Approved by BoS (12 August, 2026)

COURSE CONTENTS & SYLLABUS

(Effective from the Academic Year 2026-2027)

PG (One Year) - MICROBIOLOGY

National Education Policy (NEP) - 2020

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

DEPARTMENT OF MICROBIOLOGY

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

P.G (1 year). - Microbiology				
Sem.	**Codes**	**Credits**		**Paper name**
		T	P	
I	DSC-7	3	2	Infection Microbiology
	DSC-8	3	2	Applied Industrial Microbiology
	DSC-9	3	2	Basics of Genomics and Proteomics
	DSC-10	3	2	Food Safety Microbiology
	DSE-III	3 -	1 -	(**Any one of the following**) **E 3.1.** Biomanufacturing Technology **E 3.2.** Microbes and Ecosystem Functioning
	Total credits	**15+9=24**		
II	DSC-11	3	2	Applied Pharmaceutical Microbiology
	DSC-12	3	2	Plant Microbe Interactions
	DSC-13	- 10 -		**Option-II major** Dissertation/project work (in lieu of any two DSC)
	DSC-14			
	DSE-IV	3	1	(**Any one of the following**) **E 4.1.** Research Methods **E 4.2.** Intellectual Property Governance
	Total credits	**24**		
	NHEQF Level- 6.5	Student after successfully completing 1-Year PG Programme i.e., securing minimum 48 credits will be awarded “Postgraduate Degree” of one year, in related field/discipline/subject.		

Sem I; DSC-7: INFECTION MICROBIOLOGY (Theory)

Credits: 3 **Hours: 45**

Unit I: Pathogenesis and Antimicrobial Chemotherapy (15 h)

Pathogenicity islands; Mechanism of pathogenesis: Mechanism of bacterial adhesion, colonization and invasion, Protein toxins (Classification and mode of action), Cytoskeletal modulation of host cell; Mechanism of action of antimicrobial agents; Emergence of drug resistance in bacteria (MRSA, ESBL and MDR TB); Resistance mechanism; Various types of vaccines for prevention of infectious diseases.

Unit II: Bacterial and Viral Diseases (15 h)

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

Unit III: Protozoal and Fungal Diseases (15 h)

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.

Reference Books

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.

DSC-7P: INFECTION MICROBIOLOGY (PRACTICAL)

Credits: 2 **60 h**

1. Biosafety guidelines and biosafety levels.
2. Collection, transportation and processing of clinical samples.
3. Isolation and biochemical characterization of pathogenic bacteria.
4. Isolation and identification of fungal pathogens from clinical specimens.
5. Determination of antimicrobial susceptibility of pathogens by disc diffusion test.
6. Determination of MIC and MBC concentration of antibiotics by broth dilution test.

Reference Books

McCartney, J. E., Collee, J. G., & Mackie, T. J. (1989). *Practical medical microbiology*. Charchil Livingstone.

Sem I; DSC-8: APPLIED INDUSTRIAL MICROBIOLOGY (Theory)

Credits: 3 **45 h**

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 (10 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 (10 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 (10 hours)

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

DSC-8: APPLIED INDUSTRIAL MICROBIOLOGY - Practicals

Credits: 2 **60 h**

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.

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.

Sem I; DSC-9: Basics of Genomics and Proteomics

Credits: 3 **Hours: 45**

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

- 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 and regulatory regions.
- Genetic mapping: linkage analysis, recombination frequency, pedigree analysis and mapping functions; bacterial genetic mapping.
- Molecular markers: RFLP, VNTR/SSLP, SNPs, microsatellites and their applications in genotyping and mapping.
- Physical mapping: restriction mapping, FISH, sequence-tagged sites, contig construction and chromosome-level genome organization.
- Epigenomics: DNA methylation, histone modifications, chromatin remodeling and genomic imprinting; global and gene-specific DNA methylation analysis.
- Methods for DNA methylation analysis: methylation-sensitive PCR, bisulfite-based approaches and quantitative methylation assays.

UNIT II: Genome Sequencing, Assembly and Comparative Genomics (9 h)

- Principles and strategies of whole-genome sequencing; clone-by-clone and whole-genome shotgun approaches.
- Sanger sequencing and next-generation sequencing (NGS): sequencing-by-synthesis and related high-throughput platforms; basic workflow, read generation and quality assessment.
- Third-generation sequencing: single-molecule real-time sequencing and nanopore sequencing; advantages, limitations and applications.
- Genome assembly: read quality control, de novo and reference-guided assembly, contigs, scaffolds and genome finishing.
- Genome annotation: identification of coding sequences, ORFs, regulatory elements, non-coding RNAs and functional annotation.
- Comparative genomics: orthologs, paralogs, synteny, conserved regions, pan-genomes and genome-wide evolutionary comparisons.
- Genome variation: SNPs, indels and structural variation and their biological significance.
- Human Genome Project and subsequent large-scale genome projects; outcomes, applications, limitations and ethical considerations.

UNIT III: Transcriptomics and Functional Genomics (9 h)

- 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 massively parallel signature sequencing (MPSS): principles, applications and limitations.
- RNA sequencing (RNA-seq): library preparation, read mapping/assembly, transcript quantification and differential gene-expression analysis.

- Comparative transcriptomics, co-expression analysis and pathway-level interpretation.
- Single-cell transcriptomics: basic principles, workflow and applications.
- 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.

UNIT IV: Proteomics and Protein Identification (9 h)

- Proteome organization and scope of structural, functional, comparative and quantitative proteomics.
- Protein extraction, separation and analysis; two-dimensional gel electrophoresis (2-DE), isoelectric focusing and SDS-PAGE.
- Mass spectrometry principles: ionization, mass-to-charge ratio, mass analyzers and tandem mass spectrometry.
- MALDI-TOF and electrospray ionization (ESI); peptide mass fingerprinting and tandem MS/MS-based protein identification.
- Bottom-up and top-down proteomics; enzymatic digestion, peptide separation and database-assisted protein identification.
- Quantitative proteomics: label-free analysis, stable-isotope labeling and isobaric tagging; basic concepts of differential proteomics.
- Protein post-translational modifications: phosphorylation, glycosylation, acetylation and ubiquitination; strategies for PTM identification.
- Protein sequencing by mass spectrometry and interpretation of peptide/protein identification data.
- Applications of proteomics in biomarker discovery, microbial pathogenesis, drug discovery, diagnostics and systems biology.

UNIT V: Protein Interactions, Proteogenomics and Integrative Omics (9 h)

- Protein-protein interaction analysis: yeast two-hybrid, affinity purification-mass spectrometry, co-immunoprecipitation and protein interaction mapping.
- Phage-display libraries and protein microarrays; principles, applications and limitations.
- Chromatin immunoprecipitation (ChIP) 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 and proteomics; 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.
- Basic computational analysis: BLAST, multiple sequence alignment, phylogenetic interpretation, protein-domain/motif analysis and functional annotation.
- Applications of integrated omics in precision medicine, antimicrobial resistance, cancer biology, metabolic engineering and microbial biotechnology.
- Emerging technologies: long-read sequencing, single-cell omics, spatial omics and single-cell proteomics—principles and applications.

DSC-9: GENOMICS AND PROTEOMICS – (Practicals)

60 Hours **2 Credits**

1. **Genomic DNA isolation and quality assessment:** Isolation of genomic DNA; concentration/purity assessment and agarose-gel evaluation of integrity.
2. **Restriction mapping and DNA analysis:** Restriction digestion, agarose gel electrophoresis, fragment-size estimation and interpretation of a restriction map.
3. **DNA marker/genotyping analysis:** Analysis of RFLP, SSR or SNP data; genotype/allele frequencies and interpretation of genetic variation.
4. **PCR-based gene amplification:** Primer selection/design, target amplification, controls, gel analysis and troubleshooting.
5. **DNA methylation analysis:** Analysis of methylation-sensitive PCR or bisulfite-conversion data and interpretation of gene-specific methylation.
6. **Genome database exploration:** NCBI/ENA retrieval of complete or draft genomes; genome size, GC content, coding sequences and annotation.
7. **Genome sequence quality and assembly:** Analysis of sequencing-read quality or prepared data; contigs, scaffolds and basic assembly statistics.
8. **Genome annotation and comparative genomics:** ORF/gene identification, BLAST analysis, homolog identification and comparative interpretation.
9. **RNA-seq/transcriptomics analysis:** Interpretation of read counts, normalization, fold change, differential expression and biological significance.
10. **Microarray/SAGE dataset analysis:** Normalization concepts, expression profiles and identification of differentially expressed genes.
11. **Protein separation analysis:** SDS-PAGE/2-D PAGE data interpretation, molecular-weight estimation and differential protein abundance.
12. **Mass-spectrometry protein identification:** Interpretation of MALDI-TOF/ESI-MS data, peptide mass fingerprinting and database-based protein identification.
13. **Protein database/domain analysis:** UniProt retrieval; domain/motif identification; molecular weight/pI and subcellular-localization analysis.
14. **Protein-protein interaction analysis:** Interpretation of yeast two-hybrid or affinity-purification data and construction of interaction networks.
15. **Integrated multi-omics mini-project:** Integration of genome/transcriptome/proteome data to identify a candidate gene/protein and prepare a biological interpretation.

Suggested Reading

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

10. Baxevanis, A.D. and Bader, G.D. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Wiley.
11. Relevant and recent review, research articles published in reputed journals on sequencing, transcriptomics, proteomics, single-cell and multi-omics.

Suggested Practical References

1. Wilson, K. and Walker, J.M. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
2. Sambrook, J. and Russell, D.W. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press.
3. Pevsner, J. Bioinformatics and Functional Genomics. Wiley-Blackwell.
4. Liebler, D.C. Introduction to Proteomics: Tools for the New Biology. Humana Press.
5. Current protocols and public datasets from NCBI, GEO, SRA, UniProt and PRIDE.

Sem I; DSC-10: Food Safety Microbiology – (Theory)

Credits: 03 **45 h**

Unit I: Principles of Food Preservation (15 hours)

Food as substrate for microorganisms; Factors influencing microbial growth in food; Food preservation: Principles, Physical methods (Dehydration, freeze drying, heat and irradiation), Chemical methods (Chemical preservatives and food additives); Canning; Processing for heat treatment (D, Z and F values).

Unit II: Contamination and Spoilage (15 hours)

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

Unit III: Production of Fermented Foods (15 hours)

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

Sem I; DSC-10: Food Safety Microbiology – (Practical)

Credits: 02 **60 h**

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

Suggested Readings (Theory and Practical)

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

Sem I; DSE 3.1: Biomanufacturing Technology – (Theory)

Credits: 3 **45 h**

Unit I: Bioreactor Design (15 h)

Introduction to fermentation technology; Ideal bioreactor; Types of bioreactor (Stirred tank bioreactor, airlift bioreactor, continuous stirred tank bioreactor, immobilized cell reactors, plug flow reactor, tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors and trickle flow reactors).

Unit II: Fermentation Process and Kinetics (10 h)

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.

Unit III: Downstream Processing (10 h)

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.

Sem I; DSE 3.1: Biomanufacturing Technology – Practicals

Credits: 1 Credit **Hours: 30 h**

1. Inoculum preparation for bioreactor.
2. Media formulation for enhanced enzyme production by microbial culture *via* batch fermentation.
3. Extraction of intracellular and extracellular enzyme produced by microbial culture *via* batch fermentation.
4. Optimization of culture conditions for enhanced enzyme production by microbial culture *via* batch fermentation.

Reference Books

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. Veith, W.F. Bioprocess engineering kinetics, mass transport, reactors and gene expressions. John Wiley and Sons, New York.
4. Pauline, D. Bioprocess engineering principles. Academic Press, New York.
5. Lydersen, B., Elia, N.A.D. and Nelson, K.M. Bioprocess engineering: Systems, equipment and facilities. John Wiley and Sons, New York.
6. Hershnergev, C.L., Queener, S.W. and Hedemen, Q. Genetics and biotechnology of industrial microorganisms. ASM Press, Washington, D.C.

Sem I; DSE 3.2: Microbes and Ecosystem Functioning – (Theory)

Credits: 3 Credit **Hours: 45 h**

Unit I: Fundamentals of Microbial Ecology

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: Microbial Interactions

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

Unit III: Impact of Microbes on Environment

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

Reference Books

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

Sem I; DSE 3.2P: Microbes and Ecosystem Functioning – (Practicals)

Credits: 1 Credit **Hours: 30 h**

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

Sem II; DSC-11: Applied Pharmaceutical Microbiology

Credits: 3 **45 h**

Unit I: Drug Discovery (10 hours)

Introduction to pharmacogenomics; High throughput screening; Phases of drug discovery: Bioprospecting, Principles of extraction, purification and characterization of bioactive molecules from natural resources, Candidate drug selection, Preclinical trials, Clinical trial phase I/II/III; Toxicological evaluation of drug.

Unit II: Development of Antimicrobial Agent (10 hours)

Screening and development strategies for new antimicrobial agents; Bioassay of antimicrobial agents using standard guidelines; Factors affecting bioassay; Laboratory methods to assess activity of antimicrobial combinations (Antagonism, synergism and additive effect).

Unit III: Microbial Production and Spoilage of Pharmaceutical Products (10 hours)

Manufacturing procedures and in process control of pharmaceuticals; Pharmaceuticals produced by microbial fermentations (Streptokinase and streptodornase); Vaccines: Multivalent subunit vaccines, Purified macromolecules, Synthetic peptide vaccines, Immuno-adhesions, Recombinant antigen vaccines, Vector vaccines, Anti-idiotype vaccines, Targeted immune stimulants.

Unit IV: Quality Assurance and Validation (15 hours)

Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry; Basic principles of quality control (QA) and quality assurance (QC); Regulatory aspects of quality control; Quality assurance and quality management in pharmaceuticals: Guidelines for QA and QC (Raw materials, sterilization, media, stock cultures and products), ISO, WHO and US certification; Sterilization control and sterility testing: Heat sterilization, D value, z value, Survival curve, Radiation, gaseous and filter sterilization, Chemical and biological indicators.

DSC-11: Applied Pharmaceutical Microbiology - (Practical)

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.

Reference Books

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.

Sem II; DSC-12: Plant–Microbe Interactions – (Theory)

Credits: 3 Credit **Hours: 45 h**

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

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

Unit II: Rhizosphere and Rhizoplane Microorganisms (11 hours)

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

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

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

Unit IV: Biofertilizer (12 hours)

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

Sem II; DSC-12: Plant–Microbe Interactions – (Practical)

Credits: 2 Credit **Hours: 60 h**

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

Suggested Readings (Theory and Practical)

1. Subba Rao, N.S. Soil microorganisms and plant growth. Oxford and IBH Publishing Company, New Delhi.
2. Alexander, M. Introduction to soil microbiology. John Wiley and Sons, New York.
3. Molina, G., Usmani, Z., Sharma, M., Yasri, A., Gupta, V.K. (2023). Microbes in Agri-Forestry Biotechnology. Taylor and Francis group.
4. Dubey, R.C. and Kumar, P. (2022). Rhizosphere Engineering, Elsevier, USA
5. Kononova, M.M. Soil organic matter: Nature, its role in soil formation and in soil

fertility. Pergamon, Oxford.

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

Sem II; DSE 4.1: RESEARCH METHODS

Credits: 3 **Hours: 45 h**

Unit I: Data Collection and Hypothesis Testing **15h**

Data, types of data: Sampling techniques: Sample size; Recording of data and data summarisation; Measures of dispersion: Range, Quartile deviation, Mean deviation, Standard deviation, Coefficient of variation; Probability: Random experiment, Events, Sample space, Mutually exclusive events, Independent and dependent events, Statement of addition and multiplication theorems of probability; Hypothesis; Hypothesis-Testing Procedure; Sample Size, Tests for Differences between Means: Test for Differences between Proportions;

Unit II: Analysis of Variance **15h**

Analysis of Variance; One- way and two-way ANOVA, Inferences about Population Variance; Standard curves: Correlation, Linear regression (fitting of best line through a series of points), MLR, Multiple collinearity, Standard curves and interpolation of unknown Y-values; Chi-Square Test; The Sign Test for Paired Data; Rank Sum Tests: The Mann-Whitney U Test and the Kruskal-Wallis Test; The One-Sample Runs Test; Rank Correlation; The KolmogorovSmirnov Test.

Unit III: Basics of Bioinformatics **15h**

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).

Reference Books

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.

Sem II; DSE 4.1: RESEARCH METHODS – (Practicals)

Credits: 1 Credit **Hours: 30 h**

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

Reference Books

1. Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

Higgins, D., & Taylor, W. (2000). *Bioinformatics: Sequence, Structure and Databanks: A Practical Approach* (Vol. 236). OUP Oxford

Sem II; DSE 4.2: Intellectual Property Governance

Credits: 3 **Hours: 45h**

Unit I: Basic Aspects of Intellectual Property Rights (9 h)

Introduction to IPR; Intellectual property; WIPO; Types of Intellectual Property Rights: Copyrights, Trademarks (Collective marks, certification marks and well-known marks),Industrial designs, Geographical indications, Patents, Plant breeder's rights; Importance and business interest of IPR for industry and academia; Relationship of IPRs with biotechnology; Trade secrets; Non-disclosure agreements.

Unit II: International Treaties for Protection of Intellectual Property (9 h)

Brief background of different treaties: WIPO copyright treaty, Berne convention, Rome convention, TRIPS agreement, WIPO performances and phonograms treaty, Madrid agreement, Madrid protocol, Paris convention, Lisbon agreement, Hague agreement, Patent Cooperation Treaty; Relationship between IPR and trade: WTO, TRIPS Agreement, GATT, Enforcement and dispute settlement under the TRIPS agreement, Implication of TRIPS for developing countries in the overall WTO system.

Unit III: Patents (9 h)

Patent terminology; Patent claims; Patent life and geographical boundaries; Utilization of intellectual patents; Licensing of patents; Elements of patentability; Procedure for grant of patent in India, USA and Europe; PCT application; Patent search invention in context of "prior art"; Patent search methods; Patent databases and libraries; Country-wise patent searches (USPTO, EPO, ARIPO and India); Patent mapping; Patent harmonization; Case studies of patents in biotechnology.

Unit IV: Patent Acts, Issues in Pharmaceuticals and Patent Infringement (9 h)

Patent acts and latest amendments of Indian, European and US patent systems; Patent issues in drugs and pharmaceuticals: Generics, Compulsory licensing, Exclusive marketing rights, Bolar provision, Bayh-Dole act, Second medical use; Patent infringement (Case studies, defenses to infringement including experimental use, patent misuse, legal considerations, enforcement measures, patent valuations, competition and confidentiality issues); Assignment of Intellectual Property Rights; Technology Transfer Agreements.

Unit V: Protection of Plant Varieties and Traditional Knowledge (9 h)

Protection of plant varieties: Interface between technology and IPRs in the context of plants, Key features of UPOV 1978, UPOV 1991 and TRIPS with respect to IPRs on plants, Indian law on protection of plant varieties, DUS criteria, *Sui* generis system for protection, Patenting of genetically modified plants, Significance of IPRs in agricultural biotechnology: Case studies; Traditional knowledge: Importance and relevance of traditional knowledge for developing nations, Various approaches for protecting traditional knowledge, Case studies of patenting of health foods.

Intellectual Property Governance-Practical

Credits: 1 **Hours: 30h**

1. Online search for patents in WIPO site.
2. Case studies of different patents: Basmati, Neem, Turmeric, Oncomouse, Bald mouse, Novartis gleevec, Cre-lox, Diamond versus Chakrabarty, Round up ready crops.
3. Theoretical exercises for identifying the protection of different elements of a common discovery under different types of IPR.

Reference Books

1. Subbaram N. Patents. Pharma Book Syndicate, Hyderabad.
2. Ganguli, P. Intellectual property rights. Tata Mc-Graw Hill, New Delhi.
3. Shippey, K.C. A short course in international intellectual property rights: Protecting your brands, marks, copyrights, patents, designs and related rights worldwide. World Trade Press, Petaluma.
4. Bently, L. and Sherman, B. Intellectual property law. Oxford University Press, Oxford.
5. Parulekar, A. and D'Souza, S. Indian patent law: Legal and business implications. MacMillan Press, London.
6. Grubb, P.W. Patents for chemicals, pharmaceuticals and biotechnology: Fundamentals of global law, practice and strategy. Oxford University Press, Oxford.
7. Knight, H.J. Patent strategy: For researchers and research managers. John Wiley and Sons, New York.
8. Bryant, J.L. Protecting your ideas: The inventor's guide to patents. Academic Press, New York.
9. Durham, A.L. Patent law essentials: A concise guide. Quorum books, Westport.
10. Gordon, T.T. and Cookfair, A.S. Patent fundamentals for scientists and engineers. CRC Press, Boca Raton.
11. Halpern, S. Fundamentals of United States intellectual property law: Copyright, patent and trademark. Springer-Verlag, New York.
12. Santaniello, V., Evenson, R.E., Zilberman, D. and Carlson, G.A. Agriculture and Intellectual Property Rights: Economic, institutional and implementation issues in biotechnology. CABI Publications, New York.