**THE UNIVERSITY OF BURDWAN**

Curriculum and Credit Framework for Postgraduate Programme (CCFPP), as per N.E.P. 2020, w.e.f. 2026 – 2027 TWO YEAR POSTGRADUATE PROGRAMME In

# MICROBIOLOGY

**Department of Microbiology**
**THE UNIVERSITY OF BURDWAN**

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04.06.2026
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**Semester wise and Course wise Distribution of Credit & Marks under CCFUP as per NEP, 2020**

| SEMESTER | Course Type | Code | Name of the Course | Credit | L – T - P | Marks | Marks Dist. Th. – Pr. - IA |
|---|---|---|---|---|---|---|---|
| I | Major/Core Course | PG2MICR1011 | Research methodology, Publication Ethics, IPR and Indian Knowledge System | 6 | 4-0-2 | 75 | 40 – 20 – 15 |
| | Major/Core Course | PG2MICR1012 | Microbial and Viral Pathogenesis | 6 | 4-0-2 | 75 | 40 – 20 – 15 |
| | Major/Core Course | PG2MICR1013 | Microbes in sustainable agriculture | 6 | 4-0-2 | 75 | 40 – 20 – 15 |
| | Major/Core Course | PG2MICR1014 | Essential Tools for advanced Microbiology | 6 | 4-0-2 | 75 | 40 – 20 – 15 |
| | Minor Course | PG2MICR1021 | Any 4 Credits course from SWAYAM Or Introduction to General & Applied Microbiology | 4 | 3-0-1 | 75 | 40 – 20 – 15 |
| | Total | | | 28 | | 375 | |

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|---|---|---|---|---|---|---|---|
| II | Major/Core Course | PG2MICR2011 | Instrumentation and Biotechniques | 6 | 4-0-2 | 75 | 40 – 20 – 15 |
| | Major/Core Course | PG2MICR2012 | Microbial Ecology and Diversity | 4 | 3-0-1 | 75 | 40 – 20 – 15 |
| | Major/Core Course | PG2MICR2013 | Industrial Microbiology | 4 | 3-0-1 | 75 | 40 – 20 – 15 |
| | Major/Core Course | PG2MICR2014 | Review, Educational Tour and Social Inter-linkage | 4 | 0-0-4 | 75 | 0 – 60 – 15 |
| | Minor Course | PG2MICR2021 | Any 4 Credits course from SWAYAM or Aquatic and aero-microbiology | 4 | 3-0-1 | 75 | 40 – 20 – 15 |
| | **Total** | | | **22** | | **375** | |

**Semester-I**

**Major**

**Course Title: Research methodology, Publication Ethics, IPR and Indian Knowledge System (PG2MICR-1011)**

(FM- 75; Theory-40, Practical -20, Internal- 15)

**Course Objectives:**

The primary objectives of this course are to:

a) Systematise the Research Process: Guide students through the structural workflow of scientific inquiry—from formulating testable hypotheses and designing rigorous experiments to writing successful grant proposals.
b) Develop Data & Presentation Literacy: Equip students with advanced digital skills using spreadsheet engines for statistical analysis and professional presentation tools for scientific communication.
c) Instil High Ethical Standards: Cultivate a deep understanding of academic integrity, helping students identify and avoid scientific misconduct such as plagiarism, data fabrication, and predatory publishing.
d) Navigate the Modern Publishing Ecosystem: Familiarise students with open-access paradigms, journal indexing metrics (h-index, i10-index, Impact Factor), and digital selection tools.
e) Demystify Intellectual Property: Provide a foundational understanding of the legal mechanics behind Patents, Copyrights, and Trademarks to protect scientific innovations.
f) Bridge Heritage with Modern Science: Connect ancient Indian Knowledge Systems—specifically traditional food fermentation and ethnobotanical pharmacology—to contemporary microbiological practices.

**Expected Course Outcomes:**

Upon successful completion of this course, students will be able to:

(a) Design rigorous experimental research layouts and draft standard-compliant project proposals for minor/major funding agencies.
(b) Utilise spreadsheets to manage datasets, perform core statistical computations, generate publication-grade graphs, and deliver compelling scientific presentations.
(c) Evaluate journals for ethical integrity, avoiding predatory outlets while using tools like SHERPA/RoMEO to assess self-archiving permissions.
(d) Compute and interpret vital research metrics (such as a journal's Impact Factor or an author's h-index) across Scopus and Web of Science databases.
(e) Formulate a baseline strategy for filing patents or securing copyrights/trademarks for their independent scientific discoveries.
(f) Evaluate the scientific, microbial, and biochemical principles driving traditional Indian fermented foods, beverages, and native medicinal plants.

**Pedagogical Approaches:**

To successfully balance academic theory with the required 20-mark practical/hands-on component, a mixed-mode instructional strategy is recommended:

(a) Interactive Lectures & Case Studies: Use historical and modern real-world case studies to dissect publication ethics violations (e.g., famous retractions due to salami slicing or data falsification) and IPR legal battles.

(b) Flipped Classroom & Tool Walkthroughs: Dedicate continuous sessions to screen-sharing walkthroughs of Scopus, Web of Science, Sherpa/RoMEO, and Elsevier/Springer journal finders.

(c) Hands-on Laboratory & Computer Practicals: Implement dedicated lab hours where students actively practice data entry, formula execution, regression/ANOVA testing in spreadsheets, and presentation drafting.

(d) Grant Writing Simulation: Have students select a mock research problem and draft a mini-research proposal matching standard funding formats (e.g., DBT, DST, ICMR guidelines) as part of their internal assessment.

(e) Experiential Learning (IKS Lab Work): Integrate simple bench-top laboratory exercises, such as isolating lactic acid bacteria from traditional *Dahi* or *Kanji*, or preparing crude extractions of *Neem* and *Tulsi* to test against common microbial strains via disc diffusion assays.

**Theory: 4 Credits**

**Unit 1:** Research methodology-Research in question and its classification; Research process and scientific writing for publication and research fund-Types, Research process and steps in it, Hypothesis, Research proposals and aspects; Research Design: Definition, Need, Problem, variables, research design concepts; Literature survey and review; Research design process; Errors in research; Scientific writing: Pre-writing considerations, Publications in Research journals; Research institutes, research schemes (minor and major), preparation of research scheme proposals, formats, and role funding agencies **5 Hrs**

**Unit 2:** Computer Applications- Spreadsheet Tool: Introduction to spreadsheet application, features and functions, using formulas and functions, Data storing, Features for Statistical data analysis, Generating charts/graphs and other features. Tools used may be Microsoft Excel, Open Office or a similar tool; Presentation Tool: Introduction to presentation tool, features and functions, Creating presentation, customizing presentation, showing presentation. Tools used may be Microsoft PowerPoint, Open Office or a similar tool; Web Search: Introduction to Internet, Use of Internet and WWW, using search engines like Google, Yahoo, etc., using advanced search techniques **10 Hrs**

**Unit 3 :** Research and Publication Ethics-Philosophy of ethics-Definition, Nature and scope, concept, branches; Scientific conduct-Ethics with respect to science and research; Intellectual honesty and research integrity, Scientific misconducts, falsification and fabrication, plagiarism, Redundant publications: Duplicate and overlapping publications, salami slicing,

selective reporting and mis-presentation of data, Violation of publication ethics, authorship and contributorship, Conflict of interest. Predatory publishers and journals; Open access publications and initiatives, SHERPA/RoMEO online resource to check publisher copyright & self-achieving policies, Journal finder/journal suggestion tool viz., ZAME, Elsevier journal Finder, Springer journal suggester **8 Hrs**

**Unit 4:** Indexing databases, citation databases: Web of science, Scopus; Impact Factor of journal as per journal Citation report, Metrics: h-index, i10 index **2 Hrs**

**Unit 5:** Nature of intellectual properties (IP); Principles of IP Rights (IPR); Patent-Prerequisite of Patentability: Laws and Practices, Patent infringements; Laws and practices for Copyright, Trademark, Plant variety protection Law and Practices; Moral and Ethical Rights **5 Hrs**

**Unit 7:** Introduction to Indian Knowledge System, traditional fermented foods (sour rice, Dahi, fermented soyabean) and drinks (Kanji, Chach) ; Use of medicinal plants for the treatment of various diseases (Tulsi, Basak, Neem, Turmeric) **10 Hrs**

**Practical:** **2 Credits (40 Hrs)**

1. Drafting a research proposal for extramural grant application
2. Drafting a research project/Dissertation
3. Drafting a research paper and review
4. Plagiarism detection & similarity analysis
5. Journal Selection & Open Access Evaluation- using tools like Sherpa/RoMEO and Elsevier Journal Finder
6. Calculating Research Metrics (h-index, i10-index)- to analyse researcher impact using Scopus and Web of Science
7. Patent Search & Mapping- to search Indian and International patent databases for "prior art."
8. Documentation of Traditional Knowledge (IKS)- Document the preparation and benefits of a traditional food/drink

**Suggested Readings:**


1. Kothari, C. R., & Garg, G. (2019). *Research Methodology: Methods and Techniques* (4th New Age International Edition).
2. Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). SAGE Publications.
3. Day, R. A., & Gastel, B. (2016). *How to Write and Publish a Scientific Paper* (8th ed.). Cambridge University Press.
4. Walkenbach, J. (2016). *Microsoft Excel 2016 Bible*. John Wiley & Sons.

5. Alexander, M., & Kusleika, R. (2019). *Access and Excel Data Analysis: Your visual blueprint for creating and analyzing data, charts, and PivotTables*. Wiley.
6. Committees on Publication Ethics (COPE). *Guidelines on Good Publication Practice*. (Available Open-Access online).
7. Chaddah, P. (2018). *Ethics in Competitive Research: Do not copy, do not steal*. Macmillan Publishers India.
8. Beall, J. (2012). *Predatory publishers are corrupting open access*. Nature, 489(7415), 179-179.
9. Ahuja, V. K. (2017). *Law Relating to Intellectual Property Rights* (3rd ed.). LexisNexis.
10. Wadehra, B. L. (2016). *Law Relating to Patents, Trademarks, Copyright, Designs and Geographical Indications*. Universal Law Publishing.
11. Kapoor, K., & Singh, A. K. (2021). *Indian Knowledge Systems: Nature and Science*. Indian Institute of Advanced Study.
12. Tamang, J. P. (2016). *Ethnic Fermented Foods and Beverages of India: Science History and Culture*. Springer Nature.
13. Soni, S. K. (2007). *Microbes: A Source of Energy for 21st Century (Focusing on Traditional Fermented Foods)*. New India Publishing Agency.
14. Prajapati, J. B., & Nair, B. M. (2003). *The History of Fermented Foods in the Indian Subcontinent*. In *Handbook of Fermented Functional Foods*. CRC Press.

**Major**

**Course Title: Microbial and Viral Pathogenesis, and their therapeutic management (PG2MICR-1012)**

(FM- 75; Theory-40, Practical -20, Internal- 15)

**Course Objectives:**

The primary objectives of this course are to:

a) Unpack Host-Microbe Dynamics: Establish a baseline understanding of normal human microbiota and contrast it against the molecular mechanisms of invasion, colonization, and toxigenicity (endotoxins vs. exotoxins).
b) Master Diagnostic Methodologies: Bridge classical microbiology with rapid, cutting-edge molecular diagnostics (ELISA, PCR, and Immunofluorescence).
c) Dissect Pathogenic Taxa: Map the comprehensive etiology, symptoms, transmission modes, and intracellular mechanics of key bacterial, viral, fungal, and protozoal human pathogens.
d) Deconstruct Antimicrobial Pharmacology: Analyse the chemical mode of action of specialised antibacterial, antifungal, and antiviral agents at the cellular level.
e) Address Resistance Dynamics: Critically evaluate the emergence, genetic mechanisms, and global healthcare threat of antimicrobial resistance (AMR).
f) Cultivate Bench Competency: Train students in essential clinical microbiology laboratory techniques, from diagnostic assays to efficacy testing and selection media.

**Expected Course Outcomes**

Upon successful completion of this course, students will be able to:

a) Distinguish between mutualistic microflora and opportunistic/nosocomial pathogens across different human anatomical niches.
b) Select and conceptually troubleshoot molecular and immunological diagnostic workflows for active clinical infections.
c) Evaluate the specific virulence factors and cellular target mechanisms behind classic respiratory, gastrointestinal, systemic, and sexually transmitted infections.
d) Categorise antimicrobial drugs based on their metabolic or structural targets and predict the cellular outcomes of treatment.
e) Quantify antimicrobial susceptibility and determine Minimal Inhibitory Concentrations (MIC) using standard CLSI-aligned laboratory protocols.
f) Select, inoculate, and interpret differential and selective media (EMB, MacConkey, MSA) to identify unknown clinical bacterial strains.

**Pedagogical Approaches:**

To successfully balance academic theory with the rigorous 60-hour practical component, the following teaching methods should be deployed:

a) Case-Based Clinical Learning: Introduce real-world medical case studies where students must analyse patient symptoms, trace transmission routes, and propose rapid diagnostic pipelines (e.g., PCR vs. ELISA).
b) Mechanistic Visualisations: Use interactive structural animations to illustrate how toxins enter host cells (e.g., the A-B subunit mechanism of Cholera and Botulinum) and how drugs interfere with cell wall or protein synthesis.
c) Themed "Bug-Drug" Matching Seminars: Organise flipped-classroom presentations where students pair a specific pathogen from Units 3–6 with its respective therapeutic option from Unit 7, explaining the mechanism of action.
d) Structured Laboratory Practicals: Execute systematic, wet-lab benchmarking where students actively transition from gathering raw samples (skin swabs, oral saliva) to isolation, drug susceptibility testing (Kirby-Bauer), and quantitative pharmacology calculations (MIC).

**Theory:** **4 Credits**

**Unit 1:** Normal microflora of the human body and its importance: Microflora of skin, respiratory tract, gastrointestinal tract, urogenital tract.

Host pathogen interaction: Definitions- Infection, Invasion, entry, colonization, Pathogenicity, Virulence, bacterial toxins- exotoxins (Cholera and botulinum) and endotoxins and Toxigenicity; Opportunistic infections, Nosocomial infections. Transmission of infection, Concept of host and carrier **5 Hrs**

**Unit 2:** Diagnosis of disease, conventional method and rapid detection method (ELISA, PCR, Immunofluorescence) **5 Hrs**

**Unit 3:** Bacterial diseases: Bacterial disease of various organs and their causative agents; symptoms, mode of transmission, pathogenesis, and control
Respiratory diseases (Tuberculosis), GI Tract disease (Cholera, Peptic ulcer), Sexually transmitted disease (Syphilis) **5 Hrs**

**Unit 4:** Various viral diseases of human and their causative agents: Viral diseases with symptoms, mode of transmission, pathogenesis and control: AIDS, Dengue, Influenza (Sars-Cov-2) **5 Hrs**

**Unit 5:** Fungal Diseases: Various fungal disease of humans and their causative agents; Symptoms, mode of transmission, pathogenesis and control: Candidiasis, Aspergillosis **5 Hrs**

**Unit 6:** Unit 5. Protozoal Diseases: Various Protozoal disease of humans and their causative agents; symptoms, mode of transmission, pathogenesis and control: Malaria and Amoebiasis **5 Hrs**

**Unit 7:** Antibacterial agents: Source, general characteristics, mode of action; Mode of action-Inhibition of nucleic acid biosynthesis (nalidixic acid), Cell wall biosynthesis (penicillin), protein synthesis (streptomycin), inhibition of metabolism (sulphonamide), membrane (nisin)
Antifungal agents: Source, Mechanism of action of amphotericin B, Griseofulvin
Antiviral agents: Source, and mode of action of Amantadine, Acyclovir
General idea of antibiotic resistance and its significance. **10 Hrs**

**Practical** **2 Credits (40 Hrs)**

1. Study of bacterial flora of skin by the swab culture method
2. Determination of oral health of students by Snyder Test
3. Study of antibacterial sensitivity of one Gram-positive and one Gram-negative bacteria by the Kirby Bauer Assay
4. Determination of the Minimal Inhibitory Concentration of an antibiotic
5. Study of composition and use of important differential media for the identification of bacteria: EMB Agar, McConkey Agar, Mannitol Salt Agar
6. Determination of the effectiveness of any hand sanitiser using treated and untreated hand impressions on rich solidified medium

**Suggested Readings:**


1. Jawetz, Melnick, & Adelberg's (2019). *Medical Microbiology* (28th ed.). McGraw-Hill Education.
2. *Excellent for Unit 1 through Unit 6 host-pathogen clinical breakdowns.*
3. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2020). *Brock Biology of Microorganisms* (16th ed.). Pearson.
4. Murray, P. R., Rosenthal, K. S., & Pfaller, M. A. (2020). *Medical Microbiology* (9th ed.). Elsevier.

5. Flint, S. J., Racaniello, V. R., Rall, G. F., Hatziioannou, T., & Skalka, A. M. (2020). *Principles of Virology* (5th ed., Vol. 1 & 2). ASM Press.
6. Arora, D. R., & Arora, B. (2019). *Medical Parasitology* (5th ed.). CBS Publishers & Distributors.
7. Ananthanarayan, R., & Paniker, C. K. J. (2020). *Textbook of Microbiology* (11th ed.). Orient BlackSwan.
8. Walsh, C., & Wencewicz, T. (2016). *Antibiotics: Challenges, Mechanisms, Opportunities*. ASM Press.
9. Cappuccino, J. G., & Welsh, C. (2019). *Microbiology: A Laboratory Manual* (12th ed.). Pearson.

**Major**

**Course Title: Microbes in Sustainable Agriculture (PG2MICR-1013)**

(FM- 75; Theory-40, Practical -20, Internal- 15)

**Course specific objectives:**

a) Interpreting microbial challenges in agriculture and aquaculture that threatens global food security: mastering identification, prevention, and integrated management (chemical and biological) of bacterial, viral, and fungal diseases in staple crops, as well as microbial infections affecting finfish and shellfish.
b) Address the principles of plant-pathogen interactions: understanding how hosts recognize threats, deploy biochemical defences, and how integrated management strategies mitigate global crop losses. Bridge the gap between theoretical plant pathology/entomology and real-world field application, transforming students into interdisciplinary "plant health practitioners" capable of delivering immediate, field-level solutions to farmers.
c) Equip students with a comprehensive, advanced understanding of plant genetic engineering techniques, moving from molecular gene-transfer mechanics to real-world agricultural applications and regulatory oversight. By the end of the course, students will be able to evaluate how transgenic technology is deployed to solve global food security challenges, critique the environmental and biosafety impacts of Genetically Modified Organisms (GMOs), and navigate the regulatory frameworks governing controlled field trials.
d) Provide students with an advanced, mechanistically detailed understanding of the root-soil-microbe interface and to develop practical competencies in utilizing beneficial microorganisms as sustainable alternatives to synthetic agrochemicals. By exploring the physical, biochemical, and ecological dynamics of the rhizosphere, students will learn to isolate, mass-produce, and deploy PGPR and biofertilizers to enhance crop productivity.
e) Understanding of plant immunization technologies, shifting away from traditional chemical treatments toward molecular and biological defence priming. Students will master the core concepts, molecular pathways, and biotechnology tools used to induce

systemic immunity in crops, while critically evaluating the practical field applications and regulatory or biological limitations of deploying plant vaccines in modern sustainable agriculture.

**Course specific outcome:**

Upon successful completion of this course, students will be able to:

a) Explore and understand the dynamic biological, biochemical, and genetic processes underlying plant diseases. By examining host-pathogen co-evolution, they will understand how pathogens hijack plant systems and how plants deploy multi-layered molecular immune responses to resist infections.
b) Acquire knowledge regarding plant genetic engineering, a foundational agricultural tool that is reshaping agricultural practices, thereby providing farmers a tool to cultivate climate-resilient, high-yield and pest-resistant crops ultimately ensuring global food security even under challenging environmental conditions and also ward off threats that typically ruin harvests.
c) Understanding the concepts of plant growth enhancing rhizobacteria would provide them with a scientific framework on how to reduce reliance on synthetic agrochemicals and achieve sustainable, eco-friendly agricultural productivity.
d) Further explore microbial inoculants (biofertilizers) that are a source of sustainable agricultural solutions containing plant beneficial microorganisms. By naturally enhancing soil health, they help to reduce dependence on synthetic fertilizers, lower greenhouse gas emissions, and promote long-term farm productivity.
e) The concept of plant vaccines would provide knowledge regarding prevention and control of crop diseases while minimizing economic losses and environmental impact.

**Pedagogical Approaches:**

a) Plant pathogens significantly impact global food security. Managing them requires an integrated approach combining chemical interventions and biological controls.
b) Modern techniques allow researchers to introduce or edit traits in commercial crops that help them withstand drought, salinity, and extreme temperatures. This foundational technology ensures global food security by cultivating climate-resilient, pest-resistant, and high-yielding varieties.
c) The study of plant growth promoting rhizobacteria emphasizes on the biological mechanisms, environmental applications, and sustainable agricultural practices involving these natural biofertilizers.It bridges microbiology, agronomy, and sustainable farming, replacing harmful synthetic chemicals with eco-friendly alternatives.
d) Plant vaccination, also referred to as green vaccination, involves providing information on how to induce systemic resistance in plants using elicitor compounds rather than traditional chemical pesticides.

**Theory:** **4 Credits**

**Unit 1:** Diseases of agricultural plants and animals: Important diseases in agricultural crops by bacteria (early blight of potato, bacterial panicle blight), viruses (CaMV) and fungi (rust of wheat) and their control strategies (chemical and biological). Microbial diseases of aquacultural animals- finfish and shell fish, their prevention strategies and treatment **10 Hrs**

**Unit 2:** Significance of plant diseases; Molecular mechanism of disease development, Gene- for- gene concept, Defense mechanism in host; innate and adaptive immunity of plants, Role of Pathogenesis related proteins, phytoalexins, phytoncides, plantibodies, SAR; Hypersensitive response and Programmed cell death. Control of diseases (cultural, physical, biological, biotechnological); Plant Clinic and Plant Doctor Concept **10 Hrs**

**Unit 3:** Concept of transgenics and its current status; Gene transfer to plants- direct, Ti plasmid mediated, applications of plant genetic engineering for crop improvement: resistance against insect, abiotic stress, herbicide; Biofortification, bio-safety norms. Controlled field trials and environmental impacts of Genetically Modified Organisms (GMO'S) **8 Hrs**

**Unit 4:** Concept of Rhizodeposition, rhizosphere effect, R:S ratio; Function, mechanism and application of Plant growth promoting rhizobacteria (PGPR) in sustainable agriculture; Microbes as biofertilizer; mass production and field applications. **8 Hrs**

**Unit 5:** Concept of plant vaccines, mechanism of action, applications and limitations **4 Hrs**

**Practical** **2 Credits (40 Hrs)**

1. Isolation of *Rhizobium* from root nodules of leguminous plants, identification by phenotypic characterization
2. Isolation of free-living nitrogen fixing bacteria, *Azospirillum* and study of their distinguished features
3. Isolation of phosphate solubilizing bacteria and determination of phosphate solubilizing potential
4. Detection of IAA produced by plant growth promoting bacteria
5. Selection of sustainable carrier material for biofertiliser formulation
6. Production of carrier-based mass inoculants and its application

**Suggested Readings:**


1. Fundamentals of Plant Pathology by Mehrotra, R. S. McGraw Hill Education (India), 2013. ISBN: 1259029557
2. Reddy, S.M. et. al.(2002). Bioinoculants for sustainable agriculture and forestry, Scientific Publishers.
3. Agrios, George N. Agrios#39; Plant Pathology. Academic Press, 2024.
4. Maier RM, Pepper IL and GerbaCP. (2009). Environmental Microbiology.2 nd edition, Academic Press.

5. Hurst CJ, Crawford RL, Garland JL, Lipson DA (2007) Manual of Environmental Microbiology, 3 rd edition, ASMpress.
6. Kannaiyan, S. (2003). Bioetchnology of Biofertilizers, CHIPS, Texas.
7. Mahendra K. Rai (2005). Hand book of Microbial biofertilizers, The Haworth Press, Inc. NewYork.
8. Reddy, S.M. et. al.(2002). Bioinoculants for sustainable agriculture and forestry, Scientific Publishers.

**Major**

**Course Title: Essential Tools for advance Microbiology (PG2MICR-1014)**

(FM- 75; Theory-40, Practical -20, Internal- 15)

**Course Objective**

a) To acquaint the students to versatile tools and techniques employed in recombinant DNA technology
b) To develop an understanding of the molecular tools (restriction enzymes, vectors, modifying enzymes) required for gene manipulation.
c) To conceptualize properties and applications of versatile DNA modifying enzymes, cloning strategies, vector types, host genotype specificities for selection and screening of recombinants and/or recombinant clones.
d) To explore the ethical, legal, and biosafety implications of genetically modifying organisms.
e) To illustrate creative use of modern tools and techniques for manipulation and analysis of genomic sequences and to expose students to use recombinant DNA technology in biotechnological research

**Expected Course Outcomes:**

Upon successful completion of this course, students will be able to:

a) Design independently and execute complex microbiological experiments
b) Perform molecular biology experiments regarding restriction digestion, PCR, cloning, gene expression etc.
c) Design and optimize gene cloning strategies using appropriate cloning, vectors
d) Analyze the mechanisms of gene transfer (transformation) and successfully identify recombinant clones.
e) Interpret data from molecular techniques like PCR, agarose gel electrophoresis, and DNA sequencing.
f) Understand the strategies to check protein-protein interaction through yeast two hybrid, immunoprecipitation etc.
g) Analysis of genes through basic bioinformatic tools
h) Moving beyond basic cloning to edit whole genomes within microbial hosts, enabling engineered bacteria that can consume plastics or degrade toxic pollutants through CRISPR technology

i) Develop concepts of sequence alignment (pairwise and multiple) and similarity searching via different types of BLAST. Idea of finding different parameters of a protein and its localization through software. Concept of predicting the secondary structure of protein by software and its analysis. Basic idea about evolutionary relationship analysis by different types of phylogenetic tree building methods. Applying the principles of statistics for designing microbiological experiment, statistical analysis of data and their interpretation.

**Pedagogical Approaches:**

A hybrid teaching model blends theory with hands-on technical skills is achieved through practical exposures and group discussions

a) Traditional didactic lectures are paired with pre-class readings or video-based modules for gene editing
b) Direct bench experience is essential. Key experiments should include: Preparation of competent cells and bacterial transformation, Restriction digestion and agarose gel electrophoresis, PCR amplification and Primer Designing, Blue-white screening of recombinants
c) Using online tools, virtual labs, and sequence manipulation software
d) Group discussions centered on the ethical dilemmas of genetically modified (GM) crops, gene therapy etc.

**Theory: 4 Credits**

**Unit 1:** Bioinformatics-Concept of different types of BLAST, PROTPARAM, Protein localization (CELLO), Multiple sequence alignment, Secondary Structure Prediction (SOPMA), Different approaches of phylogenetic tree construction - Neighbour joining, Maximum Parsimony, Maximum likelihood

Biostatistics-Principles of statistical analysis of biological data. Scope of statistics: utility in biological research. Sampling parameters: concept of sample and population, Standard Error **5 Hrs**

**Unit 2:** Basics of PCR, Types of PCR: Nested PCR, Inverse PCR, Multiplex PCR, RT-PCR, Real-Time PCR; Sanger's method of DNA Sequencing: traditional and automated sequencing, Primer walking and shotgun sequencing, next generation sequencing **5 Hrs**

**Unit 3:** Restriction modification systems: Restriction enzymes- Types I, II and III, DNA modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyl transferase, kinases and phosphatases, and DNA ligases; Cloning Vectors: Definition and Properties of plasmid vectors: pBR and pUC series, Bacteriophage lambda and M13 based vectors cosmids, TA cloning, TOPO cloning**,** Gateway cloning**,** ligation-independent cloning (LIC)**,** Sequence and Ligase Independent Cloning (SLIC), BACs, YACs, Use of linkers and adaptors Expression vectors: *E. coli* lac and T7 promoter-based vectors**,** Transformation of DNA: Chemical method, Electroporation Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral mediated delivery**;** DNA mutation: Site directed mutagenesis, in frame deletion, transposon mutagenesis **15 Hrs**

**Unit 4:** Southern and Northern blotting techniques, dot blot, SDS-PAGE, 2D-gel, Western blotting, Yeast two hybrid, Yeast one hybrid, Immunoprecipitation, Chromatin immunoprecipitation, immunolocalisation, phage Display, South-Western, EMSA and DNaseI foot printing, DNA fingerprinting **5 Hrs**

**Unit 5:** Construction of genomic and cDNA libraries, Screening of libraries, Colony hybridization and colony PCR, Chromosome walking and chromosome jumping **5 Hrs**

**Unit 6:** Gene Editing Tools- Basic concept of siRNA technology, Basic concept of Clustered regularly interspaced short palindromic repeats (CRISPR)/Cas9 technology and applications; Nanotechnology: Concept and applications**;** Systems biology: Concept and application**;** Synthetic biology: Concept of synthetic genome and application **5 Hrs**

**Practicals** **2 Credits (60 Hrs)**

1. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis
2. Concentration and purity check of DNA
3. Isolation of plasmid DNA
4. Designing of primers
5. Amplification of DNA by PCR
6. Extraction of DNA from agarose gel
7. Expression of recombinant protein in *E. coli* and analysis by SDS-PAGE
8. Sequence alignment and construction of phylogenetic tree

**Suggested Readings:**


1. S. B. Primrose and R. M. Twyman, John Wiley & Sons. Principles of Gene Manipulation and Genomics 7 th Edn. Oxford Publisher (2009), USA
2. Julia Lodge, Pete Lund and Steve Minchin, Gene Cloning Taylor and Francis (2006). NY
3. Desmond S.T. Nicholl, An introduction to Genetic Engineering 3 th Edn 2008. Cambridge University Press. Scotland
4. T. A. Brown, Gene Cloning and DNA Analysis. An Introduction (2016) 7 thEdn Blackwell Scientific Publications. India
5. Sambrook, J., Russell, D.W., Molecular cloning: A Laboratory Manual 3 th Edn. (2001) Cold Spring Harbor, New York.
6. Molecular Cloning: A laboratory manual by J. Sambrook, D. Russell. 4th edition. Cold Spring Harbor laboratory Press. 2012.
7. DNA Technology: The Awesome Skill by I. Edward Alcamo. Harcourt Academic Press. 2001. Molecular Biology of the Gene by J. Watson, T. Baker, S. Bell, A. Gann, M. Levine, R. Losick. 7th edition. Pearson. 2014.
8. Jeremy W Dale and Malcom von Schantz. From Genes to Genomes: Concepts

and Applications of DNA Technology (2002) John Wiley & Sons, Ltd.
9. Bioinformatics: Fundamental Concepts and Practical Applications. Author(s): Dr. Pankaj Bagga Dr. Subham Kapil, Walnut Publication, 2025. ISBN-10 : 9359114367.
10. Bioinformatics: A Practical Manual, 2 July 2018. by K Kasturi (Author), K Sri Lakshmi (Author), Pharmamed Press, St ed. ISBN-10 : 9389974593.
11. Essential Bioinformatics By Jin Xiong, Cambridge University Press, First Edition, ISBN-10 : 0521706106.
12. Bioinformatics for Beginners Paperback by Dr. Rashi Srivastava, Bluerose Publishers Pvt. Ltd. ISBN-10: 9356682488.

**Minor**
**Course Title: Any 4 Credits course from SWAYAM (PG2MICR-1021)**

**OR**
**Course Title: Introduction to General & Applied Microbiology (PG2MICR-1021)**
(FM- 75; Theory-40, Practical -20, Internal- 15)

**Course Objective**

a) To acquaint the students to versatile tools and techniques employed in recombinant DNA technology
b) To illustrate creative use of modern tools and techniques for manipulation and analysis of genomic sequences and to expose students to use recombinant DNA technology in biotechnological research

**Expected Course Outcomes:**

Upon successful completion of this course, students will be able to:

a) Design basic microbiological experiments
b) Design gene cloning strategies using appropriate cloning, vectors
c) Interpret data from molecular techniques like PCR, agarose gel electrophoresis, and DNA sequencing.
d) Analysis of genes through basic bioinformatics tools

**Pedagogical Approaches:**

A blended learning with theoretical knowledge and demonstration of basic microbiology and molecular biology instruments will help students to understand the techniques.

a) Traditional didactic lectures are paired with pre-class readings or video-based modules
b) Using online tools, virtual labs, and sequence alignment tools
c) Group discussions on microbial diversity and recombinant DNA technology

**Theory:** **4 Credits**

**Unit 1: Microbial Diversity and Applications**

Diversity of Prokaryotes and their applications in agriculture, Biodiversity of Prokaryotes: Major Groups, experimental evidence including Great plate count anomaly, Culture dependent & independent studies, outcome. Species definition. Need for Metagenomics. Application of Metagenomics. Extremophiles: Habitat, diversity and adaptations. Biotechnological applications of extremophilic microorganisms and their relation to the extraterrestrial life forms.Plant-microbe interactions: Concept of the rhizosphere, ectorhizosphere, endorhizosphere, and rhizoplane; Rhizodeposition and Rhizosphere effect. Functional aspects:Plant growth promoting rhizobacteria-direct and indirect mechanisms of plant growth enhancement. Microbes as biofertilizer; mass production and field applications.

1**2 Hrs**

**Unit 2: Metabolic regulation of microbes**

Various strategies adopted by microbes at enzyme activity and synthesis level to regulate their metabolism- regulation of catabolic and anabolic pathways, concept of metabolomics.

8 **Hrs**

**Unit 3: Introduction to Molecular Biology and Recombinant DNA technology**

History of molecular biology, DNA and RNA as genetic materials, experiments of Griffith, Avery, Macleod and McCarty. Hershey and Chase, Chargaff's principles, Structure and forms of DNA and RNA. Introduction to recombinant DNA technology – tools for rDNA technology, Gene amplification, cloning, Screening and selection of recombinant host cells: blue/white screening, Expression of recombinant proteins, Applications of rDNA technology

1**2 Hrs**

**Unit 4: Basic bioinformatics:**

Definition and applications of Bioinformatics, concept of various web based tools used in Bioinformatics, Concept of pair wise and multiple sequence alignment. Database similarity searching through BLAST. **8 Hrs**

**Practical** **2 Credits (40 Hrs)**

1. Demonstration of microscope
2. Demonstration of centrifuge
3. Demonstration of spectrophotometer
4. Demonstration of thermal cycler
5. Demonstration of horizontal and vertical gel electrophoresis
6. Demonstration of biosafety cabinet
7. Practical on PROTPARAM and BLAST.

**Suggested Readings:**

1. Prescott's Microbiology by J. Willey, L. Sherwood, C. J. Woolverton. 10th edition. McGraw Hill Education. 2017.

2. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D. Stahl. 15th Edition. Pearson Education. 2018.
3. Alcamo's Fundamentals of Microbiology by J. C. Pommerville. 10th Edition. Jones and Bartlett Learning. 2013.
4. Archaea Molecular and Cellular Biology by Ricardo Cavicchioli. American Society of Microbiology. 2007.
5. The Physiology and Biochemistry of Prokaryotes by D. White, J. Drummond, C. Fuqua. 4 th Edition. Oxford University Press. 2011.
6. T. A. Brown, Gene Cloning and DNA Analysis. An Introduction (2016) 7 thEdn Blackwell Scientific Publications. India Molecular Biology by D.P. Clarke, N. Pazdernik. 2nd edition. Academic Press. 2012. Department of Microbiology, University of Delhi 57
7. Molecular Cloning: A laboratory manual by J. Sambrook, D. Russell. 4th edition. Cold Spring Harbor laboratory Press. 2012.
8. Jeremy W Dale and Malcom von Schantz. From Genes to Genomes: Concepts and Applications of DNA Technology (2002) John Wiley & Sons, Ltd.
9. Reddy, S.M. et. al.(2002). Bioinoculants for sustainable agriculture and forestry, Scientific Publishers.

## Semester-II

**Major**

**Course Title: Instrumentation & Biotechniques (PG2MICR 2011)**

(FM- 75; Theory-40, Practical -20, Internal- 15)

### Course Objectives

The course aims to equip students with the theoretical foundation and practical expertise required to handle advanced analytical instruments and modern biological methodologies in research and industrial environments. The core objectives of this program are to provide students with:

a) Advanced Imaging Knowledge with deep understanding of advanced optical, electron, and atomic force microscopy methods.

b) Mastery over physical separation principles including analytical ultra-centrifugation and cell fractionation.

c) Conceptual clarity on structural determination techniques like NMR, spectrophotometry, and mass spectrometry.

d) Training in animal and plant cell culture techniques, tissue engineering, and gene expression analysis.

e) Expertise in immunological assays including monoclonal antibody production and highly sensitive antigen-antibody detection systems.

f) Competence in running microbial and antioxidant biological assays combined with chromatography.

## Expected Course Outcomes

Upon successful completion of this course, students will be able to:

a) Differentiate between fluorochromes (FITC, TRITC, DAPI, GFP) for specific cellular targets, explain the high-resolution mechanism of Confocal, FRET, SEM, TEM, and Atomic Force Microscopy (AFM) and prepare complex biological samples using freeze-fracture replication and freeze etching.
b) Calculate Relative Centrifugal Force (RCF) and sedimentation coefficients, determine macromolecular molecular weights using boundary and zone sedimentation principles and isolate sub-cellular eukaryotic components via differential and density-gradient centrifugation.
c) Identify the $\lambda_{max}$ of unknown samples and compute extinction coefficients, analyze the structural properties of biomolecules using NMR and emission spectroscopy and interpret m/z ratios and mass spectra generated via MALDI-TOF and ESI mass spectrometry.
d) Maintain primary and secondary cell lines alongside organoid or 3D cultures, assess cell viability and death cycles using specialized colony formation assays and evaluate gene expression patterns utilizing functional microarrays and gene chips.
e) Formulate monoclonal antibodies using standard hybridoma technology, execute sensitive immunoassays including RIA, RIST, RAST, and flow cytometry.
f) Detect antimicrobial and antioxidant capabilities via agar overlays and DPPH methods and assess the presence of estrogenic compounds using direct TLC bioautography techniques.

## Pedagogical Approach

The course is delivered using a multi-faceted, active learning approach designed to balance theory with practical execution.

a) Interactive Theoretical Lectures, slide presentations, and deep mathematical/physical derivation of instrument mechanics.

b) Hands-on laboratory training, focused on calculating critical experimental constants ($\lambda_{max}$ , extinction coefficients) and running biological assays.

c) Supervised walkthroughs on high-end instruments like flow cytometers, ultracentrifuges, and confocal microscopes.

d) Planned institutional exposures to reputed research centers/universities to witness industrial-scale bio-instrument setups in action.

e) Progress evaluation divided transparently into a Final Written Theory exam (40 marks), Practical exam (20 marks), and Internal Evaluation (15 marks).

**Theory:** **4 Credits**

**Unit 1:** Fluorescence microscopy: fluorochromes- FITC, TRITC, DAPI, GFP and its use, FRET, Confocal microscopy, Time lapse video microscopy and its use, SEM & TEM, sample preparation for electron microscopy, Freeze-Fracture Replication and Freeze Etching, Basic principle of atomic Force Microscopy (AFM) **8 Hrs**

**Unit 2:** Principle of sedimentation: Boundary and Zone sedimentation; Factors affecting sedimentation; velocity and sedimentation co-efficient Preparative and analytical centrifugation, RCF and sedimentation coefficient, determination of molecular weight from sedimentation, differential centrifugation, density gradient centrifugation and ultracentrifugation and their applications, eukaryotic cell fractionation **8 Hrs**

**Unit 3:** Basic concept of Spectrophotometry and Spectrofluorimetry and applications, Introduction to emission spectroscopy: Fluorescence and Phosphorescence and their applications in biology, Basic concept of NMR spectroscopy, Principles of mass spectrometry, m/z ratio, time of Flight analysis, MALDI and ESI Mass spectrometry **6 Hrs**

**Unit 4:** Cell culture, primary and secondary cell culture techniques, colony formation assay, organoid culture, study of cell cycle, Study of cell death, Transgenic animal and plants, production of knock-out mice, study of gene expression by gene chip, microarray **6 Hrs**

**Unit 5:** Hybridoma technique and preparation of monoclonal antibody, the use of monoclonal antibody in modern biology, abzymes, Immunoprecipitation based techniques (RIA, RIST, RAST), Immunocytochemistry and Immunohistochemistry, Flow cytometry, Immunoelectron microscopy **6 Hrs**

**Unit 6:** Bioautography-Definition, factors affecting bioautography. Detection of antimicrobial activity using Contact Bioautography, agar overlay method, direct TLC Bioautography, detection of antioxidant activity using DPPH method, ABTs method, beta-carotene method, detection of Estrogenic compounds, Advantages over other Chromatographic techniques **6 Hrs**

**Practical** **2 Credits (60 Hrs)**

8. Demonstration of fluorescence and confocal microscope
9. Demonstration of ultracentrifuge
10. Determination of $\lambda_{max}$ for an unknown sample and calculation of extinction coefficient

11. Demonstration of fluorescence spectrophotometer
12. Demonstration of flow cytometer
13. Visit to University/ reputed research Institute/industry for demonstration of high end instruments

**Suggested Readings:**


1. Biophysical Chemistry (Principles & techniques). Upadhyay, A. Upadhyay, K. and Nath, N. Himalaya Publishing house. ISBN: 978-81-83188-65-4.
2. Principles of Biochemistry. Nelson DL and Cox MM (2008). 5th Edition., W.H. Freeman and Company.
3. Voet, D. and Voet J.G. (2004). Biochemistry 3rd edition, John Wiley and Sons.
4. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology, 7th Edition, Cambridge University Press, 2010.
5. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
6. Nigam A and Ayyagari A. 2007. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill.


**Major**

**Course Title: Microbial Ecology and Biodiversity (PG2MICR-2012)**

(FM- 75; Theory-40, Practical -20, Internal- 15)

**Course Objectives**

a) To inculcate basic concepts and knowledge of microbial ecology, its components, possible interactions, functioning and how it operates to the students.
b) To develop thorough understanding of microbial diversity, its possible impact and potential importance. To develop understanding of microbial community structure and inculcate practical skill to identify their constituting microbial members through culture dependent and independent techniques.
c) Develop practical sense and skills for culturing wide range of diverse groups of microbes from different habitats. Their identification process mainly through 16SrRNA gene sequence information and molecular phylogenetic tree.
d) To develop and inculcate comprehensive knowledge and skill on the microbiology of air, water and soil with practical emphasis on bacteria and fungi.
e) To develop thorough understanding of importance of microbes living in air, water and soil.
f) To develop practical skills for microscopic examination of any environmental samples and their associated microorganisms.

g) To inculcate practical skills for: studying bacterial biofilm, death curve, isolation of methylotrophic bacteria from phyllosphere, isolation of aquatic bacteria and fungi and finally to inculcate the concept of identification of bacteria based on 16S rRNA gene based molecular phylogenetic approach.

**Expected Course Outcomes**

By the completion of this course, the students will acquire:

a) Basic concepts and knowledge of microbial ecology, its components, possible interactions, functioning and how it operates; thorough understanding of microbial diversity, its possible impact and potential importance; understanding of microbial community structure and inculcate practical skill to identify their constituting microbial members through culture dependent and independent techniques; practical sense and skills for culturing wide range of diverse groups of microbes from different habitats. Their identification process mainly through 16SrRNA gene sequence information and molecular phylogenetic tree.
b) Comprehensive knowledge and skill on the microbiology of air, water and soil with practical emphasis on bacteria and fungi; thorough understanding of importance of microbes living in air, water and soil.
c) Practical skills for microscopic examination of any environmental samples and their associated microorganisms; practical skills for: studying bacterial biofilm, death curve, isolation of methylotrophic bacteria from phyllosphere, isolation of aquatic bacteria and fungi and finally to inculcate the concept of identification of bacteria based on 16S rRNA gene based molecular phylogenetic approach

**Pedagogical Approach**

To fulfil the course requirements, interactive theoretical and hands on practical classes are recommended.

a) Interactive classroom lectures in chalk and talk as well as power point presentation audio-visual mode for general understanding of the theoretical concepts.
b) Virtual labs, simulations and case based learnings.
c) Rigorous hands on training for inculcating practical skills associated with microbe culturing, characterization, identification etc.
d) Simple scalable objects (like low cost ecosystem in a jar) may be used for simulating Winogradsky column for understanding community succession etc.

**Theory:** **4 Credits**

**Unit 1:** Basic concept of microbial ecology (historical milestones towards its development- Contribution of S. Winogradsky, M. Beijerinck, CB van Neil, TD Brock, N Pace, Jo Handelsman and Craig Venter), Habitat & Niche, energy flow within ecosystems, community structure. Biodiversity, biodiversity indices, basic concept of Development of microbial

community in biosphere, ecological homeostasis and co-evolution, Biofilm & its ecological implications **7 Hrs**

**Unit 2:** Microbial diversity- Comparative diagnostic characters, Major phylogenetic groups, Functional attributes; Current estimates. Culture dependent & independent methods for studying microbial diversity (DGGE, t-RFLP) **5 Hrs**

**Unit 3:** Evidence of unseen majority- Great Plate count anomaly, Renaturation kinetics, Complexity of DNA based studies, 16S rRNA gene based studies. Reasons for cultivation failure. Development of metagenomics; Basic concept of metagenomics, application in ecology, human health and agriculture **7 Hrs**

**Unit 4:** Aero Microbiology: Basic concept, air sampling methods, air quality assessment. Indoor aero microbiology. Bio-aerosols: nature, fate, transport and medical significance, Microbial aero allergen **7 Hrs**

**Unit 5:** Soil Microbiology: Physical and chemical characters of soil; micro-flora of various soil types; Autochthonous, allochthonous, subterranean microbes; Rhizosphere and phyllosphere; Role of microorganisms in soil quality management; Cosmopolitan groups in soil ecosystems **7 Hrs**

**Unit 6:** Aquatic Microbiology: Types of aquatic ecosystems and their cosmopolitan groups of microbes (Freshwater & marine). Zonation of aquatic ecosystems. Organic matter cycling in marine ecosystem. Economic importance and Applications of aquatic microorganisms **7 Hrs**

**Practical** **2 Credits (40 Hrs)**

1. Microscopic examination of bacterial biofilm by crystal violet staining technique
2. Demonstration of 'Great Plate count anomaly'
3. Isolation of C1 carbon metabolising bacteria from rice Phylloplane
4. Isolation of aquatic fungi by baiting technique and its microscopic study
5. Demonstration of death curve
6. Demonstration on utility of 16S rRNA gene: Identity values and phylogenetic tree for phylogenetic affiliation of bacteria

**Suggested readings**


1. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing,USA
2. Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms. 14th edition. Pearson/ BenjaminCummings
3. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, AcademicPress
4. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer, NewYork
5. Singh A, Kuhad, RC &Ward OP (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, BerlinHedeilberg

6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition,WileyBlackwell, USA Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
7. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
8. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication,U.K.
9. Martin A. (1977). An Introduction to Soil Microbiology. 2ndedition. John Wiley &Sons Inc. New York &London.
10. Stolp H. (1988). Microbial Ecology: Organisms Habitats Activities. Cambridge University Press, Cambridge,England.
11. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. NewDelhi.
12. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill HigherEducation.

**Major**

**Course Title: Industrial Microbiology (PG2MICR-2013)**

(FM- 75; Theory-40, Practical -20, Internal- 15)

**Course Objectives**

a) To inculcate basic concepts and knowledge of Industrial Microbiology. Industrially important microorganisms and their sources. Screening and strain improvement strategies; preservation techniques of the production strains; stock culture. Formulation of media & Optimization and sterilization of industrial media
b) To develop thorough understanding of basic principle, types and working of bioreactors; Principle, types of fermentations and their application; Types of bioreactors, configuration; Mass transfer coefficient (KLA); gas-liquid mass transfer; monitoring and control of bioreactors: sensors; Sterilization of fermenter; Scale up and scale down process, optimization of fermentation process.
c) To inculcate knowledge and concepts on Removal of microbial cells and solid matters, cell disruption method, foam separation, precipitation, flocculation, centrifugation, liquid-liquid extraction, chromatography, membrane process, drying and crystallization.

d) To develop systematic understanding on fermentative production through case studies of Alcohol, amino acid, vitamin, enzyme, antibiotic and organic acid production; application of immobilization of enzymes for better production.
e) To inculcate and develop practical skill for Production of wine, Isolation of exo-polysaccharide producing microbes and purification of the polysaccharide, Production of probiotic drink; understanding working of bioreactor.

**Expected Course Outcomes**

By the completion of this course, the students will acquire

a) Basic concepts and knowledge of Industrial Microbiology. Industrially important microorganisms and their sources. Screening and strain improvement strategies; preservation techniques of the production strains; stock culture. Formulation of media & Optimization and sterilization of industrial media.
b) Understanding of basic principle, types and working of bioreactors; Principle, types of fermentations and their application; Types of bioreactors, configuration; Mass transfer coefficient (KLA); gas-liquid mass transfer; monitoring and control of bioreactors: sensors; Sterilization of fermenter; Scale up and scale down process, optimization of fermentation process.
c) Knowledge on Removal of microbial cells and solid matters, cell disruption method, foam separation, precipitation, flocculation, centrifugation, liquid-liquid extraction, chromatography, membrane process, drying and crystallization.
d) Understanding on fermentative production through case studies of Alcohol, amino acid, vitamin, enzyme, antibiotic and organic acid production; application of immobilization of enzymes for better production.
e) Practical skill for Production of wine, Isolation of exo-polysaccharide producing microbes and purification of the polysaccharide, Production of probiotic drink; understanding working of bioreactor.

**Pedagogical Approach**

a) The basic approach should include integrated classroom lectures followed by inquiry based experimental learning.
b) Real live example of microorganisms in laboratory based simulation/ model based studies may be recommended for in depth understanding.
c) Live working demonstration of various types of bioreactors, industrial fermenters showing how production process may be executed, would allow greater imbibition of concept and technology.
d) Critical data analyses, graph preparation and computational based modelling studies are recommended for general understanding on optimization principle and industrial production of analytes.

**Theory:** **4 Credits**

**Unit 1:** General concept of Industrial Microbiology; brief history and scope of industrial microbiology **2 Hrs**

**Unit 2:** Industrially important microorganisms and their sources. Screening and strain improvement strategies; preservation techniques of the production strains; stock culture. Formulation of media- crude and synthetic media. Optimization and sterilization of industrial media: Response-surface optimization **6 Hrs**

**Unit 3:** Bioreactor: Basic principle and function, design, components and their function; Principles of fermentations: batch, fed-batch, and continuous operation; liquid state fermentation (surface and submerged) and solid state fermentation; Types of bioreactors- Laboratory, pilot-scale and production fermenters; Configurations: stirred tank, airlift reactor, packed bed, trickle bed fermenter; Mass transfer coefficient (KLA); gas-liquid mass transfer; monitoring and control of bioreactors: sensors, Sterilization of fermenter; Scale up and scale down process, optimization of fermentation process **8 Hrs**

**Unit 4:** Removal of microbial cells and solid matters, cell disruption method, foam separation, precipitation, flocculation, centrifugation, liquid-liquid extraction, chromatography, membrane process, drying and crystallization **8 Hrs**

**Unit 5:** Fermentative production of alcohol (wine, beer), organic acid (acetic acid), amino acid (lysine), antibiotic (Penicillin), enzyme (Glucose isomerase) and Vitamin B12 (micro-organisms involved, media, fermentation conditions, downstream processing and uses); Microbial transformation of steroids, Biomining of copper. Microbial production of biofuel, microbial biofuel cell **8 Hrs**

**Unit 6:** Enzymes immobilization strategies (cross linking, entrapment, adsorption and covalent bonding) Advantages and applications of immobilization; large scale applications of immobilized enzymes **8 Hrs**

**Practical** **2 Credits (40 Hrs)**

1. Production of wine from fruits
2. Isolation of exo-polysaccharide producing microbes and purification of the polysaccharide
3. Preparation of column with immobilized baker's yeast cells in calcium alginate beads
4. Demonstration of a stirred tank bioreactor
5. Production of probiotic drink, kombucha


1. Patel A.H. (1996). Industrial Microbiology. 1st edition, Macmillan IndiaLimited
2. Okafor N. (2007). Modern Industrial Microbiology and Biotechnology. 1st edition. Bios Scientific Publishers Limited.USA
3. WaitesM.J., Morgan N.L., Rockey J.S. and Higton G. (2001). Industrial Microbiology: An Introduction. 1st edition. Wiley –Blackwell
4. Glaze A.N. and N ikaido H. (1995). Microbial Biotechnology: Fundamentals of Applied Microbiology. 1st edition. W.H. Freeman and Company

5. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley EasternLimited.
6. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. NewDelhi.
7. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier ScienceLtd.

**Major**
**Course Title:** Review, Educational Tour and Social Inter-linkage **(PG2MICR-2014) 4 Credits**

**Course Objectives**

a) An educational tour and social inter-linkage course bridges theoretical knowledge with real-world application.
b) It aims to provide experiential learning, foster social awareness, and develop critical interpersonal skills by immersing students in diverse environments outside traditional classrooms.
c) Review course ensure students to develop the necessary skills to evaluate, existing research. These learning outcomes focus on building information literacy, identifying research gaps, and establishing a foundation for future microbiological research.

**Expected Course Outcomes**

a) Direct interactions with farmers, rural populations, school students foster a deeper understanding of microbiology and its application in society.
b) Students bridge the gap between classroom theory and practical, hands-on industry or site visits.
c) Students build confidence, self-reliance, and maturity by adapting to new routines and situations away from home.
d) Experiential exposure to various industries and institutions aids in career planning and professional development.

**Pedagogical Approach**

a) It bridges classroom theory with real-world, place-based learning. It transforms passive learners into active participants by immersing them in diverse cultural, ecological, and societal environments, thereby enhancing both academic retention and emotional intelligence.
b) Students are placed in novel environments where they must problem-solve, collaborate in groups, and communicate with diverse populations.

**Marks distribution**
Review-20, internal-5
Educational Tour-20, internal-5
Social Inter-linkage-20, internal-5

**Minor**
**Course Title: Any 4 Credits course from SWAYAM (PG2MICR-2021)**
**OR**
**Course Title: Aquatic and Aeromicrobiology (PG2MICR-2021)**
(FM- 75; Theory-40, Practical -20, Internal- 15)

## Course Objectives

a) To understand the diversity, distribution, and ecological roles of microorganisms in aquatic and aerial environments.
b) To study the sources, transmission, and significance of airborne and waterborne microorganisms in environmental and public health.
c) To learn methods for microbial sampling, isolation, identification, and enumeration from air and water.
d) To assess the microbiological quality of air and water using standard monitoring and analytical techniques.
e) To understand water pollution, wastewater treatment processes, and microbial indicators of contamination.
f) To develop practical laboratory skills in environmental microbiology, including water potability testing and environmental monitoring.
g) To evaluate the impact of microbial activities on ecosystem functioning, environmental sustainability, and human health.
h) To apply microbiological knowledge for the management and control of environmental contamination.

## Expected Course Outcomes

Upon successful completion of the course, students will be able to:

a) Explain the occurrence, diversity, and ecological importance of microorganisms in air and aquatic ecosystems.
b) Identify major airborne and waterborne microbial contaminants and their public health implications.
c) Perform microbial sampling and quality assessment of air and water using standard microbiological techniques.
d) Analyze and interpret microbiological data related to environmental monitoring and hygiene assessment.
e) Evaluate water quality and determine the potability of water using microbial indicators and testing methods.

f) Understand and explain the role of microorganisms in wastewater treatment and bioremediation processes.
g) Demonstrate practical competency in laboratory techniques related to aquatic and aeromicrobiology.
h) Apply acquired knowledge to solve environmental and public health problems associated with microbial contamination.

**Pedagogical Approaches**

a) Interactive lectures with audio-visual and digital learning tools.
b) Demonstration-based teaching of air and water microbiological techniques.
c) Hands-on laboratory training in microbial sampling, MPN testing, and microbial enumeration.
d) Case studies on air-borne and water-borne diseases, pollution, and environmental issues.
e) Student seminars, group discussion and presentations to enhance communication and analytical skills.
f) ICT-enabled learning using online resources, databases, and scientific literature.

**Theory:** **4 Credits**

**Unit 1:** Introduction to Aeromicrobiology and Aeromicroflora; Composition of air and factors influencing microbial survival. Types of aeromicroflora and their transport mechanisms, aerosols, droplet nuclei. Sources and reservoirs of airborne microbes. Common air-borne diseases (name and causative agent), Airborne Bioterrorism **8 Hrs**

**Unit 2:** Aerobiological Sampling Techniques; passive sampling methods- Gravity slide method, Settle plates, Active sampling methods: Impingers, Impactors, Andersen multi-stage air sampler. Air hygiene, sanitation/control of microbial contamination in air. Air quality assessment based on microbial load **8 Hrs**

**Unit 3:** Introduction to Aquatic Microbiology and Aquatic Microflora**,** types of aquatic ecosystems: fresh water (ponds, lakes, rivers), marine (estuaries, deep sea), benthic zones. Microbial distribution: planktonic microbes, benthic microorganisms, biofilms, microbial mats. Physiochemical characteristics of water bodies (pH, nutrients, dissolved oxygen) and their effect on microbes **8 Hrs**

**Unit 4:** Water pollution: sources, eutrophication, algal blooms. Water quality assessment: indicator organisms, coliforms. Potability assessment of water. Water-borne diseases and their microbial causes. Wastewater treatment: primary, secondary (activated sludge, trickling filter), tertiary treatment. Water disinfection (chlorination, filtration, UV, etc.) **8 Hrs**

**Unit 5: Public health:** Principles and practices; prevention, social determinants of health;

One health concept; Environmental health policy and legal mechanisms in a national and international context; Basic Epidemiology including communicable and non-communicable diseases; Basic concept of health promotion **8 Hrs**

**Practical:** **2 Credits (40 Hrs)**

1. Sampling of airborne microbes using settle plate method
2. Microbial load monitoring in classrooms, labs and outdoor sites
3. Testing of potability of water by MPN test
4. Membrane filtration for detection of *E. coli* (demonstration only)
5. Enumeration of microbial load in water/salad vegetables/fruit juice through dilution plating technique

**Suggested Readings:**


1) Atlas, R. M., & Bartha, R. *Microbial Ecology: Fundamentals and Applications*. Benjamin Cummings, USA.
2) Maier, R. M., Pepper, I. L., & Gerba, C. P. *Environmental Microbiology*. Academic Press.
3) Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. *Brock Biology of Microorganisms*. Pearson Education.
4) Mitchell, R., & Gu, J. D. *Environmental Microbiology*. Wiley-Blackwell.
5) Prescott, L. M., Harley, J. P., & Klein, D. A. *Microbiology*. McGraw Hill Education.
6) Pandey, P. K. (Ed.). *Handbook of Aquatic Microbiology*. CRC Press. Handbook of Aquatic Microbiology
7) Dubey, R. C., & Maheshwari, D. K. *Practical Microbiology*. S. Chand Publishing.
8) Kumar, H. D. *Modern Concepts of Ecology*. Vikas Publishing House.
9) Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. *Microbiology*. Tata McGraw Hill.
10) Aneja, K. R. *Experiments in Microbiology, Plant Pathology and Biotechnology*. New Age International Publishers.