMESTER SLS/MIC/DSC-12: RESEARCH METHODOLOGY

Hours: 75 **Credits: 5**

Unit I: Research Problem and Experimental Planning (15 hours)

Literature survey; Identification of research problem; Defining the aim and objectives, Planning of experimental work: Designing of experimental protocol; Principles of experimental designs; Randomized block and Latin square designs; Description of strategies to meet the objectives.

Unit II: 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 IV: 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 IV: 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).

Unit V: Scientific Writing (15 hours)

Different types of scientific writing: Thesis, Book, Review, Proceedings, Research article, Research proposal; Title, Abstract, Introduction, Aims and objectives, Review of literature, Methodology, Results, Discussion, Summary and Conclusions, Bibliography.

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.

DSC-Practical-4 (Practical exercises based on DSC 10-12)

Hours: 90 **Credits: 3**

AGRICULTURAL MICROBIOLOGY

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

PHARMACEUTICAL MICROBIOLOGY

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.

RESEARCH METHODOLOGY

1. Literature survey on selected problem and its proper citation.
2. Defining aim and objectives of the problem.
3. Statistical and graphical representation of data.
4. Normal distribution.

IV SEMESTER SLS/MIC/DSE 4.1: INTELLECTUAL PROPERTY RIGHTS

Hours: 60 **Credits: 4**

Unit I – Basic Aspects of Intellectual Property Rights (12 Hours)

Introduction to Intellectual Property Rights (IPR); concept, scope and importance of intellectual property; evolution and role of IPR in innovation and research; role of WIPO; major types of intellectual property rights: copyright; trademarks including collective marks, certification marks and well-known marks; industrial designs; geographical indications; patents; plant breeders' rights; importance and business relevance of IPR for industry and academia; relationship of IPR with microbiology and biotechnology; intellectual property generated through academic and industrial research; ownership, inventorship and authorship; trade secrets and confidential information; non-disclosure agreements (NDAs); responsible disclosure of research findings and basic institutional IP considerations.

Unit II – International Treaties and Global Framework for Intellectual Property (12 Hours)

International framework for protection of intellectual property; role of WIPO and WTO; historical development and significance of major international instruments: Paris Convention, Berne Convention, Rome Convention, WIPO Copyright Treaty, WIPO Performances and Phonograms Treaty, Madrid Agreement, Madrid Protocol, Lisbon Agreement, Hague Agreement and Patent Cooperation Treaty (PCT); TRIPS Agreement and its relationship with GATT and international trade; principles of national treatment and minimum standards; enforcement and dispute-settlement mechanisms under TRIPS; implications of TRIPS for developing countries; relationship between IPR, international trade, technological development and access to medicines/health technologies; international harmonization of patent systems and its implications for biotechnology.

Unit III – Patents, Patentability and Patent Searching (12 Hours)

Concept and significance of patents; patent terminology; invention, inventor, applicant, assignee and priority; patent specification and structure; abstract, description, drawings and patent claims; independent and dependent claims; patent term/life and geographical boundaries; utilization and commercialization of patents; licensing; elements of patentability: novelty, inventive step/non-obviousness, industrial applicability and enabling disclosure; patentable and non-patentable subject matter with reference to biotechnology and biological inventions; procedure for grant of patents in India, with comparative overview of USA and European systems; PCT application and international patenting route; prior art and patentability assessment; patent search methods and strategies; patent databases including IP India, WIPO PATENTSCOPE, USPTO and EPO/Espacenet; patent families, classification and citation searching; patent mapping, technology landscapes and basic freedom-to-operate concepts; patent harmonization; case studies of patents in microbiology and biotechnology.

Unit IV – Patent Acts, Pharmaceutical IP and Patent Infringement (12 Hours)

Overview of the Indian Patents Act and important provisions/amendments relevant to biotechnology and pharmaceuticals; comparative overview of European and US patent systems; patent issues in drugs and pharmaceuticals; generic medicines; compulsory licensing; exclusive marketing rights; Bolar provision; Bayh-Dole Act and its significance for academic research commercialization; second medical use; patent infringement and identification of potentially infringing subject matter; case studies; defenses to infringement including experimental/research use; patent misuse and other legal considerations; enforcement measures; patent valuation; competition and confidentiality issues; assignment of intellectual property rights; licensing and technology-transfer agreements; commercialization of university and biotechnology innovations; research-to-market pathways.

Unit V – Protection of Plant Varieties and Traditional Knowledge (12 Hours)

Protection of plant varieties and interface between technology and IPR in the context of plants; TRIPS provisions relating to plant varieties; key features of UPOV 1978 and UPOV 1991; Indian law and institutional framework for protection of plant varieties; Protection of Plant Varieties and Farmers' Rights (PPV&FR) framework; plant breeders' rights, farmers' rights and researchers' rights; DUS (Distinctness, Uniformity and Stability) criteria; sui generis system for protection; patenting of genetically modified plants; significance of IPR in agricultural biotechnology; case studies from agricultural biotechnology; traditional knowledge: importance and relevance for developing nations; approaches for protection of traditional knowledge; biopiracy and benefit-sharing concepts; traditional knowledge databases and defensive protection; case studies of patenting of traditional health foods and biological resources.

Suggested References and Reading

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.*

IV SEMESTER SLS/MIC/DSE 4.1: INTELLECTUAL PROPERTY RIGHTS-Practical

Hours: 60 **Credits: 2**

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. Claims exercise: mark independent/dependent claims and identify essential technical features.
11. Patent landscape: collect and categorize patents around an assigned topic such as antimicrobial peptides, microbial enzymes, probiotics, diagnostics or natural products.
12. Technology mapping: group retrieved patents by applicant/assignee, year, jurisdiction and technological theme.

13. Basic FTO exercise: identify potentially relevant active patent documents and explain why the exercise is preliminary and not a legal opinion.
14. Pharmaceutical IP case study: generic medicine, compulsory licensing or patent-infringement dispute.
15. Biotechnology case study: vaccine, diagnostic, recombinant product or microbial process patent.
16. Plant variety case study: DUS, breeders' rights, farmers' rights and researchers' rights.
17. Traditional-knowledge case study: identify claims of biopiracy and benefit-sharing issues.
18. Confidentiality exercise: decide what should be kept confidential before publication or patent filing.
19. Prepare a one-page invention disclosure for a hypothetical microbiological invention.
20. Draft a simplified patent abstract and 2–3 illustrative claims for the hypothetical invention.
21. Mini-project: prepare a 3–5 page patent landscape and oral presentation on a selected microbiology/biotechnology technology.

Practical Record / Outputs (Minimum 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.

IV SEMESTER SLS/MIC/DSE 4.2: DRUG DESIGNING AND NANOBIOTECHNOLOGY

Hours: 60 **Credits: 4**

Unit I: Drug Receptor Interactions (12 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 (12 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: Structure Activity Relationship (12 hours)

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

Unit IV: Molecular Modelling (12 hours)

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

Unit V: Nanobiotechnology (12 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.

Suggested Readings (Theory and Practical)

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

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

IV SEMESTER

SLS/MIC/DSE 4.2: DRUG DESIGNING AND NANOBIOTECHNOLOGY- Practical

Hours: 60 **Credits: 2**

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 (Practical)

1. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.
2. Ausubel, F.M., Breut, R., Kingston, R.E. and Moore, D.D., Siedman, J.G., Smith, J.A. and Struhl, K. Short protocols in molecular biology. Wiley, New York.
3. Balows, A., Hausler, W.J., Ohashi, M. and Turano, A. Laboratory diagnosis of infectious diseases: Principles and practice. Springer-Verlag, New York.
4. Baltz, R.H., Demain, A.L and Davies, J.E. Manual of industrial microbiology and biotechnology. ASM Press, Washington, D.C.
5. Baxevanis A.D and Ouellette, B.F.F. Bioinformatics – A practical guide to the analysis of genes and proteins. Wiley – Interscience, New York.
6. Burrell, R.G. and Mascoli, C.C. Experimental immunology. Burgess Publishing Company, Stockland.
7. Chorghade, M.S. Drug discovery and development. John Wiley and Sons, New York.

8. Clayton, D. and Hills, M. Statistical models in epidemiology. Oxford University Press, Oxford.
9. Collee, J.C., Duguid, J.P., Fraser, A.C. and Marimon, B.P. Mackie and McCartney practical medical microbiology. Churchill Livingstone, London.
10. Dewick, P.M. Medicinal natural products: A biosynthetic approach. John Wiley and Sons, New York.
11. Faddin, J.F.M. Biochemical tests for identification of medical bacteria. Williams and Wilkins, Baltimore.
12. Garcia, L.S and Isenberg, H.D. Clinical microbiology procedures handbook. ASM Press, Washington, D.C.
13. Graly, J.O. and Joubert, P.H. Handbook of phase I / II clinical drug trials. CRC Press, Boca Raton.
14. Grubb, P.W. Patents for chemicals, pharmaceuticals and biotechnology: Fundamentals of global law, practice and strategy. Oxford University Press, Oxford.