



**BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI - 620 024.**

**M.Sc. MICROBIOLOGY**

**CHOICE BASED CREDIT SYSTEM -  
LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (CBCS - LOCF)**

**(Applicable to the candidates admitted from the academic year 2026 - 2027 onwards)**

| Sem.                                                                                                | Course                                               | Course Title                                                                                 | Ins.<br>Hrs. | Credit    | Exam<br>Hrs. | Marks |      | Total      |
|-----------------------------------------------------------------------------------------------------|------------------------------------------------------|----------------------------------------------------------------------------------------------|--------------|-----------|--------------|-------|------|------------|
|                                                                                                     |                                                      |                                                                                              |              |           |              | Int.  | Ext. |            |
| I                                                                                                   | Core Course - 1 (CC - 1)                             | General Microbiology                                                                         | 6            | 4         | 3            | 30    | 70   | 100        |
|                                                                                                     | Core Course - 2 (CC - 2)                             | Biological Macromolecules                                                                    | 6            | 4         | 3            | 30    | 70   | 100        |
|                                                                                                     | Core Practical - 1 (CP - 1)                          | General Microbiology &<br>Biological Macromolecules                                          | 6            | 4         | 3            | 40    | 60   | 100        |
|                                                                                                     | Discipline Centric Elective<br>Course - 1 (DCEC - 1) | 1. Virology<br>(or)<br>2. Applied Biological Sciences                                        | 5            | 4         | 3            | 30    | 70   | 100        |
|                                                                                                     | Generic Elective Course - 1 (GEC<br>- 1)             | 1. Microbial diversity and<br>Extremophiles<br>(or)<br>2. Marine Microbiology                | 5            | 3         | 3            | 30    | 70   | 100        |
|                                                                                                     | Skill Enhancement Course - 1<br>(SEC - 1)            | Probiotic Microbiology                                                                       | 2            | 2         | 3            | 30    | 70   | 100        |
|                                                                                                     | Value Added Course - 1<br>(VAC - 1)*                 | Medical Laboratory Technology                                                                | -            | 2*        |              | 30    | 70   | 100*       |
| <b>Total</b>                                                                                        |                                                      |                                                                                              | <b>30</b>    | <b>21</b> | -            | -     | -    | <b>600</b> |
| II                                                                                                  | Core Course - 3 (CC - 3)                             | Microbial Physiology and<br>Metabolism                                                       | 6            | 4         | 3            | 30    | 70   | 100        |
|                                                                                                     | Core Course - 4 (CC - 4)                             | Microbial Genetics and<br>Molecular Biology                                                  | 6            | 4         | 3            | 30    | 70   | 100        |
|                                                                                                     | Core Practical - 2 (CP - 2)                          | Microbial Physiology and<br>Metabolism, Microbial Genetics<br>and Molecular Biology          | 6            | 4         | 3            | 40    | 60   | 100        |
|                                                                                                     | Discipline Centric Elective<br>Course - 2 (DCEC - 2) | 1. Microbial Genomics and<br>Proteomics<br>(or)<br>2. Molecular Taxonomy and<br>Phylogeny    | 4            | 4         | 3            | 30    | 70   | 100        |
|                                                                                                     | Generic Elective Course - 2<br>(GEC - 2)             | 1. Next Generation Microbiology<br>(or)<br>2. Herbal Technology and<br>Cosmetic Microbiology | 4            | 3         | 3            | 30    | 70   | 100        |
|                                                                                                     | Skill Enhancement Course - 2<br>(SEC - 2)            | Food Processing Technology                                                                   | 2            | 2         | 3            | 30    | 70   | 100        |
|                                                                                                     | Non-Major Elective Course - 1<br>(NMEC - 1)          | One Course from Outside<br>Department                                                        | 2            | 2         | 3            | 30    | 70   | 100        |
| <b>Total</b>                                                                                        |                                                      |                                                                                              | <b>30</b>    | <b>23</b> | -            | -     | -    | <b>700</b> |
| <b>Summer Internship / Industrial Activity during the Summer Vacation after 1<sup>st</sup> Year</b> |                                                      |                                                                                              |              |           |              |       |      |            |

|                    |                                                   |                                                                                                       |           |           |          |          |          |             |
|--------------------|---------------------------------------------------|-------------------------------------------------------------------------------------------------------|-----------|-----------|----------|----------|----------|-------------|
| III                | Core Course - 5 (CC - 5)                          | Immunology                                                                                            | 6         | 4         | 3        | 30       | 70       | 100         |
|                    | Core Course - 6 (CC - 6)                          | Medical Microbiology                                                                                  | 6         | 4         | 3        | 30       | 70       | 100         |
|                    | Core Practical - 3 (CP - 3)                       | Immunology, Medical and Industrial Microbiology                                                       | 6         | 4         | 2        | 40       | 60       | 100         |
|                    | Discipline Centric Elective Course - 3 (DCEC - 3) | 1. Research Methodology and Bioethics<br>(or)<br>2. Microbiome Biology                                | 5         | 4         | 2        | 30       | 70       | 100         |
|                    | Generic Elective Course - 3 (GEC - 3)             | 1. Industrial and Pharmaceutical Microbiology<br>(or)<br>2. Life Science for Competitive Examinations | 5         | 3         | 3        | 30       | 70       | 100         |
|                    | Non-Major Elective Course - 2 (NMEC - 2)          | One Course from Outside Department                                                                    | 2         | 2         | 3        | 30       | 70       | 100         |
|                    | Internship / Industrial Activity                  |                                                                                                       |           | 2         |          | 20       | 80       | 100         |
| <b>Total</b>       |                                                   |                                                                                                       | <b>30</b> | <b>23</b> | <b>-</b> | <b>-</b> | <b>-</b> | <b>700</b>  |
| IV                 | Core Course - 7 (CC - 7)                          | Environment and Agricultural Microbiology                                                             | 6         | 4         | 3        | 30       | 70       | 100         |
|                    | Core Course - 8 (CC - 8)                          | Food and Dairy Microbiology                                                                           | 6         | 4         | 3        | 30       | 70       | 100         |
|                    | Core Course - 9 (CC - 9)                          | Microbial Biotechnology and Genetic Engineering                                                       | 6         | 4         | 3        | 30       | 70       | 100         |
|                    | Discipline Centric Elective Course - 4 (DCEC - 4) | Biosafety and Intellectual Property Rights                                                            | 4         | 4         | 2        | 30       | 70       | 100         |
|                    |                                                   | Clinical Research and Clinical Trials                                                                 |           |           |          |          |          |             |
|                    | Entrepreneurship / Industry Based Course          | Entrepreneurship in Microbiology                                                                      | 3         | 3         | 3        | 30       | 70       | 100         |
|                    | Project Work                                      |                                                                                                       | 5         | 5         | -        | 20       | 80       | 100         |
|                    | Value Added Course - 2 (VAC - 2)*                 | Quality Assurance in Food and Pharmaceutical Industries                                               | -         | 2*        |          | 30       | 70       | 100*        |
| <b>Total</b>       |                                                   |                                                                                                       | <b>30</b> | <b>24</b> | <b>-</b> | <b>-</b> | <b>-</b> | <b>600</b>  |
| <b>Grand Total</b> |                                                   |                                                                                                       |           | <b>91</b> |          |          |          | <b>2600</b> |

## LIST OF DISCIPLINE CENTRIC ELECTIVE COURSE

| <b>Discipline Centric Elective Course - 1 (DCEC - 1)</b> |                                            |
|----------------------------------------------------------|--------------------------------------------|
| 1.                                                       | Virology                                   |
| 2.                                                       | Applied Biological Sciences                |
| <b>Discipline Centric Elective Course - 2 (DCEC - 2)</b> |                                            |
| 1.                                                       | Microbial Genomics and Proteomics          |
| 2.                                                       | Molecular Taxonomy and Phylogeny           |
| <b>Discipline Centric Elective Course - 3 (DCEC - 3)</b> |                                            |
| 1.                                                       | Research Methodology and Bioethics         |
| 2.                                                       | Microbiome Science                         |
| <b>Discipline Centric Elective Course - 4 (DCEC - 4)</b> |                                            |
| 1.                                                       | Industrial and Pharmaceutical Microbiology |
| 2.                                                       | Clinical Research and Clinical Trials      |

## LIST OF NON-MAJOR ELECTIVE COURSE (for other Department Students only)

| <b>NON-MAJOR ELECTIVE COURSE - 1 (NME-1)</b> |                            |
|----------------------------------------------|----------------------------|
| 1                                            | Human and Microbes         |
| <b>NON-MAJOR ELECTIVE COURSE - 2 (NME-2)</b> |                            |
| 2                                            | Public Health Microbiology |

## LIST OF GENERIC ELECTIVE COURSE (GEC)

| <b>GENERIC ELECTIVE COURSE - 1 (GEC - 1)</b> |                                             |
|----------------------------------------------|---------------------------------------------|
| 1.                                           | Microbial Diversity and Extremophiles       |
| 2.                                           | Marine Microbiology                         |
| <b>GENERIC ELECTIVE COURSE - 2 (GEC - 2)</b> |                                             |
| 1.                                           | Next Generation Microbiology                |
| 2.                                           | Herbal Technology and Cosmetic Microbiology |
| <b>GENERIC ELECTIVE COURSE - 3 (GEC - 3)</b> |                                             |
| 1.                                           | Biosafety and Intellectual Property Rights  |
| 2.                                           | Life Science for Competitive Examinations   |

## SUMMARY OF CURRICULUM STRUCTURE OF PG PROGRAMMES

| Sl. No.               | Types of the Course                        | No. of Courses | Credits for each Course | Total Credits | Marks       |
|-----------------------|--------------------------------------------|----------------|-------------------------|---------------|-------------|
| 1.                    | Core Course                                | 9              | 4                       | 36            | 900         |
| 2.                    | Core Practical                             | 3              | 4                       | 12            | 300         |
| 3.                    | Discipline Centric Elective Course         | 4              | 4                       | 16            | 400         |
| 4.                    | Generic Elective Course                    | 3              | 3                       | 9             | 300         |
| 5.                    | Skill Enhancement Course                   | 2              | 2                       | 4             | 200         |
| 6.                    | Non-Major Elective Courses                 | 2              | 2                       | 4             | 200         |
| 7.                    | Internship / Industrial Activity @         | 1              | 2                       | 2             | 100         |
| 8.                    | Entrepreneurship / Industry Based Course @ | 1              | 3                       | 3             | 100         |
| 9.                    | Project @                                  | 1              | 5                       | 5             | 100         |
| <b>Total</b>          |                                            | <b>26</b>      | <b>-</b>                | <b>91</b>     | <b>2600</b> |
| Value Added Courses * |                                            | 2*             | 2                       | 4*            | 200*        |

| *           | <b>The value added courses credit will not be included in the total CGPA. These courses are extra-credit courses. Instruction hours for these courses is 30 hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                        |             |       |        |    |      |    |       |     |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------|--------|----|------|----|-------|-----|
| @           | <p>Summer Internship will be carried out during the summer vacation after the First year. Viva Voce will be conducted by the college and Marks shall be sent to the University and the same will be included in the 3<sup>rd</sup> semester Mark Statement.</p> <p style="text-align: center;"><b>Summer Internship / Industrial Activity &amp; Project<br/>Scheme of Evaluation:</b></p> <table border="1"> <tr> <th>Description</th><th>Marks</th></tr> <tr> <td>Report</td><td>80</td></tr> <tr> <td>Viva</td><td>20</td></tr> <tr> <td>Total</td><td>100</td></tr> </table> | Description | Marks | Report | 80 | Viva | 20 | Total | 100 |
| Description | Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |             |       |        |    |      |    |       |     |
| Report      | 80                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |             |       |        |    |      |    |       |     |
| Viva        | 20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |             |       |        |    |      |    |       |     |
| Total       | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |             |       |        |    |      |    |       |     |

## PROGRAMME OUTCOMES

- Disciplinary Knowledge:** Broad and in-depth knowledge of advanced scientific concepts, principles, and methodologies within the chosen domain. Ability to critically explain, integrate, and apply scientific knowledge to theoretical and practical problems. Opportunities to earn additional credits through specialized and interdisciplinary courses further enhance expertise and broaden disciplinary understanding.
- PO 1**
- Critical Thinking:** Field visits, academic interactions, and experiential learning activities will help students develop critical observation, interpretation, and analytical skills. Ability to evaluate and interpret scientific data, formulate hypotheses, and draw logical conclusions. Encourages independent thinking and the ability to assess scientific problems from multiple perspectives.
- PO 2**
- Analytical Reasoning:** Through classroom discussions, scientific literature reviews, and interactive learning environments, students will strengthen their analytical reasoning abilities. Ability to critically evaluate scientific texts, identify gaps in existing knowledge, formulate research questions, and synthesize new ideas and concepts. Promotes evidence-based reasoning and logical interpretation of scientific information.
- PO 3**
- Scientific Reasoning:** Strong foundation in scientific methods, experimental design, and data interpretation through laboratory-based courses. Enhances practical knowledge of scientific instrumentation, calibration procedures, laboratory safety, and appropriate research techniques. Ability to conduct scientifically sound experiments and interpret results accurately.
- PO 4**
- Self-Directed Learning:** Encourages independent and self-directed learning through assignments, field reports, project work, and literature-based studies. Ability to organize, analyze, and present scientific findings in professional formats relevant to academic and industrial settings. Fosters responsibility, time management, and continuous self-improvement in learning.
- PO 5**
- Reflective Thinking:** Laboratory-intensive core courses will expose students to a broad range of research methodologies and experimental techniques. Ability to reflect on learning experiences, evaluate the effectiveness of scientific approaches, and understand the broader applications of scientific techniques within the discipline.
- PO 6**
- Problem-Solving Skills:** Ability to develop and apply scientific principles, quantitative reasoning, and mathematical concepts to solve discipline-specific problems. Ability to analyze experimental data, interpret scientific observations, and derive meaningful conclusions. Prepares students to address real-world scientific and societal challenges effectively.
- PO 7**
- Research-Related Skills:** Internships, dissertation work, and research-oriented projects provide opportunities to design, develop, and execute independent research studies. Students gain hands-on experience in research methodology, experimental techniques, data analysis, scientific writing, and ethical research practices. These experiences strengthen laboratory competence and prepare students
- PO 8**

for advanced research and professional careers.

**PO 9 Lifelong Learning:** Cultivates a mindset of continuous learning and professional adaptability. Ability to identify gaps in knowledge and skills, adapt to emerging technologies and scientific advancements, and pursue self-directed learning throughout their careers. Encourages lifelong learning that supports academic growth, employability, and professional excellence.

**PO 10 Leadership Readiness:** Ability to take initiative, work collaboratively, and manage academic and research responsibilities effectively. Through seminars, group projects, internships, and research activities, students develop decision-making, problem-solving, organizational, and interpersonal skills. Ability to lead scientific teams, communicate effectively in professional environments, and contribute responsibly to academic, industrial, and societal development.

#### **PROGRAMME SPECIFIC OUTCOMES:**

**PSO1 Domain Knowledge:** Students will learn about various elements of microbiology, including physiological and metabolic characteristics, evolutionary tendencies, and biological activities in the ecosystem, through a progressive, research-based in-depth study.

**PSO2 Specialization:** After completing an M.Sc. program in this field, students can specialize in a variety of category sectors of microbiology, including medical microbiology, applied microbiology, industrial microbiology, marine microbiology, agriculture microbiology, and more.

**PSO3 Skill development:** Through courses in biotechnology, immunology, virology, microbial ecology, soil microbiology, aquatic microbiology, environmental microbiology, clinical microbiology, and microbial genetics, this curriculum will advance students' scientific understanding and abilities.

**PSO4 Problem Solving:** Microbiologists use methodically applied contemporary quantitative and qualitative problem solving tools and techniques to find/identify, formulate, and provide urgent and innovative solutions to problems, such as new and emerging diseases, through to long-term issues, like antimicrobial drug resistance, food security, and environmental sustainability.

**PSO5 Research and Innovation:** Ability to lead from the front to achieve organizational goals and maximize outcomes for all stakeholders while achieving collaborative cooperation for synergy within and across organizational boundaries. aptitude for learning newer information and abilities, assimilating them, and adapting them such that one is prepared to face an undiscovered world with science and assurance.

**PSO6 Disease management:** Major roles for microorganisms are played in human, animal, and plant illnesses. Through the development of efficient treatments, microbiologists have played a crucial role in both their diagnosis and the treatment of such diseases

**PSO7 Professionalism:** Students who complete this program will be better equipped with the abilities necessary for careers in a variety of microbiology-related scientific and professional disciplines. Students will learn about various elements of microbiology, including physiological and metabolic characteristics, evolutionary tendencies, and biological

activities in the ecosystem, through a progressive, research-based in-depth study.

- PSO8 Employability:** Students who complete this course will be more employable in a variety of industries, including the food standards agency, water and waste management businesses, public and private sector organizations, government agencies, research institutions, hospitals, private laboratories for public health, pharmaceutical, biochemical, and biotechnology businesses, universities, and food and beverage producers.
- PSO9 Entrepreneurship:** After completing this course, students will be able to identify and utilize the potential of microorganisms by creating microbial products that may help with plant and animal growth, human and animal welfare, environmental challenges (such as the chemical or biochemical destruction of plastics), increased food production, etc.
- PSO10 Environment and Sustainability:** Through global environmental processes, the recycling of materials and waste products, and other factors, microorganisms play a crucial role in the sustainability of the environment and biosphere. The SDGs that address food security, health and wellness, clean energy, environmental degradation, and climate change are all directly related to microbiology.
- PSO11 Ethics, Effective citizenship and Social competence:** Uphold the responsibility as a global citizen maintaining professional and ethical values. Ensure bio-safety and bioethics for social responsibility, environmental sensitization and obtain Intellectual Property Rights for various research findings.  
Apply the concepts of Genomics and Proteomics through analytical, molecular and *in silico* techniques for the betterment of society.
- PSO12 Continuous evolution:** Ability to upgrade knowledge independently and act upon means of improvement for lifelong learning. Apply computing, communicative and entrepreneurial skills for employability and lifelong learning.

**SEMESTER – I****GENERAL MICROBIOLOGY**

| <b>Course Code</b>   | CC - 1                                                                                                                                                           | <b>Course Type</b> | <b>Core</b> | <b>L</b> | <b>6</b> | <b>T</b> | <b>-</b> | <b>P</b> | <b>-</b> | <b>C</b> | <b>4</b> | <b>Syllabus version</b> | <b>2026-2027</b> |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------|----------|----------|----------|----------|----------|----------|----------|----------|-------------------------|------------------|
| <b>Pre-requisite</b> | A basic understanding of the diversity of life, taxonomic hierarchies, and the general characteristics that distinguish living organisms from non-living matter. |                    |             |          |          |          |          |          |          |          |          |                         |                  |

**Course Objectives:**

- ✓ Introduce the historical development and fundamental principles of microbiology.
- ✓ Explain microbial diversity, taxonomy, and the general ultra-structural organization of microbial cells.
- ✓ Impart basic microbiological techniques, including sterilization, aseptic culturing, and microscopy.
- ✓ Develop an understanding of microbial metabolism, growth kinetics, and physiological roles in various ecosystems
- ✓ Foster problem-solving and entrepreneurial skills for identifying and managing microbes in health, industry, and the environment.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| <b>COs</b> | <b>COURSE OUTCOMES</b>                                                                                                                                                                                   | <b>KNOWLEDGE LEVEL</b> |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| CO1        | Define key terminologies and identify major groups of microorganisms (e.g., bacteria, fungi, viruses, and parasites) and recognize historical milestones and contributions of pioneering microbiologists | K1                     |
| CO2        | Describe the cellular structures of microorganisms and explain the differences between Gram-positive and Gram-negative bacteria                                                                          | K1, K2                 |
| CO3        | Demonstrate proficiency in standard microbiological laboratory techniques, including Gram Staining and preparation of culture media                                                                      | K1 – K3                |
| CO4        | Analyze the structural and functional differences in microbial world influence life                                                                                                                      | K4                     |
| CO5        | Assess the effectiveness of various sterilization and disinfection methods.                                                                                                                              | K5                     |
| CO6        | Develop innovative, viable scientific strategies or entrepreneurial ventures that leverage microbiological processes                                                                                     | K5, K6                 |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

|                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-I: <b>Evolution and taxonomy of microbial world</b><br>(18 hours)          | Pathway of discovery in Microbiology - contributions of early microbiologists: Leeuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Alexander Fleming & Winogradsky; Microbial Taxonomy - Definition and systematics, nomenclature and identification. Classification of microorganisms & its basis - Haeckel's three kingdom concept, Whittaker's five kingdom concept and Three domain concept of Carl Woese. Major characteristics used in taxonomy – morphological, physiological, metabolic, serological and molecular. Classification and salient features of bacteria according to Bergey's Manual of Determinative Bacteriology - Ninth edition. Numerical taxonomy - 16S rRNA based classification. |
| Unit-II: <b>Microscopy, Sterilization and Cultural Techniques</b><br>(18 hours) | Bright field, Dark field, Phase contrast, Fluorescent and Polarization microscopes, Electron Microscopy – TEM and SEM, Confocal Microscopy - applications. Sterilization - Physical and chemical control of microorganisms. Types of culture media. Isolation and Preservation of different types of microorganisms. Pure culture techniques. Staining methods.                                                                                                                                                                                                                                                                                                                                                 |
| Unit-III: <b>Ultra-structure of Prokaryotic Cell</b><br>(18 hours)              | Difference between prokaryotes and eukaryotes. Ultra-structure of prokaryotic cell – cell wall, cell membrane, flagella, cilia, pili, gas vesicles, chlorosomes, carboxysomes, magnetosomes and phycobilisomes. Capsule structure, composition and properties. Reserve food materials – polyhydroxybutyrate, polyphosphate, oil droplets, cyanophycin granules and sulphur inclusions. Cell division, Endospore – Structure and properties. Archeabacteria – cell structure and differentiating features.                                                                                                                                                                                                       |
| Unit-IV: <b>Structure of Eukaryotic Cells</b><br>(18 hours)                     | Fungi: Structure and organization – fungal body and cells – hyphae, reproductive structures. Ultra-structures - cell wall, cell membrane and cytoplasmic organelles. Algae: forms – unicellular, multi-cellular and filamentous, tubular and membranous. Structure of algal cells and reproduction. Protozoa: classification, organization, forms and structure of protozoan cell – reproduction.                                                                                                                                                                                                                                                                                                               |
| Unit – V: <b>Cellular Microbial Diversity</b><br>(18 hours)                     | General characteristics of following groups of microorganisms. Bacteria - Proteobacteria, Rickettsiae, Chlamydiae, Spirochaetes, Actinomycetes, Cyanobacteria and Mycoplasmas. Algae - <i>Chlamydomonas</i> and <i>Chlorella</i> spp. Biological and Economic importance of macroalgae and Lichens. Fungi - <i>Aspergillus</i> spp. and <i>Saccharomyces cerevisiae</i> . Protozoa: <i>Entamoeba</i> and <i>Plasmodium</i> .                                                                                                                                                                                                                                                                                    |

Unit-VI: **Current Contours** (For Continuous Internal Assessment only): Microbiome & Health: Importance of microbial communities in Human, Animal, and Plant systems; Soil-Plant-Human microbiome links. Modulation: Impact of Diet and Environment on microbiome diversity. Metagenomics Tools: Using NCBI and MG-RAST for data analysis; creating OTU Mapping Files and metadata collection. Global Monitoring: Tracking daily news and research on AMR, COVID-19 updates, and microbial evolution.

#### Mapping with Programme Specific Outcomes

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>C01</b> | S    | S    | L    | S    | S    | L    | M    | M    | L    | L     | L     | L     |
| <b>C02</b> | S    | S    | L    | S    | S    | S    | M    | S    | L    | L     | L     | L     |
| <b>C03</b> | S    | S    | M    | S    | S    | S    | M    | S    | L    | L     | L     | L     |
| <b>C04</b> | S    | S    | M    | S    | S    | S    | M    | S    | S    | S     | M     | M     |
| <b>C05</b> | S    | S    | L    | S    | S    | S    | S    | S    | L    | L     | L     | L     |
| <b>C06</b> | S    | S    | M    | S    | S    | S    | M    | S    | S    | S     | M     | M     |

#### Recommended References:

1. Arora, D. R., and Arora, B. B. (2020). *Textbook of microbiology*, 6th edition. CBS Publishers and Distributors, India.
2. Black, J. G. (2013). *Microbiology*, 8th edition. John Wiley and Sons, United States.
3. Dubey, R. C., and Maheswari, D. K. (2022). *A textbook of microbiology*, 5th edition. S. Chand Publishing, India.
4. Harvey, R. A., Cornelissen, C. N., and Fisher, B. D. (2013). *Lippincott's illustrated reviews: Microbiology*, 3rd edition. Lippincott Williams and Wilkins, United States.
5. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., and Stahl, D. A. (2021). *Brock biology of microorganisms*, 16th edition. Pearson Prentice Hall, United States.
6. Pelzar, M. J., Chan, E. C. S., and Krieg, N. R. (2023). *Microbiology*, 7th edition. McGraw Hill Publishing, United States.
7. Pommerville, J. C. (2014). *Alcamo's fundamentals of microbiology*, 10th edition. Jones & Bartlett Learning, United States.
8. Wiley-Blackwell. (2015). *Bergey's manual of systematics of Archaea and Bacteria*, Digital edition. Wiley, United States.
9. Willey, J. M., Sandman, K., and Wood, D. (2022). *Prescott's microbiology*, 12th edition. McGraw Hill LLC, United States.
10. Willey, J. M., Sherwood, L., & Woolverton, C. J. (2016). *Prescott's microbiology*, 10th edition. McGraw Hill Publishing, United States.

#### Related Online Contents:

1. [mg-rast.org](http://mg-rast.org)
2. [bit.ly/NCBI-Tax](https://bit.ly/NCBI-Tax)
3. [hmpdacc.org](http://hmpdacc.org)
4. [nature.com](http://nature.com)

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**SEMESTER – I****BIOLOGICAL MACROMOLECULES**

| Course Code   | CC-2                                                                                                                     | Course Type | Core | L | T | P | C | Syllabus version | 2026-2027 |
|---------------|--------------------------------------------------------------------------------------------------------------------------|-------------|------|---|---|---|---|------------------|-----------|
| Pre-requisite | Foundational understanding of general chemistry principles and the basic structure and function of biological molecules. |             |      |   |   |   |   |                  |           |

**Course Objectives:**

- ✓ To educate the structure and functions biological molecules.
- ✓ To know the interrelationship between various biomolecules and consequences of any deviation from normal.
- ✓ To understand the structure and functions of blood, hormones and phytohormones.
- ✓ To study the basic metabolic regulators' characteristic features.
- ✓ To understand the interrelationships among biological energy, functions and health.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES                                                                                                                                                                                                                                     | KNOWLEDGE LEVEL |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1 | Acquire a comprehensive understanding of the structure and function of biological molecules.                                                                                                                                                        | K1, K2          |
| CO2 | Discuss the interrelationship between various biomolecules and consequences of deviation from normal.                                                                                                                                               | K4              |
| CO3 | Understand the structure and functions of blood, hormones and phytohormones.                                                                                                                                                                        | K2, K3          |
| CO4 | Provide the information about basic metabolic regulators' characteristic features.                                                                                                                                                                  | K1 - K4         |
| CO5 | Able to explain the interrelationships among biological energy, functions and health.                                                                                                                                                               | K1 - K5         |
| CO6 | Analyze the biochemical mechanisms of endocrine disorders, metabolic syndrome, and lifestyle diseases. Evaluate nutritional strategies and bioactive food components as targeted therapeutic agents to prevent and manage these chronic conditions. | K5, K6          |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation**

Unit-I:  
**Carbohydrate, Proteins and Amino Acids**  
(8 hours)

Carbohydrate: Definition, sources, classification, structure of glucose, biological significance, digestion and absorption. Proteins: Definition, sources, classification and structure of proteins (Primary, secondary, tertiary), Amino acids-structure- classification - essential and non essential, protein and non-protein amino acids.

Unit-II: **Lipids, Fatty Acids and**

Lipids: Definition, sources, classification, structure, properties and functions, Fatty acids-saturated, unsaturated

**Nucleic Acids**  
(8 hours)

and essential fatty acids. Nucleic acids: Definition, structure, forms and functions of DNA. Types, structure and functions of RNA (mRNA, tRNA, rRNA).

**Unit-III: Plant and Animal Hormones**  
(8 hours)

Hormones: Definition, classification of hormones, Human-Endocrine glands – Pituitary, thyroids, Para thyroid, pancreas, adrenal, testis and ovary. Phytohormones: Structure and functions of auxin, gibberellins, cytokinins and abscissic acid.

**Unit-IV: Vitamins and Minerals**  
(8 hours)

Vitamins – Definition, sources, deficiency syndromes and functions of Fat-soluble vitamins (A, D, E and K) and Water-soluble vitamins (B complex and C). Minerals Zn, Ca, Iodine, Fe, and Mg.

**Unit – V: Blood and Plant Pigments**  
(8 hours)

Blood: Introduction, origin, composition, characterization, functions and coagulation of blood. General account and secondary metabolites. Major and accessory microbial pigments – chlorophylls, carotenoids, phycobilins and anthocyanins.

**Unit-VI: Current Contour** (For Continuous Internal Assessment Only)

Diseases associated with deficiency of endocrine hormones-hypo and hyper secretions. Life style diseases and metabolic diseases. Diet biochemical-health. Food as drug.

**Mapping with Specific Programme Outcomes**

|      | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 | PSO 9 | PSO10 | PSO11 | PSO12 |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| CO 1 | S     | S     | S     | S     | S     | L     | S     | S     | M     | L     | L     | L     |
| CO 2 | S     | S     | L     | S     | S     | S     | S     | S     | L     | L     | L     | L     |
| CO 3 | S     | S     | M     | S     | S     | S     | M     | S     | L     | L     | L     | L     |
| CO 4 | S     | S     | M     | S     | S     | S     | S     | S     | S     | S     | M     | M     |
| CO 5 | S     | S     | L     | S     | S     | S     | S     | S     | L     | L     | M     | M     |
| CO 6 | S     | S     | S     | S     | S     | S     | M     | S     | S     | S     | M     | S     |

**Recommended References:**

1. Deb, A. C. (2011). *Fundamentals of biochemistry*, 10th edition. New Central Book Agency (P) Ltd., United Kingdom.
2. Devlin, T. M. (2010). *Textbook of biochemistry with clinical correlations*, 7th edition. John Wiley & Sons, United States.
3. Ferrier, D. R. (2013). *Biochemistry*, 6th edition. Lippincott Williams & Wilkins (LWW) / Wolters Kluwer, United Kingdom.

4. Garrett, R. H., and Grisham, C. M. (2012). *Biochemistry*, 5th edition. Brooks/Cole, Cengage Learning, United States.
5. Lehninger, A. L., Nelson, D. L., and Cox, M. M. (2010). *Lehninger principles of biochemistry*, 2nd edition. W. H. Freeman / Wiley Publisher, United States.
6. Pratt, C. W., and Cornely, K. (2013). *Essential biochemistry*, 3rd edition. John Wiley & Sons, United States.
7. Rafi, M. D. (2014). *Textbook of biochemistry for medical students*, 2nd edition. Universities Press (India) Pvt. Ltd., India.
8. Rajagopal, G. (2010). *Concise textbook of biochemistry*, 2nd edition. Ahuja Publishing House, India.
9. Sathyanarayana, U., and Chakrapani, U. (2013). *Biochemistry*, 4th edition. Elsevier Publishers, India.
10. Shanmugam, A. (1998). *Fundamentals of biochemistry for medical students*. Nagaraj and Company Pvt. Ltd., India.

**Related Online Contents:**

1. [nptel.ac.in](http://nptel.ac.in)
2. [coursera.org](http://coursera.org)
3. [nih.gov](http://nih.gov)
4. [microbenotes.com](http://microbenotes.com)
5. [qiime2.org](http://qiime2.org)
6. [biorender.com](http://biorender.com)

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**SEMESTER – I****GENERAL MICROBIOLOGY & BIOLOGICAL MACROMOLECULES (P)**

| Course Code   | CP-1                                                                                                                      | Course Type | Core | L | T | P | C | Syllabus version | 2026-2027 |
|---------------|---------------------------------------------------------------------------------------------------------------------------|-------------|------|---|---|---|---|------------------|-----------|
| Pre-requisite | Basic theoretical understanding of microbiology, biochemistry, cell biology, and fundamental laboratory safety protocols. |             |      |   |   |   |   |                  |           |

**Course Objectives:**

- ✓ Acquire hands-on skills in aseptic techniques, sterilization, and the operation of fundamental laboratory instruments.
- ✓ Address challenges in isolating, enumerating, and maintaining pure cultures of microorganisms from various environmental samples.
- ✓ Become a creative problem solver in identifying unknown bacterial isolates using differential staining and biochemical characterization.
- ✓ Understand the practical methods for the qualitative and quantitative estimation of biological macromolecules.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                     | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Handle basic microbiological equipment and perform sterilization techniques safely.                 | K1, K2, K3      |
| CO2                                                                                                                    | Prepare culture media and isolate pure cultures using streaking, pouring, and spreading methods.    | K1, K2, K3      |
| CO3                                                                                                                    | Perform simple, differential, and structural staining techniques to observe microbial morphology.   | K3              |
| CO4                                                                                                                    | Characterize unknown bacterial isolates using standard biochemical tests (e.g., IMViC, catalase).   | K3, K4          |
| CO5                                                                                                                    | Quantitatively estimate carbohydrates, proteins, DNA, and RNA using colorimetric assays.            | K1 - K3         |
| CO6                                                                                                                    | Maintain accurate laboratory records, interpret experimental data, and draw scientific conclusions. | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                     |                 |

**GENERAL MICROBIOLOGY**

1. Introduction to Good Laboratory Practices (GLP) and biosafety guidelines.
2. Physical and chemical methods of sterilization (moist heat, dry heat, and membrane filtration).
3. Simple staining, Negative staining, Differential staining: Gram staining technique and Acid-fast staining (Ziehl-Neelsen method).
4. Structural staining: Endospore staining (Schaeffer-Fulton method) and Capsule staining.
5. Observation of bacterial motility using the Hanging drop method.
6. Enumeration of bacteria from soil, water and spoiled food samples using Serial dilution - Pour plate and Spread plate methods, Preparation of pure cultures from mixed populations using Streak plate method
7. Maintenance and preservation of microbial cultures (agar slants and glycerol

stocks).

8. Biochemical identification of bacteria Performing the IMViC series: Indole test, Methyl Red test, Voges-Proskauer test, and Citrate utilization test. Carbohydrate fermentation tests, Catalase test and Oxidase test, Urease test, extracellular enzymes: Starch hydrolysis

### **BIOLOGICAL MACROMOLECULES**

1. Qualitative color tests for carbohydrates (Benedict's test, Iodine test) and proteins (Biuret test, Ninhydrin test).
2. Quantitative estimation of reducing sugars using the 3,5-Dinitrosalicylic acid (DNSA) method.
3. Quantitative estimation of proteins using the Lowry's method or Bradford assay.
4. Quantitative estimation of DNA using the Diphenylamine (DPA) method.
5. Quantitative estimation of RNA using the Orcinol method.

### **Mapping with Specific Programme Outcomes**

|     | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| CO1 | S    | S    | S    | S    | S    | L    | S    | S    | S    | L     | L     | S     |
| CO2 | S    | S    | S    | S    | S    | L    | S    | S    | S    | L     | L     | S     |
| CO3 | S    | S    | S    | S    | S    | L    | S    | S    | S    | L     | L     | S     |
| CO4 | S    | S    | S    | S    | S    | L    | S    | S    | S    | L     | L     | S     |
| CO5 | S    | S    | S    | S    | S    | L    | S    | S    | S    | L     | L     | S     |
| CO6 | S    | S    | S    | S    | S    | L    | S    | S    | S    | L     | L     | S     |

### **Recommended References:**

1. Aneja, K. R. (2007). Experiments in microbiology, plant pathology and biotechnology, 4th edition. New Age International Publishers, India.
2. Benson, H. J. (2001). Microbiological applications: Laboratory manual in general microbiology, 8th edition. McGraw-Hill, United States.
3. Cappuccino, J. G., & Welsh, C. (2017). Microbiology: A laboratory manual, 11th edition. Pearson, United States.
4. Plummer, D. T. (1998). An introduction to practical biochemistry, 3rd edition. McGraw-Hill Education, United States.
5. Sadasivam, S., & Manickam, A. (2008). Biochemical methods, 3rd edition. New Age International Publishers, India.

### **Related Online Contents:**

1. <https://vlab.amrita.edu/?sub=3> (Amrita Vishwa Vidyapeetham Virtual Lab - Biotechnology and Microbiology)
2. <https://bitesizebio.com/> (Articles and protocols on fundamental lab techniques)
3. <https://www.jove.com/> (Journal of Visualized Experiments - Video protocols for staining and biochemical assays)

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**SEMESTER – I****1. VIROLOGY**

| Course Code          | DCEC - 1                                                                                       | Course Type | Core | L<br>5 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|----------------------|------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Fundamental features of bacterial, plant & animal viruses and viruses investigation techniques |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ To enhance understanding on the basics of viruses, virus discovery, properties, classification & replication of viruses.
- ✓ To provide a complete over- view of bacteriophages' diversity, typing, cultivation & applications.
- ✓ To describe representative animal viruses, their cultivation and investigations strategies.
- ✓ To present important plant viruses, their cultivation, control and investigations methods.
- ✓ To highlight emerging viruses, current status of controlled/ eradicated viruses, common control / preventive measures, and viral cancer.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES                                                                                                                                                       | KNOWLEDGE LEVEL |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1 | Acquire a strong knowledge on virus properties and multiplication cycle.                                                                                              | K1, K2          |
| CO2 | Be skilled with steps in bacterial, plant and animal virus infection, transmission, patterns of infection, virus virulence, and host defense against virus infection. | K4              |
| CO3 | Upskill the methods of making virus vaccines and anti-viral drugs, factors of virus evolution, and emerging viruses.                                                  | K3, K4          |
| CO4 | Have an understanding of unusual viral infectious agents (sub-viral agents), virus mediated cellular transformation and oncogenesis.                                  | K4, K5          |
| CO5 | A knowledge on methods of viral cultivation, purification and assays.                                                                                                 | K3, K4          |
| CO6 | Possess the ability to teach and coach others as well as to learn from other sources.                                                                                 | K6, K7          |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation**

Unit I:  
**Viruses & Fundamentals**  
(15 hours)

Virus – Virion - Discovery of Viruses – Properties of Viruses – Classification of Viruses (LHT, Baltimore and ICTV) - Ultra structure of Viruses – Sub viral agents- viroids, prions, virusoids and satellite viruses – Replication of Viruses - Virus attachment, Initiation of infection, cellular receptor for viruses, entry of viruses, genome replication, assembly, Packaging signals, packaging of segmented genome, acquisition of an envelope, budding strategies.

|                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit II: <b>Bacterial Viruses</b><br>(15 hours)                                       | Bacteriophages – Classification - Structure and life cycle - T4, MS2, Lambda, Mu, M13, P1 Phage – lytic and lysogenic Life cycles - Bacteriophage typing, Phage therapy, Cyanophages, Mycoviruses (Mycophages), Rhizobiophages – Cultivation strategies of phages from sewage and other ecosystem – Importance of phages in pollution control.                                                                                                                                                                                                                                                                                                                   |
| Unit III:<br><b>Animal and Human Viruses</b><br>(15 hours)                            | Classification - Structure, Multiplication, Pathogenesis, Diagnosis, Prevention and Treatment of following animal viruses – Papovaviridae - Human Papilloma Virus, Adenoviridae, Herpesviridae - Chicken Pox, Poxviridae - Human monkey pox, Hepadnaviridae - HBV, Picornaviridae - Polio Virus, Rhabdoviridae - Rabies virus, Orthomyxoviridae (Swine- Flu), Pneumoviridae (HRSV), Reoviridae - Rota Virus, Retroviridae (HIV) Flaviviridae - Chikungunya virus and Coronaviridae (SARS-CoV2) - Cultivation of human viruses- Embryonated eggs, Tissue culture and cell culture – Purification of viruses - Serological and immunological methods of diagnosis. |
| Unit IV:<br><b>Plant Viruses</b><br>(15 hours)                                        | Classification– TMV, CMV, CaMV & Geminiviruses. Transmission of plant viruses – Symptoms of viral infection in plants - Control of plant viral diseases - Cultivation of Plant viruses – Meristem culture -- Common viral diseases in paddy, cotton, tomato and sugar cane - Name of diseases, pathogens and symptoms. Generation of virus-free planting material.                                                                                                                                                                                                                                                                                               |
| Unit V: <b>Emerging Viruses, Oncogenic Virus and Control of Viruses</b><br>(15 hours) | Control of Viruses - requirement of an effective vaccine, different ways of making vaccine, types of vaccine. Anti-viral drugs - Theories on origin of virus, evolution of new viruses, emerging viruses, Factors that drive viral emergence - viral cancer, transformation and oncogenesis-Virus-induced cancer, Avian leucosis retroviruses, Proviral DNA sequences, Proto-oncogenes, DNA tumor Viruses, the link between DNA virus biology and transformation. Current status of polio and small pox viruses.                                                                                                                                                 |
| Unit VI: <b>Current Contours (For continuous internal assessment only):</b>           | Advanced case studies from reliable sources, scientific models making / poster preparation on viral epidemics, viral transmissions, preventions, traditional methods of infection prevention shall be given as assignments & seminars. Group discussions in class rooms on methods of viral infection prevention/ control in a community and about emerging viruses. Pursuing a Swayam- NPTEL course on 'Techniques in virology' should be encouraged.                                                                                                                                                                                                           |

### Mapping with Specific Programme Outcomes

|      | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 | PSO 9 | PSO10 | PSO11 | PSO12 |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| CO 1 | S     | S     | L     | S     | S     | S     | S     | S     | L     | L     | L     | M     |
| CO 2 | S     | S     | L     | S     | S     | S     | S     | S     | L     | L     | L     | M     |
| CO 3 | S     | S     | L     | S     | S     | S     | S     | S     | L     | L     | L     | M     |
| CO 4 | S     | S     | L     | S     | S     | S     | S     | S     | L     | L     | L     | M     |
| CO 5 | S     | S     | L     | S     | S     | S     | S     | S     | L     | L     | L     | M     |
| CO 6 | S     | S     | L     | S     | S     | S     | S     | S     | L     | L     | S     | S     |

### Recommended References:

1. Alan J. Cann. 2015. Principles of Molecular Virology. 6<sup>th</sup> edition, Academic press, California.
2. John Carter and Venetia Saunders. 2013. Virology: Principles and applications, 2<sup>nd</sup> Edition, John Wiley and son's publishers, USA.
3. Roger Hull. 2002. Mathews' Plant Virology, 4<sup>th</sup> edition, Academic press- A Harcourt Science and technology company, New York.
4. Martinez J. Hewlett, David Camerini, David C. Bloom. 2021. Basic Virology, Fourth Edition, Wiley Blackwel.
5. Shilpa U. Nair 2015. Virology – A condensed review, 3<sup>rd</sup> edition, CBS Publishers & Distributors. India
6. Saravanan. P. 2006. Virology. MJP Publishers. India
7. Baijayanthimala Mishra. 2025. Textbook of Medical Virology. 2<sup>nd</sup> edition; CBS Publishers & Distributors. India.
8. Rajan S and Kumaresan. S. 2007. Virology. Saras Publications. India.
9. Malik B.S. and Malik M. 2024. Objective & short answer questions in Vetrinary Virology. 2<sup>nd</sup> edition. CBS Publishers & Distributors. India
10. Flint, S. J., Enquist, L. W., Racaniello, V. R., and Skalka, A. M. 2015. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses, 4<sup>th</sup> ed. ASM Press, USA.
11. Dimmock. N.J and Eatson, A.J., Leppard, K.N. 2016. Introduction to Modern Virology. VII edition. 7<sup>th</sup> Edition. Blackwell Scientific Publications, Oxford.
12. Kenneth M Smith. 1972. A text book of plant viral diseases, 3<sup>rd</sup> edition, Elsevier Inc, New York.
13. Maureen A Harrison and Ian F Rae. 2010. General techniques of cell cultures, Cambridge University Press, England.
14. Nicklin J, Greame Cook and Killington, R. 2003. Instant notes in Microbiology, 2<sup>nd</sup> Edition, Viva Books private Limited, New Delhi.
15. Michale J. Pelczar JR., ECS Chan, Noel R. Krieg. 2024. 7<sup>th</sup> edition. MedTech Science Press. India.
16. Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley & David A. Stahl. 2017. Brock Biology of Microorganisms. 14<sup>th</sup> edition. Pearson. USA.

17. Rajan S and Selvichristy J. 2018. Essentials of Microbiology, CBS Publishers, New Delhi.
18. Robert I Krasner. 2002. The Microbial challenge: Human Microbe Interaction, 2<sup>nd</sup> edition, American Society for Microbiology, Washington.

**Related Online Contents:**

1. <https://www.nature.com/scitable/topicpage/the-origins-of-viruses-14398218/>
2. <https://bsppjournals.onlinelibrary.wiley.com/doi/10.1111/j.1364-3703.2011.00752.x>
3. <https://www.sciencedirect.com/journal/virology>
4. <https://www.news-medical.net/health/What-is-Virology.aspx>
5. <https://www.sciencedirect.com/science/article/pii/S0160412019305410>.
6. <https://journal.hep.com.cn/fese/EN/article/downloadArticleFile.do?attachType=PDF&id=28677>.
7. <https://www.nature.com/scitable/topicpage/the-origins-of-viruses-14398218/>
8. <https://www.sciencedirect.com/journal/virology>
9. <https://www.news-medical.net/health/What-is-Virology.aspx>
10. <https://www.coursera.org/courses?query=virus>.

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**SEMESTER – I****2. APPLIED BIOLOGICAL SCIENCES**

| Course Code   | DCEC-1                                                                                | Course Type | Core | L<br>5 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|---------------|---------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| Pre-requisite | Knowledge of fundamental biology, algae, fungi, plants, invertebrates and vertebrates |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ To enable the students to understand the basics components of biology.
- ✓ To understand the biological diversity, uniqueness and their characteristic features.
- ✓ Become a creative problem solver in industrial bioprocessing and the development of bio-based products.
- ✓ To educate about the farm animals developmental principles and essential qualities
- ✓ To create an awareness as to ensure nature based activities and minimize usage of experimental animals

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES                                                                                   | KNOWLEDGE LEVEL |
|-----|---------------------------------------------------------------------------------------------------|-----------------|
| CO1 | Exploring the Thallophytes structure, classification, life cycle, importance                      | K1, K2          |
| CO2 | To learn about Lichens, Bryophytes, Pteridophytes, Gymnosperms and their economic importance      | K4              |
| CO3 | To characterize monocot and dicot plants for morphological taxonomy                               | K3              |
| CO4 | To analyse the classification and importance of Protozoa, Porifera, Coelenterata, Platyhelminthes | K3, K4          |
| CO5 | Understanding the importance of Aschelminthes, Annelida, Arthropoda and Echinodermata             | K1, K2          |
| CO6 | To demonstrate structure and importance of Pisces, Amphibia Reptilia, Aves and Mammalia.          | K5, K6          |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation**

Unit-I:  
**Algae and Fungi**  
(15 hours)

Thallophytes: Algae-General characteristics- Economic importance, Types of life cycle- Outline of various classifications. Fungi: General characteristics- Classifications and Economic importance

Unit-II:  
**Cryptogamic plants**  
(15 hours)

General characteristics- Economic importance and outline of reproduction methods in Lichens, Bryophytes, Pteridophytes and Gymnosperms. Stellar evolution.

Unit-III:  
**Phanerogamic plants**

Salient features of monocot and dicot. Taxonomy: Systems of classification, (Artificial, Phylogenetic and Natural). Morphometric diversity: Morphology; types of inflorescences.

(15 hours) Technical description of flower and floral diagram and types of fruits. Economic importance.

Unit-IV:

**Invertebrates**

(15 hours)

General characteristics and outline classification up to classes in Protozoa, Porifera, Coelenterata, Platyhelminthes, Aschelminthes, Annelida, Arthropoda and Echinodermata; Economic importance of invertebrates. General characters - a brief study on Star fish.

Unit – V:

**Vertebrates**

(15 hours)

Classification of Chordata – General characteristic features and Classification (up to the orders) – Prochordata, Pisces, Amphibia Reptilia, Aves and Mammalia- Economic importance of Vertebrates. Farm animals – Controlling of breeding animals.

Unit-VI: **Current**

**Contours** (For

Continuous

Internal

Assessment only):

Phytoplankton sampling, environmental tracking, digital record of microalgae collected water samples, Field collection and herbarium preparation of Lichens, Bryophytes, Pteridophytes and Gymnosperms, in-Situ Photography of mushroom, Daily news and research papers on Pisces, Amphibia Reptilia, Aves and Mammalia. Drawing the structure of Star fish, Annelida, Arthropoda and Echinodermata

**Mapping with Specific Programme Outcomes**

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>C01</b> | S    | S    | L    | S    | S    | L    | S    | S    | M    | L     | L     | M     |
| <b>C02</b> | S    | S    | L    | S    | S    | L    | S    | S    | M    | S     | S     | M     |
| <b>C03</b> | S    | S    | L    | S    | S    | S    | S    | S    | S    | L     | L     | M     |
| <b>C04</b> | S    | S    | L    | S    | S    | S    | S    | S    | S    | M     | L     | M     |
| <b>C05</b> | S    | S    | L    | S    | S    | S    | S    | S    | S    | L     | L     | M     |
| <b>C06</b> | S    | S    | L    | S    | S    | S    | S    | S    | L    | M     | S     | S     |

**Recommended References:**

1. Arumugam N. 2002. Invertebrate Zoology, Saras publication, Nagercoil.
2. Ekambaranatha Iyar M and Ananthakrishnan TN. 1994. Manual of Zoology. Vol. I. part I and II, S. Visvanathan publication, Chennai.
3. Ranganathan TN. 1996. Chordata Zoology, Rainbow printers, Palayamkottai.
4. Ekambaranatha Ayyar. 2000. Outlines of Zoology. Vols. I and II S. Viswanathan Pvt. Ltd., Chennai.
5. Kotpal RL. 2026. Invertebrata, Rastogi Publication, Meerut. India
6. Jordan EL and Verma PS. 1995. Invertebrate Zoology, 12th Edition, S. Chand and Co., India
7. Mani MS. 1982. General Entomology, Oxford and IBH publishing Co., New Delhi.

**Related Online Contents:**

1. <https://oer.galileo.usg.edu/biology-textbooks/>
2. [https://DAMS-CSIR-Companion-Handbook-Applied-Biology-CCH12/dp/B07J5YTZV9#detailBullets\\_feature\\_div](https://DAMS-CSIR-Companion-Handbook-Applied-Biology-CCH12/dp/B07J5YTZV9#detailBullets_feature_div)

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**SEMESTER – I****1. MICROBIAL DIVERSITY AND EXTREMOPHILES**

| Course Code          | GEC-1                                                                                                             | Course Type | Core | L<br>5 | T<br>- | P<br>- | C<br>3 | Syllabus version | 2026-2027 |
|----------------------|-------------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Knowledge of fundamental microbiology, basic biochemistry, microbial genetics, and general environmental ecology. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the vastness of microbial diversity across the three domains of life and the methods used to study unculturable microorganisms.
- ✓ Address challenges in understanding the physiological, structural, and molecular adaptations that allow life to thrive in extreme environments.
- ✓ Become a creative problem solver in utilizing extremophiles for novel biotechnological, industrial, and bioremediation applications.
- ✓ Understand the ecological roles of extremophiles and their significance in astrobiology and the origin of life.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                  | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Exploring the scope of microbial diversity, the Tree of Life, and modern taxonomic approaches.                   | K1, K2          |
| CO2                                                                                                                    | To learn about the major extreme environments on Earth and the classification of extremophilic microorganisms.   | K1, K2          |
| CO3                                                                                                                    | To characterize the survival mechanisms of temperature-dependent extremophiles (thermophiles and psychrophiles). | K3              |
| CO4                                                                                                                    | Exploring the physiological adaptations of halophiles, alkaliphiles, acidophiles, and piezophiles.               | K3, K4          |
| CO5                                                                                                                    | Understanding the importance of extremozymes and extremolytes in industrial biotechnology.                       | K1, K2          |
| CO6                                                                                                                    | To demonstrate knowledge of extremophiles in astrobiology, space research, and planetary protection.             | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                  |                 |

Unit-I:

**Introduction to Microbial Diversity**  
(15 hours)

The Three Domains of Life (Archaea, Bacteria, Eukarya). Overview of microbial evolution and the universal phylogenetic tree. Morphological, physiological, and metabolic diversity of microorganisms. The concept of the "unculturable majority" and microbial dark matter. Introduction to culture-independent techniques (metagenomics) for exploring environmental diversity.

|                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-II: <b>Biology of Extremophiles</b><br>(15 hours)                      | Definition and classification of extremophiles and polyextremophiles. Habitats of extremophiles: deep-sea hydrothermal vents, hot springs, hypersaline lakes, permafrost, subglacial lakes, and acidic mine drainage. The role of Archaea in extreme environments. Evolutionary significance of extremophiles and theories regarding the origin of life on early Earth.                                                                                         |
| Unit-III:<br><b>Thermophiles and Psychrophiles</b><br>(15 hours)            | Thermophiles and Hyperthermophiles: Molecular adaptations to high temperatures (membrane lipid composition, ether linkages in Archaea, thermostable proteins, chaperone proteins, and DNA reverse gyrase). Psychrophiles: Adaptations to freezing temperatures (cold-shock proteins, membrane fluidity maintenance, antifreeze proteins, and cryoprotectants).                                                                                                  |
| Unit-IV:<br><b>Halophiles and Alkaliphiles</b><br>(15 hours)                | Halophiles: Osmoregulation mechanisms ("salt-in" vs. "compatible solute" strategies), bacteriorhodopsin, and photophosphorylation in <i>Halobacterium</i> . Acidophiles and Alkaliphiles: Mechanisms of intracellular pH homeostasis and specialized cell wall/membrane bioenergetics. Piezophiles (Barophiles): Adaptations to high hydrostatic pressure in the deep ocean. Polyextremophiles (e.g., <i>Deinococcus radiodurans</i> and radiation resistance). |
| Unit – V:<br><b>Applications of Extremophiles</b><br>(15 hours)             | Industrial importance of extremozymes: Taq polymerase (PCR), thermostable amylases/proteases (detergents, food processing), and cold-adapted enzymes (biosensors, bioremediation in cold climates). Extremolytes and their applications in cosmetics and pharmaceuticals. Role of extremophiles in biomining (bioleaching of heavy metals) and the bioremediation of toxic wastes under extreme conditions.                                                     |
| Unit-VI: <b>Current Contours</b> (For Continuous Internal Assessment only): | Daily news and research papers on newly discovered extreme environments and astrobiology missions (e.g., Mars rovers, Europa Clipper). Public awareness of climate change impacts on extreme ecosystems (e.g., melting permafrost microbiomes). Computational analysis utilizing databases like the Extremophiles Database. Drafting a scientific model on how extremophile biology informs the search for extraterrestrial life.                               |

**Mapping with Specific Programme Outcomes**

|             | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>CO 1</b> | S    | S    | L    | S    | S    | M    | S    | S    | L    | L     | L     | M     |
| <b>CO 2</b> | S    | S    | L    | S    | S    | M    | S    | S    | L    | L     | L     | M     |
| <b>CO 3</b> | S    | S    | L    | S    | S    | M    | S    | S    | L    | L     | L     | M     |
| <b>CO 4</b> | S    | S    | L    | S    | S    | M    | S    | S    | L    | L     | L     | M     |
| <b>CO 5</b> | S    | S    | L    | S    | S    | M    | S    | S    | L    | L     | L     | M     |
| <b>CO 6</b> | S    | S    | L    | S    | S    | M    | S    | S    | L    | L     | L     | S     |

**Recommended References:**

1. Horikoshi, K., Antranikian, G., Bull, A. T., Robb, F. T., & Stetter, K. O. (Eds.). (2011). *Extremophiles Handbook*. Springer. USA.
2. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2020). *Brock Biology of Microorganisms*, 16th Edition. Pearson. USA.
3. Gerday, C., & Glansdorff, N. (Eds.). (2007). *Physiology and Biochemistry of Extremophiles*. ASM Press. USA.
4. Rothschild, L. J., & Mancinelli, R. L. (2001). Life in extreme environments. *Nature*, 409(6823), 1092-1101.
5. Rampelotto, P. H. (Ed.). (2016). *Biotechnology of Extremophiles: Advances and Challenges*. Springer. USA.

**Related Online Contents:**

1. <https://astrobiology.nasa.gov/>
2. <https://www.coursera.org/learn/astrobiology>
3. <https://microbewiki.kenyon.edu/>

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**SEMESTER – I****2. MARINE MICROBIOLOGY**

| Course Code          | GEC-1                                                                                                                  | Course Type | Core | L<br>5 | T<br>- | P<br>- | C<br>3 | Syllabus version | 2026-2027 |
|----------------------|------------------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Knowledge of basic microbiology, introductory ecology, and fundamental concepts of physical and chemical oceanography. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the vast diversity, distribution, and ecological roles of microorganisms in the marine environment.
- ✓ Address challenges in studying marine microbes, including unculturability and extreme environmental sampling.
- ✓ Become a creative problem solver regarding the impacts of climate change on marine microbial ecosystems.
- ✓ Understand the critical role of marine microbes in global biogeochemical cycles, food webs, and blue biotechnology.
- ✓ To explore the marine derived natural products like antimicrobials and heavy metal degradation.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                           | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Exploring the diversity, taxonomy, and spatial distribution of marine microorganisms.                     | K1, K2          |
| CO2                                                                                                                    | To learn about the physiological and structural adaptations of microbes in extreme marine environments.   | K4, K5          |
| CO3                                                                                                                    | To characterize the role of marine microbes in global biogeochemical cycling and climate regulation.      | K3, K4          |
| CO4                                                                                                                    | Exploring the ecological significance of the microbial loop, marine viruses, and symbiotic relationships. | K3, K4          |
| CO5                                                                                                                    | Understanding the importance of marine bioprospecting and microbial biotechnology in industry.            | K1, K2          |
| CO6                                                                                                                    | To demonstrate knowledge of advanced sampling techniques and omics-based approaches in marine research.   | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                           |                 |

**Unit-I: The Marine Environment and Microbial Diversity**  
(15 hours)

Physical and chemical properties of the ocean (salinity, temperature, pressure, light penetration). Zones of the ocean. Diversity of marine microorganisms: Marine Archaea, Bacteria, Cyanobacteria, and eukaryotic phytoplankton. The concept of the "unculturable majority" and marine microbial dark matter.

|                                                                             |                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-II: <b>Marine Microbial Ecology and Interactions</b><br>(15 hours)     | Primary production in the oceans. The Microbial Loop and the viral shunt: role of marine bacteriophages in nutrient cycling. Symbiotic relationships in the ocean: mutualism in coral reefs, bioluminescent symbioses, and chemosynthetic symbioses in deep-sea invertebrates.                                         |
| Unit-III: <b>Marine Biogeochemical Cycles</b><br>(15 hours)                 | The Biological Carbon Pump and marine snow. Role of marine microbes in the Carbon cycle - photosynthesis and respiration, Nitrogen cycle- nitrogen fixation, nitrification, denitrification, Phosphorus, and Sulfur cycles. Methanogenesis and anaerobic oxidation of methane in marine sediments.                     |
| Unit-IV: <b>Extremophiles and Deep-Sea Microbiology</b><br>(15 hours)       | Microbial life in extreme marine environments. Adaptations of psychrophiles- sea ice and deep ocean, thermophiles and hyperthermophiles-hydrothermal vents, halophiles-hypersaline basins, and piezophiles/barophiles. Chemosynthesis as the primary energy source in deep-sea ecosystems.                             |
| Unit – V: <b>Marine Biotechnology and Bioremediation</b><br>(15 hours)      | Marine bioprospecting: discovery of novel bioactive compounds, marine-derived antibiotics, anticancer agents, and industrial enzymes. Marine microorganisms in aquaculture. Role of marine microbes in the bioremediation of oil spills, heavy metals, and plastic degradation in the oceans.                          |
| Unit-VI: <b>Current Contours</b> (For Continuous Internal Assessment only): | Daily news and research papers on ocean warming, acidification, and their impact on marine microbiomes. Public awareness of marine pollution and coral bleaching. Computational analysis of marine metagenomic data (e.g., Tara Oceans expedition datasets). Collection of metadata from global oceanographic surveys. |

#### Mapping with Specific Programme Outcomes

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>CO1</b> | S    | S    | L    | S    | S    | L    | S    | S    | L    | L     | L     | M     |
| <b>CO2</b> | S    | S    | L    | S    | S    | L    | S    | S    | L    | L     | L     | M     |
| <b>CO3</b> | S    | S    | L    | S    | S    | L    | S    | S    | L    | L     | L     | M     |
| <b>CO4</b> | S    | S    | L    | S    | S    | L    | S    | S    | L    | L     | L     | M     |
| <b>CO5</b> | S    | S    | L    | S    | S    | S    | S    | S    | L    | L     | L     | M     |
| <b>CO6</b> | S    | S    | L    | S    | S    | L    | S    | S    | L    | L     | L     | M     |

#### Recommended References:

1. Munn, C. B. (2019). Marine Microbiology: Ecology & Applications, 3rd Edition. CRC Press. USA.
2. Paul, J. H. (2001). Marine Microbiology (Methods in Microbiology, Vol. 30). Academic Press. UK.
3. Kirchman, D. L. (2018). Processes in Microbial Ecology, 2<sup>nd</sup> Edition. Oxford University Press. UK.

4. Gasol, J. M., & Kirchman, D. L. (Eds.). (2018). Microbial Ecology of the Oceans, 3<sup>rd</sup> Edition. John Wiley & Sons. USA.
5. Azam, F., Fenchel, T., Field, J. G., Gray, J. S., Meyer-Reil, L. A., & Thingstad, F. (1983). The ecological role of water-column microbes in the sea. Marine Ecology Progress Series, 10(3), 257-263.

**Related Online Contents:**

1. <https://oceanobservatories.org/>
2. <https://oceans.taraexpeditions.org/en/m/science/news/tara-oceans/>
3. <https://www.edx.org/learn/oceanography>

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**SEMESTER – I****PROBIOTIC MICROBIOLOGY**

| Course Code          | SEC-1                                                                                                        | Course Type | Core | L<br>2 | T<br>- | P<br>- | C<br>2 | Syllabus version | 2026-2027 |
|----------------------|--------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Knowledge of basic microbiology, microbial physiology, gastrointestinal anatomy, and fundamental immunology. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the fundamental concepts, history, taxonomy, and selection criteria of probiotic microorganisms.
- ✓ Address challenges in the industrial production, formulation, viability, and delivery of probiotics.
- ✓ Become a creative problem solver in the development of functional foods using prebiotics, probiotics, and synbiotics.
- ✓ Understand the mechanisms of action, clinical applications, and regulatory guidelines governing probiotic use in human health.
- ✓ Understand the probiotics, prebiotics in gastrointestinal health.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                      | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Exploring the biology, taxonomy, and screening protocols for potential probiotic strains.                            | K1, K2          |
| CO2                                                                                                                    | To learn about the mechanisms of action and immunomodulatory effects of probiotics in the host.                      | K4              |
| CO3                                                                                                                    | To characterize the industrial scale-up, microencapsulation, and quality control of probiotic formulations.          | K3, K4          |
| CO4                                                                                                                    | Exploring the synergistic roles of prebiotics, synbiotics, and the emerging concept of postbiotics.                  | K3, K4          |
| CO5                                                                                                                    | Understanding the importance of probiotics in managing gastrointestinal disorders and systemic health.               | K1, K2          |
| CO6                                                                                                                    | To demonstrate knowledge of safety assessments, regulatory frameworks (FDA/EFSA), and commercial product evaluation. | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                      |                 |

Unit-I:  
**Introduction to Probiotics**  
(6 hours)

History and evolution of the probiotic concept (Metchnikoff's theory). FAO/WHO definitions. Taxonomy and characteristics of common probiotic microorganisms: *Lactobacillus* species, *Bifidobacterium* species, *Saccharomyces boulardii*, and spore-forming probiotics (*Bacillus* spp.). Criteria for the selection of probiotic strains (acid and bile tolerance, adhesion capacity).

|                                                                             |                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-II:<br><b>Mechanisms of Action</b><br>(6 hours)                        | Host-microbe interactions in the gastrointestinal tract. Mechanisms of probiotic action: competitive exclusion of pathogens, enhancement of the epithelial barrier function, production of antimicrobial compounds -bacteriocins, organic acids, hydrogen peroxide, and modulation of the host immune system-gut-associated lymphoid tissue.                              |
| Unit-III:<br><b>Prebiotics, Synbiotics, and Postbiotics</b><br>(6 hours)    | Concept and definition of prebiotics. Types of prebiotics: Fructooligosaccharides, Galactooligosaccharides, Inulin, and resistant starch. Mechanism of prebiotic fermentation and production of Short-Chain Fatty Acids. Concept of Synbiotics. Types, mechanism and importance of postbiotics                                                                            |
| Unit-IV:<br><b>Production and Formulation</b><br>(6 hours)                  | Industrial scale-up and fermentation of probiotic strains. Downstream processing: harvesting and drying techniques (freeze-drying, spray-drying). Challenges in maintaining cell viability and stability during storage and gastric transit. Microencapsulation technologies for targeted delivery. Quality control and enumeration of probiotics in commercial products. |
| Unit-V: <b>Clinical Applications and Health Benefits</b><br>(6 hours)       | Probiotics in gastrointestinal health: prevention and treatment of antibiotic-associated diarrhea, irritable bowel syndrome, inflammatory bowel disease, and <i>Helicobacter pylori</i> infection. Alleviation of lactose intolerance. Emerging roles of probiotics in the gut-brain axis, obesity, metabolic syndrome, and oral/skin health.                             |
| Unit-VI: <b>Current Contours</b> (For Continuous Internal Assessment only): | Daily news and research papers on probiotic discoveries. Public awareness of functional foods, fermented beverages (Kombucha, Kefir), and dietary supplements. Scientific model on gut microbiome modulation via diet. Analysis of commercial probiotic product labels and understanding regulatory guidelines (GRAS status, QPS).                                        |

#### Mapping with Specific Programme Outcomes

|            | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 | PSO 9 | PSO10 | PSO1 1 | PSO1 2 |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|
| <b>CO1</b> | S     | S     | M     | S     | S     | L     | S     | S     | M     | L     | L      | M      |
| <b>CO2</b> | S     | S     | M     | S     | S     | L     | S     | S     | M     | L     | L      | M      |
| <b>CO3</b> | S     | S     | L     | S     | S     | L     | S     | S     | S     | L     | L      | M      |
| <b>CO4</b> | S     | S     | L     | S     | S     | S     | S     | S     | L     | L     | L      | M      |
| <b>CO5</b> | S     | S     | L     | S     | S     | S     | S     | S     | L     | L     | L      | S      |
| <b>CO6</b> | S     | S     | L     | S     | S     | L     | S     | S     | L     | L     | L      | S      |

#### Recommended References:

1. Tannock, G. W. (Ed.). (2005). Probiotics and Prebiotics: Scientific Aspects. Caister Academic Press. UK.

2. Gibson, G. R., and Roberfroid, M. B. (1995). Dietary modulation of the human colonic microbiota: introducing the concept of prebiotics. *The Journal of Nutrition*, 125(6), 1401-1412.
3. Liong, M. T. (Ed.). (2011). Probiotics: Biology, Genetics and Health Aspects. Springer. USA.
4. Fuller, R. (1989). Probiotics in man and animals. *Journal of Applied Bacteriology*, 66(5), 365-378.
5. Salminen, S., von Wright, A., and Ouwehand, A. (Eds.). (2004). Lactic Acid Bacteria: Microbiological and Functional Aspects. CRC Press. USA.
6. FAO/WHO. (2002). Guidelines for the Evaluation of Probiotics in Food. Food and Agriculture Organization of the United Nations and World Health Organization.

**Related Online Contents:**

1. <https://isappscience.org/>
2. <https://worldgastroenterology.org/guidelines/probiotics-and-prebiotics>
3. <https://www.nccih.nih.gov/health/probiotics-what-you-need-to-know>

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**SEMESTER – I****MEDICAL LABORATORY TECHNOLOGY**

| Course Code   | VAC -1                                                                       | Course Type | Value Added | L | T | P | C | Syllabus version | 2026-2027 |
|---------------|------------------------------------------------------------------------------|-------------|-------------|---|---|---|---|------------------|-----------|
| Pre-requisite | Basic understanding of infectious diseases, immunity and diagnostic methods. |             |             |   |   |   |   |                  |           |

**Course Objectives:**

- ✓ Knowledge (Cognitive): Introduce students to principles of hematology, clinical chemistry, microbiology, and immunohematology.
- ✓ Application (Cognitive): Enable students to apply scientific principles of pathology to diagnostic laboratory testing.
- ✓ Skill (Psychomotor): Develop proficiency in collecting, processing, and analyzing biological specimens with high precision.
- ✓ Analysis (Cognitive): Train students to interpret laboratory data, identify discrepancies, and relate findings to clinical diagnosis.
- ✓ Affective (Professionalism): Emphasize ethical standards, quality assurance (QA), and safe laboratory practices.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                                                                          | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Recall laboratory protocols, defining medical terms, identifying blood cell types, and understanding safety regulations.                                                 | K1              |
| CO2                                                                                                                    | Explain the principles behind diagnostic tests and interpreting quality control data.                                                                                    | K1, K2          |
| CO3                                                                                                                    | Perform laboratory procedures such as blood typing, pipetting, or operating analyzers. This includes using point-of-care testing in clinical settings.                   | K1 - K3         |
| CO4                                                                                                                    | Evaluate complex laboratory results to distinguish normal from abnormal findings, identifying procedural errors, and determining if results align with patient symptoms. | K1- K4          |
| CO5                                                                                                                    | Justify test selection, auditing laboratory procedures for quality maintenance, and validating results before reporting.                                                 | K1 - K5         |
| CO6                                                                                                                    | Design new laboratory procedures, implementing improvements to workflows, and conducting research for diagnostic improvements                                            | K1 - K6         |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                                                                          |                 |

|                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                      |
|-----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Unit-I: Basics of medical lab technology</b>                             | Role, responsibility, ethics to be followed by medical lab technologist, types of hazards and laboratory accidents – first aid and safety measures to be followed. Units of measurement: SI Unit, reference range, conversion factor, Units for measurement of bio metabolite, enzymes, protein, drugs, hormones, vitamins.                                                                          |
| <b>Unit-II: Specimen collection and processing</b>                          | Specimen collection and processing of blood, urine, stool and CSF - normal & abnormal constituents. Semen Analysis<br>Hyperglycemia & hypoglycemia-Diabetes mellitus.<br>Histopathology: Tissue Processing- Fixing, Embedding, Microtomy, Staining, mounting, decalcifications.                                                                                                                      |
| <b>Unit-III: Culture techniques and serological test for diagnosis</b>      | Culture Techniques, Bacterial, Fungal culture media & their uses, Antibiotic sensitivity test, Diagnostic test for HIV, Hepatitis B, Hepatitis C, Malaria, Tuberculosis. WIDAL, VDRL, RA, CRP, ELISA, Pregnancy test, Hyper sensitivity reactions. Stool examination-Identification of different ova & cysts.                                                                                        |
| <b>Unit-IV: Liver and renal function test</b>                               | Liver, Renal Functions & their Assessment, Jaundice and its types and their biochemical findings, Blood urea estimation, Serum uric acid, total protein, albumin, globulin, glucose, total HDL-LDL cholesterol, Triglyceride, Bilirubin total estimation, Serum SGOT, SGPT estimation, Clinical enzymology and automation.                                                                           |
| <b>Unit – V: Hormones and Cancer diagnosis</b>                              | Hormones of the Thyroid gland - chemistry and normal physiology, Thyroid test. Hormones of the gonads- Estimation of FSH, LH, HCG, Progesterone, Testosterone. Cancer- Estimation of cancer marker, Pap smear test for cervical cancer. Drug abuse screening. Molecular methods in diagnosis. Biomedical waste management, Visit to clinical laboratory and hospital.                                |
| <b>Unit-VI: Current Contours (For Continuous Internal Assessment only):</b> | Review and discussion on AI-Powered Diagnostics, Intelligent Automation, Image Analysis & Annotation, Molecular Diagnostics and Molecular Testing like Ready-to-Use PCR Panels, Expansion of Multiplex Testing, Molecular Data Interpretation; Digital Transformation and Interoperability like Metaverse in Laboratory Medicine, Data Integration, Internet of Things in biomedical instrumentation |

## Mapping with Specific Programme Outcomes

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>C01</b> | S    | S    | M    | S    | S    | L    | S    | S    | S    | L     | M     | S     |
| <b>C02</b> | S    | S    | M    | S    | S    | L    | S    | S    | S    | L     | M     | S     |
| <b>C03</b> | S    | S    | M    | S    | S    | L    | S    | S    | S    | L     | M     | S     |
| <b>C04</b> | S    | S    | M    | S    | S    | L    | S    | S    | S    | L     | M     | S     |
| <b>C05</b> | S    | S    | M    | S    | S    | L    | S    | S    | S    | L     | M     | S     |
| <b>C06</b> | S    | S    | M    | S    | S    | L    | S    | S    | S    | L     | M     | S     |

### RECOMMENDED REFERENCES:

1. Baker F.J. and R.E. Silvertown. 1976. Introduction to Medical Laboratory Technology. Fifth Edition, Elsevier, USA.
2. Mehdi SR. 2013 Essentials of Blood banking. Jaypee Brothers, Medical Publishers Pvt. Limited. India.
3. Satish Gupte. 2014. The short text book of Medical Laboratory for technicians- Jaypee Brothers Pvt. Limited. India.
4. Sood Ramnik. 2009. Medical Laboratory Technology: Methods and Interpretations. Jaypee Brothers, Medical Publishers Pvt. Limited.
5. Ganendrakumar Chakravarti. 1978. A hand book of Clinical Pathology, Academic Publishers, Calcutta.
6. Ochei. J and A. Kolhatkar, 2000. Medical Laboratory science: Theory and practice, McGraw Hill Education. India.
7. Dacie and Lewis, 2016. Practical Haematology, Elsevier. USA.
8. Praful Godkar, Darsan, 2014. Text book of Medical Laboratory Technology Vol I & II, Bhalani Publishing House. India.

### Related Online Contents:

1. <http://www.winthrop.org/diagnostic-technologytechniques>
2. <http://www.ttsglobalinitiative.com/newsletter/clinicaldiagnostic-technologies- face-new-obstacles/>
3. <https://www.mooc-list.com/tags/medical-diagnosis>
4. <https://www.mooc-list.com/tags/clinical-diagnostics>

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**SEMESTER – II****MICROBIAL PHYSIOLOGY AND METABOLISM**

| Course Code          | CC-3                                                                                                                       | Course Type | Core | L<br>6 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|----------------------|----------------------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Fundamental knowledge of biochemistry and general microbiology concepts such as metabolism, enzymes, and microbial growth. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ To provide the learners a strong base of bacterial cell physiology so as to impart them with the principal knowledge of functions of bacterial organelles
- ✓ To describe the anabolic and catabolic sections of metabolism deeply
- ✓ To impart the knowledge of extremophilic organisms and their merits
- ✓ To understand metabolic processes of energy substrates
- ✓ To teach unique physiological features like methanogenesis, bioluminescence and quorum sensing

**Expected Course Outcomes:**

**On the completion of the course, the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                                                                                                                | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Understand the nutrient requirement for bacterial cell.                                                                                                                                                        | K1, K2          |
| CO2                                                                                                                    | Assimilate the mechanism of bacterial cell wall synthesis.                                                                                                                                                     | K4              |
| CO3                                                                                                                    | Differentiate the types of energy generating mechanisms among prokaryotes.                                                                                                                                     | K4              |
| CO4                                                                                                                    | Understand the microbial adaptation on chemical-ecological processes.                                                                                                                                          | K1, K2          |
| CO5                                                                                                                    | Clearly understand carbohydrate and nitrogen metabolisms.                                                                                                                                                      | K1, K2          |
| CO6                                                                                                                    | Understand bacterial cell structure, metabolism (phototrophy, chemolithotrophy, carbohydrate and nitrogen pathways), and apply knowledge through biofertilizer preparation and scientific presentation skills. | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                                                                                                                |                 |

**Unit-I: Microbial nutrients and Growth**  
(18 hours)

Common nutrient requirements, Growth factors - nutritional groups/ types - Bacterial growth - Phases of growth curve - measurement of growth - calculations of growth rate - generation time - synchronous growth - induction of synchronous growth, synchrony index - factors influencing growth - Uptake of nutrients by the cell - Facilitated diffusion - Active transport - Group translocation, Iron uptake - Pinocytosis and Phagocytosis. Survival at extreme environments - starvation - Extremophiles: adaptative mechanisms in thermophilic, alkalophilic, osmophilic and psychrophilic organisms.

|                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-II:<br><b>Biosynthesis of microbial cell structures</b><br>(18 hours)              | Biosynthesis of bacterial cell components – cell wall – peptidoglycan – teichoic acid - lipid bilayer (inner membranes) – periplasmic space constituents - cytoplasmic membrane (outer membrane). Exopolysaccharides, Capsules, Slime layer. Surface appendages - pili, fimbriae, flagella. Fungal and algal cell wall biosynthesis. Electron carriers – artificial electron donors – inhibitors uncouplers – energy bond – phosphorylation.                                                                                        |
| Unit-III:<br><b>Phototrophy and Chemolithotrophy</b><br>(18 hours)                      | Autotrophs - photosynthetic bacteria and green algae – heterotrophs – bacteria, fungi, myxotrophs. Photosynthetic and accessory pigments: Chlorophyll, bacteriochlorophyll, carotenoids, phycobilliproteins, fluorescence, phosphorescence, rhodopsin, Oxygenic and anoxygenic Photosynthesis– Autotrophic generation of ATP. Fixation of CO <sub>2</sub> . – C3, C4 pathways. Chemolithotrophy – Sulphur, Iron, Hydrogen, Nitrogen oxidations. Physiology and regulation - methanogenesis, bioluminescence and quorum sensing.     |
| Unit-IV:<br><b>Carbohydrate Metabolism – Respiration and Fermentation</b><br>(18 hours) | Glycolytic pathways – Embden – Meyerhoff pathway - the pentose phosphate pathway – the Entner Doudoroff pathway – the Tricarboxylic acid cycle – glyoxylate cycle. Electron Transport Chain. ATP synthesis- Substrate level phosphorylation – Oxidative phosphorylation – reverse TCA cycle – gluconeogenesis – lipid catabolism – beta oxidation. Anaerobic respiration – sulfur compounds – nitrate and carbon dioxide as electron acceptors. Homo and heterolactic acid fermentations. Fermentation by <i>Ruminococcus albus</i> |
| Unit-V:<br><b>Nitrogen Metabolism and Bacterial Sporulation</b><br>(18 hours)           | Biological nitrogen fixation – nitrogenase enzymes – structure and properties – ‘ <i>nif</i> ’ gene cluster – regulation – functions. Assimilation of inorganic nitrogen –nitrate, nitrite – dinitrogen – ammonia. Cell division – endospore – structure – properties – germination. Microbial sporulation and morphogenesis: Bacteria including cyanobacteria and actinobacteria, fungi and algae.                                                                                                                                 |
| Unit-VI: <b>Current Contours</b> (For Continuous Internal Assessment only):             | Chart preparation showing bacterial cell structure and functions of each part, biochemical pathways of Phototrophy and chemolithotrophy, Carbohydrate metabolism and Fermentation, and Nitrogen metabolism & bacterial sporulation - preparation of a biofertilizer using any one nitrogen fixing organism and a locally available carrier material – Quiz classes - short seminar presentations on the prepared charts.                                                                                                            |

### Mapping with Specific Programme Outcomes

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>C01</b> | S    | S    | L    | S    | S    | L    | S    | S    | L    | L     | L     | S     |
| <b>C02</b> | S    | S    | L    | S    | S    | L    | S    | S    | L    | L     | L     | S     |
| <b>C03</b> | S    | S    | L    | S    | S    | L    | S    | S    | L    | L     | L     | S     |
| <b>C04</b> | S    | S    | L    | S    | S    | L    | S    | S    | L    | L     | L     | S     |
| <b>C05</b> | S    | S    | L    | S    | S    | L    | S    | S    | L    | L     | L     | S     |
| <b>C06</b> | S    | S    | L    | S    | S    | L    | S    | S    | L    | L     | L     | S     |

### Recommended References:

1. Harley JP and Klein DA. Microbiology. Latest edition, 2013. Prescott LM, McGraw Hill, New York.
2. Byung Hong Kim and Geoffrey Michael Gadd. 2016. Bacterial physiology and metabolism, Cambridge University Press, USA
3. Moat. A.G. and Foster. J.W. 2017. Microbial Physiology, John Wiley sons, 4<sup>th</sup> edition, New York.
4. Stainer, R.Y., Ingraham, J.L. and Wheelis, M.L. 1986. General Microbiology. 5<sup>th</sup> edition, The McMillan Press Ltd., London.
5. David L. Nelson and Michael M. Cox 2017 . Lehninger Principles of Biochemistry, 7<sup>th</sup> edition W.H. Freeman Publisher, New York.
6. David White, James Drummond, and Clay Fuqua, 2011. The Physiology and Biochemistry of Prokaryotes. 4<sup>th</sup> Edition, Oxford University Press, England,
7. Michael M. Madigan, Kelly S. Bender, Daniel H. Buckley, W Matthew Sattley, and David A. Stahl, 2017. Brock Biology of Microorganisms, 15<sup>th</sup> edition, Pearson Education, UK.
8. Caldwell DR. 1995. Microbial Physiology and metabolism, Wm. C. Brown Publishers, USA.
9. Rajan S and Selvichristy. 2019. Exam Oriented Biochemistry. CBS Publishers, New Delhi.
10. Lansing M. Prescott, John P. Harley and Donald A. Klein. 2003. Microbiology. 5<sup>th</sup> edition. McGraw-Hill Company, New York.

### Related Online Contents

1. National Center for Biotechnology Information – <https://www.ncbi.nlm.nih.gov>
2. PubMed – <https://pubmed.ncbi.nlm.nih.gov>
3. Khan Academy – <https://www.khanacademy.org>
4. MIT OpenCourseWare – <https://ocw.mit.edu>
5. Coursera – <https://www.coursera.org>

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**SEMESTER – II**  
**MICROBIAL GENETICS AND MOLECULAR BIOLOGY**

| Course Code          | CC - 4                                                                       | Course Type | Core | L<br>6 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|----------------------|------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Basics of nucleic acids' replication, gene expression, regulation & mutation |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ To impart the current updated knowledge on molecular genetics of prokaryotes, eukaryotic and phages in addition to the most essential fundamentals of the subject.
- ✓ To provide molecular details of genome replication, its damage and repair mechanisms
- ✓ To understand molecular regulation of gene expression in bacteria and phages
- ✓ To impart molecular mechanisms of gene transfer and their importance in natural evolution
- ✓ To describe the significance & processes behind mutations, other genetic changes, and about mutagens

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                        | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Have a complete bird- eye view of molecular biology and microbial genetics including advanced topics of the course.    | K1, K2          |
| CO2                                                                                                                    | Possess a deeper understanding of the central dogma of protein synthesis from DNA/ RNA replication to gene expression. | K4              |
| CO3                                                                                                                    | Describe the molecular mechanisms of gene expression regulation in prokaryotes, eukaryotes and phages.                 | K2              |
| CO4                                                                                                                    | Elaborate the gene transfer methods and proficiency on specific biological problems with genetic relevance.            | K3, K4          |
| CO5                                                                                                                    | Display the know- how of mutation, its diversity and all associated molecular events.                                  | K1, K2          |
| CO6                                                                                                                    | Self- create and self-evaluate the course proficiency.                                                                 | K6, K7          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation</b> |                                                                                                                        |                 |

Unit I: **Genome organization and DNA replication**  
(18 hours)

Evidences for DNA as the genetic material (genome): Direct (Griffith, Avery *et.al.*, Hershey & Chase and bacterial conjugation) & Indirect experiments. Organization of genome: Prokaryotes – Eukaryotes: nucleus and nucleosomes, chromatin, chromosomes, heterochromatin, euchromatin, lamp brush and giant chromosomes. Central Dogma – Types of DNA Replication: Semi- conservative, Conservative & Dispersive; DNA replication models: Rolling circle, D-loop &

Linear replication - Mechanism, enzymes and proteins of replication – Replication of RNA. Differences between prokaryotic and eukaryotic replication. Plasmids – types and structure. Inhibitors of DNA replication – Causes & sources of DNA damage – DNA damage repair mechanisms: Excision repair, SOS repair and mismatch repair.

Unit II:  
**Transcription and translation**  
(18 hours)

DNA transcription process: initiation, elongation – termination. Synthesis of mRNA in prokaryotes and eukaryotes. Synthesis of rRNA and tRNA. Precursor mRNA processing – capping, polyadenylation and splicing. Inhibitors of transcription. Genetic code, Process of mRNA translation – initiation, elongation and termination. Post translation processing. Signal sequences and protein transport. Inhibitors of translation.

Unit III:  
**Regulation of gene expression**  
(18 hours)

Genes organization in Prokaryotes and Eukaryotes - Introduction - Operon concept, *lac*, *trp*, arabinose operons, promoters and repressors. Regulation of gene expression – Transcriptional control – promoters, terminators, attenuators and anti-terminators; Induction and repression; The *lac* operon – catabolite repression; *trp* operon, two-components regulatory system. Translational control – ribosome binding, codon usage, antisense RNA; post-transcriptional gene silencing – RNAi. Regulation of gene expression in temperate phages.

Unit IV:  
**Gene transfer and genetic recombination mechanisms** (18 hours)

Bacterial Transformation – competence cells, regulation, general process; Transduction – general and specialized; Conjugation – Discovery, mechanism of F<sup>+</sup> v/s F<sup>-</sup>, Hfr<sup>+</sup> v/s F<sup>-</sup>, F' v/s F<sup>-</sup>, triparental mating, self-transmissible and mobilizable plasmids, pili. Linkage and genetic maps – genetic mapping of T4 phage. C- value paradox. Hardy-Weinberg Equilibrium.

Unit V: **Mutation and transposable elements**  
(18 hours)

Mutation: genome & gene mutations types and molecular basis – Agents of mutation - Importance of mutations in evolution of species. Mutagens - Discovery of insertion sequences, complex and compound transposons – T10, T5, and retroposon – Nomenclature- Insertion sequences – Mechanism – Transposons of *E. coli*, Bacteriophage and Yeast. Isolation, analysis and detection methods of mutants. Uses of mutants. Importance of transposable elements in horizontal transfer of genes and evolution. Mobile genetic Elements – IS elements.

Unit VI: **Current Contours** (For continuous internal assessment only):

Learners shall be given topics of the course to prepare a PPT and present a seminar as a commitment to understand the topics. They should be encouraged to take-up internship in research institutes; university departments, to attend summer trainings or training programs and to participate in

workshops. Swayam- NPTEL courses on Basics of microbial genetics and molecular biology topics should be recommended for an enhanced understanding. Quiz events and round-table scientific chats / discussions (molecular aspects of COVID 19); open talk / literature seminar on upcoming molecular topics (biomedical tattoo, disorder due to mutation to the FGFR2 gene, CRISPR-Cas9, molecular medicine, synthetic biology, advanced techniques in molecular biology etc.,) should also be scheduled / assigned.

### Mapping with Specific Programme Outcomes

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>CO1</b> | S    | S    | M    | S    | S    | L    | S    | S    | L    | L     | L     | S     |
| <b>CO2</b> | S    | S    | M    | S    | S    | L    | S    | S    | L    | L     | L     | S     |
| <b>CO3</b> | S    | S    | M    | S    | S    | L    | S    | S    | L    | L     | L     | S     |
| <b>CO4</b> | S    | S    | M    | S    | S    | L    | S    | S    | L    | L     | L     | S     |
| <b>CO5</b> | S    | S    | M    | S    | S    | L    | S    | S    | L    | L     | L     | S     |
| <b>CO6</b> | S    | S    | M    | S    | S    | L    | S    | S    | L    | L     | L     | S     |

### Recommended References:

1. George M Malacinski. 2008. Freifelder's Essentials of Molecular Biology. 4th edition. Narosa Publishing House. New Delhi.
2. David Frifelder. 2008. Molecular Biology, Narosa publishing house, New Delhi.
3. Jayanthi G P. (2009) Molecular Biology, MJP Publications. India
4. De Robertis EDP and De Robertis EMF. 2006. Cell and Molecular Biology, 8th edition. Lippincott Williams and Wilkins, Philadelphia.
5. Sambamurthy AVSS. 2008. Molecular biology. Narosa publishing house, New Delhi.
6. James D Watson, Tania A Baker, Stephen P Bell and Alexander Gann. 2008. Molecular Biology of the Gene, 5th edition. CSHL Press, USA.
7. Antony JF, Griffiths, Gilbert WM, Lewontin RC and Miller JH. 2007. Modern Genetic Analysis, Integrating Genes and Genomes, 2nd edition, W. H. Freeman and Company. USA.
8. Ajoy Paul. 2002. Text Book of Cell and Molecular Biology, Books and Allied (P) Ltd. Kolkata.
9. Gardner EJ, Simmons MJ, Snustad DP. 2008. Principles of Genetics. 8th edition. John Wiley and sons. USA.
10. Stanly R Maloy, John E Cronan and David Freifelder Jr. 2006. Microbial Genetics. 2nd edition. Narosa publishing house, New Delhi.
11. Channarayappa A. 2010. Cell Biology, Universities Press, (India) Pvt. Ltd, Hyderabad, India.
12. Channarayappa A. 2010. Molecular Biology, Universities Press, Pvt. Ltd, Hyderabad, India.
13. Watson JD, Tania AB, Stephen PB, Alexander G, Michael L, Richard L 2017. Molecular Biology of the Gene. 7th Edition. Pearson Education. USA.
14. Wilson K, Walker J. 2010 Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, Cambridge. UK.
15. Verma P S. & Agarwal V.K. 2012. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, S. Chand & Company Ltd. India.

16. Larry Synder and Wendy Champness. 2003. Molecular Genetics of Bacteria, 2nd edition, American Society for Microbiology, Washington. USA.
17. Karp G. 2010. Cell and Molecular Biology: Concepts and Experiments, 6th edition, John Wiley and Sons. Inc. USA.

**Related Online Contents:**

1. [https://swayam.gov.in/nc\\_details/NPTEL](https://swayam.gov.in/nc_details/NPTEL)
2. <http://www.dailymail.co.uk/sciencetech/article-4884760/DNA-nanobot-deliver-medicine-human-bloodstream.htm>
3. <https://cen.acs.org/biological-chemistry/genomics/DNAmotifs-found-human-cells/96/i1>
4. Roger Hull. Mathews' Plant Virology, 4<sup>th</sup> edition, Academic press- A Harcourt Science and technology company, New York. 2002.

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**SEMESTER – II**  
**MICROBIAL PHYSIOLOGY AND METABOLISM, MICROBIAL GENETICS**  
**AND MOLECULAR BIOLOGY (P)**

| Course Code          | CP - 2                                                                                                                       | Course Type | Core Practical | L | T | P | C | Syllabus version | 2026-2027 |
|----------------------|------------------------------------------------------------------------------------------------------------------------------|-------------|----------------|---|---|---|---|------------------|-----------|
|                      |                                                                                                                              |             |                | - | - | 6 | 4 |                  |           |
| <b>Pre-requisite</b> | Bacterial culture & macromolecules handling methods and instrumentation - centrifugation, spectrophotometry, electrophoresis |             |                |   |   |   |   |                  |           |

**Course Objectives:**

- ✓ To provide a fundamental knowledge and primary techniques of microbial genetics and molecular biology.
- ✓ To be able to isolate bacterial chromosomal DNA and plasmid DNA & RNA
- ✓ To skill- acquire the quality and quantity estimation of DNA / RNA/ Plasmids
- ✓ To upskill with blotting, agarose gel electrophoresis, SDS- PAGE & PCR
- ✓ To orient isolation of mutants and antibiotic-resistant bacterial isolates

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES                                                                                                 | KNOWLEDGE LEVEL |
|-----|-----------------------------------------------------------------------------------------------------------------|-----------------|
| CO1 | Evaluate the physiological effects of environmental parameters (pH, temperature, salinity) on microbial growth. | K3 to K5        |
| CO2 | Characterize the amino acid and nitrogen metabolism of various bacterial isolates.                              | K3 to K5        |
| CO3 | Separate and purify DNA/ RNA, plasmids from bacteria.                                                           | K3 to K5        |
| CO4 | Estimate the concentration of DNA/ RNA & plasmid macromolecules of a sample.                                    | K3 to K5        |
| CO5 | Handle phages and conduct studies, isolate mutants and isolate antibiotic-resistant bacteria                    | K3 to K5        |
| CO6 | Upskill others with respect to DNA/ RNA isolation, quantification, visualization and amplification procedures.  | K3 to K7        |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

**List of the Experiment**

1. Bacterial growth curve and determination of the generation time using the turbidimetric method.
2. Effect of temperature and pH on microbial growth
3. Demonstration of homolactic and heterolactic fermentation by lactic acid bacteria.

4. Detection of respiratory enzymes: Catalase test, Cytochrome Oxidase test, methylene blue reduction test.
5. Extracellular enzyme amylase, protease, lipase activity.
6. Nitrate Reduction Test, Urease test and hydrogen sulfide production test
7. Isolation of chromosomal DNA, plasmid DNA from bacteria
8. Isolation of RNA from bacteria
9. Quantification of the genomic DNA / RNA or Plasmid DNA by UV- Visible Spectrophotometric method
10. Characterization of DNA/ RNA or plasmid DNA by agarose gel electrophoresis.
11. Competent bacterial cell preparation and Bacterial transformation
12. Demonstration of DNA amplification by PCR.
13. Blotting techniques (Southern, Northern, Western and Dot blotting's)
14. Restriction digestion and Ligation of DNA
15. Extraction of whole cell protein separation by SDS – PAGE technique.
16. Generalized transduction in *E. coli*.
17. Isolation of antibiotic- resistant microbes
18. Isolation of mutants by spontaneous mutation – Gradient plate technique
19. Isolation of auxotrophic and antibiotic-resistant mutants by physical and chemical mutagens

### Mapping with Specific Programme Outcomes

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>C01</b> | S    | S    | S    | S    | S    | M    | S    | S    | S    | L     | L     | S     |
| <b>C02</b> | S    | S    | S    | S    | S    | M    | S    | S    | S    | L     | L     | S     |
| <b>C03</b> | S    | S    | S    | S    | S    | M    | S    | S    | S    | L     | L     | S     |
| <b>C04</b> | S    | S    | S    | S    | S    | M    | S    | S    | S    | L     | L     | S     |
| <b>C05</b> | S    | S    | S    | S    | S    | M    | S    | S    | S    | L     | L     | S     |
| <b>C06</b> | S    | S    | S    | S    | S    | M    | S    | S    | S    | L     | L     | S     |

### Recommended References:

1. John Vennison. 2009. Laboratory Manual for Genetic Engineering. PHI Learning Private Ltd, New Delhi.
2. Sambrook J and Russell DW. 2001. Molecular cloning - A laboratory manual, 3rd Edition, Cold Spring Laboratory Press, New York.
3. Surzyeki S (2000). Basic Techniques in Molecular Biology, Springer. USA.
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5. Atlas RM and Bartha R. 1993. Microbial Ecology: Fundamentals and Applications, 3rd Ed., Benjamin and Cummings Pub. Co. New York.
6. Rajan S and Selvi Christy R. 2018. Experimental Procedures in Life Sciences. Anjanaa Book House, Chennai
7. Monica Cheesbrough. 2011. District Laboratory Practice in Tropical Countries - Part I and II, 2nd edition, Cambridge University Press, UK.
8. Betty A Forbes, Daniel F Sahm and Alice S Weissfeld. 2007. Bailey and Scott's Diagnostic Microbiology, 12th Edition Mosby Elsevier. USA.

**Related online contents**

1. [https://ocw.ehu.eus/pluginfile.php/46700/mod\\_folder/content/0/1.\\_Extraction\\_of\\_DNA\\_from\\_bacteria.pdf](https://ocw.ehu.eus/pluginfile.php/46700/mod_folder/content/0/1._Extraction_of_DNA_from_bacteria.pdf)
2. <https://microbenotes.com/rna-isolation-protocol/>
3. <https://www.neb.com/en/tools-and-resources/usage-guidelines/guidelines-for-rna-purification-from-bacteria?srsltid=AfmBOoo2VTV1JfJnX1gULaHSr8M056U8ivrCXuiIvy3fp2mXmJwynrNt>

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**SEMESTER – II****1. MICROBIAL GENOMICS AND PROTEOMICS**

| Course Code          | DCEC-2                                                                                              | Course Type | Core | L<br>4 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|----------------------|-----------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Knowledge of basic molecular biology, microbial genetics, microbial genomics and proteome analysis. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the structural organization of microbial genomes and the principles of whole-genome sequencing.
- ✓ Address challenges in analyzing global gene expression patterns using transcriptomic approaches.
- ✓ Become a creative problem solver in characterizing microbial proteomes and determining protein structures and functions.
- ✓ Understand the integration of comparative genomics and proteomics to study microbial evolution, pathogenicity, and complex environmental communities.
- ✓ To explore the protein and proteome analysis in the microorganisms.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                                  | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Compare the metagenome and Genomes of microorganisms.                                                                            | K1, K2          |
| CO2                                                                                                                    | Understand the Genome mining by high throughput sequencing to analyse gene clusters using antismash, and microbial metabolomics. | K1- K4          |
| CO3                                                                                                                    | Analyze the Proteome Mapping in microbial genome using OrthoVenn3.                                                               | K3              |
| CO4                                                                                                                    | Describe the proteomics and antimicrobial peptides discovery.                                                                    | K3, K4          |
| CO5                                                                                                                    | Estimate and analyse the antimicrobial resistance genes in pathogen whole genome.                                                | K2, K4          |
| CO6                                                                                                                    | To demonstrate the ability to utilize bioinformatic databases and multi-omics pipelines for data interpretation.                 | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                                  |                 |

**Unit-I: Structural Genomics**  
(12 hours)

Organization and structure of microbial genomes, Genome size, General features and structure properties of genome, genomics of Chlorella, Lactobacillus and Streptomyces. Microbial metabolomics: Metabolome, metabolites. Polyketides synthases Type I, II, II - polyketide biosynthesis pathway, Non-ribosomal Peptide synthetase Gene Clusters. Antimicrobial resistance gene profiling in microbial whole genome AMRFinder and CARD Database.

|                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-II:<br><b>Functional Genomics</b><br>(12 hours)                            | DNA sequence functional analysis, metabolome, proteome Metatranscriptomic analysis- nano-LC MSMS, Proteome Discoverer software. Functional mining of metagenomes, Plant growth promoting genes in metagenome and whole genome using RAST server, KEGG Pathway Database. Core microbiome analysis using Krona version.                                                                                                                                                                                                                                                                  |
| Unit-III:<br><b>Metagenomics and Microbial Genome Engineering</b><br>(12 hours) | Extraction of metagenomic DNA, 16S rRNA gene amplification by Next generation sequencing, Sequencing and library preparation using Illumina Miseq Platform, Microbiome profiling QIIME pipeline, unique operational taxonomic units, Whole genome sequencing – Genome assembly and Annotation and whole genome sequence comparison. Genome mining: high throughput sequencing to analyze biosynthetic gene clusters production using antiSMASH and BAGEL tool, NaPDoS, and NP Searcher.                                                                                                |
| Unit-IV:<br><b>Microbial Community Analysis</b><br>(12 hours)                   | Microbiome- Human, Animal, Plant and Environmental microbiomes, Microbiome engineering- Natural and artificial microbiome Engineering- climatic conditions, diet and geography. Holobiome: Hologenome theory, holobiont evolution, Symbiogenesis, types of holobiont- plant, animal, human, coral. Holobiome engineering.                                                                                                                                                                                                                                                              |
| Unit-V: <b>Microbial Proteomics</b><br>(12 hours)                               | Proteome- Protein extraction and quantification of protein by TCA method, Exoproteome analysis of <i>Spirulina</i> , <i>Streptomyces</i> . Separation of protein by SDS-PAGE, identification of proteins: LC-MS and Mascot database search, Gene ontology analysis Search Tool for the Retrieval of Interacting Genes/Proteins-Uniprot, SWISS, Cytoscape, STRING. Microbial pathogenesis at the proteome level. Antimicrobial peptides- molecular docking and molecular simulation of antimicrobial peptides against pathogens. Proteome Mapping in microbial genome using OrthoVenn3. |
| Unit-VI: <b>Current Contours</b> (For Continuous Internal Assessment only):     | Debate on – advantage and disadvantage of Functional Genomics. Paper presentation on biosynthetic gene clusters and comparison. Assignment on-Future of Cyanobacterial, actinobacterial, fungal Genomics and proteomics, Scientific model on plant, animal, human microbiome concept. Computational analysis microbiome data, metagenomic data from Web Resources.                                                                                                                                                                                                                     |

## Mapping with Specific Programme Outcomes

|     | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| C01 | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| C02 | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| C03 | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| C04 | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| C05 | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| C06 | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |

### Recommended References:

1. Andréa D, Baxevanis BF, Francis O. (2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. 3rd edn., Wiley Publications, USA.
2. Brendan Wren and Nick Dorrell. (2002). Functional Microbial Genomics (Vol. 33) (Methods in Microbiology), Academic Press, UK.
3. Brown TA. (2006). Genomes, John Wiley and Sons, Pvt. Ltd., Singapore.
4. Campbell A, Heyer. 2004, Discovering Genomics, Proteomics and Bioinformatics, Pearson Education, New Jersey.
6. Aharon O. and Thane P. (2010). Molecular Phylogeny of Microorganisms. Academic Press, USA.
7. Sambrook, J and Russell DW. (2012). Molecular Cloning – A Laboratory Manual (4th edn., Vol. 1, 2, 3) Cold Spring Laboratory Press, New York.
8. Sandy B. Primrose RM and Twyman. (2009). Principles of Genome Analysis and Genomics, 3rd edn., John Wiley and Sons, USA.
9. Baxevanis AD and Francis O. (2009). Bioinformatics- a Practical Guide to the Analysis of Genes and Proteins. Wiley India Pvt. Ltd., New Delhi.
10. Kress, W.J. and Erickson, D.L., 2012. DNA Barcodes: Methods and Protocols. Humana Press, USA.

### Related Online Contents:

1. <https://www.pdfdrive.com/taxonomy-systematics-and-phylogeny-e56450008.html>
2. <https://www.pdfdrive.com/molecular-evolution-a-phylogenetic-approach-pdf-e15374856.html>
3. <https://www.pdfdrive.com/taxonomy-and-biosystematics-e33453099.html>

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**SEMESTER – II****2. MOLECULAR TAXONOMY AND PHYLOGENY**

| Course Code   | DCEC-2                                                    | Course Type | Core | L<br>4 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|---------------|-----------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| Pre-requisite | Knowledge of basic genetics, classical microbial taxonomy |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the evolutionary principles underlying molecular taxonomy and the microbial species concept.
- ✓ Address challenges in microbial identification using advanced molecular markers and genomic parameters.
- ✓ Become a creative problem solver in aligning sequences and calculating evolutionary distances.
- ✓ Understand the computational methods and algorithms used to construct, evaluate, and interpret phylogenetic trees.
- ✓ Address the integration of microbial genomic data with phenotypic and chemotaxonomic data

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                               | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Exploring the shift from classical phenetic classification to modern molecular and polyphasic taxonomy.                       | K1, K2, K4      |
| CO2                                                                                                                    | To learn about various molecular chronometers, including 16S rRNA, ITS, and whole-genome markers.                             | K1, K2, K4      |
| CO3                                                                                                                    | To characterize and perform sequence alignments, understanding nucleotide substitution models.                                | K3, K4          |
| CO4                                                                                                                    | Exploring tree-building algorithms: distance-matrix, maximum parsimony, and maximum likelihood methods.                       | K3, K4          |
| CO5                                                                                                                    | Understanding the importance of evolutionary relationships in epidemiological tracking and discovering novel taxa.            | K1 – K4         |
| CO6                                                                                                                    | To demonstrate proficiency in using bioinformatics software (e.g., MEGA, BLAST) to construct and interpret phylogenetic data. | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                               |                 |

|                                                                             |                                                                                                                                                                                                                                                                                                                                                                               |
|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-I:<br><b>Introduction to Molecular Evolution</b><br>(12 hours)         | Historical perspective: Classical vs. Molecular taxonomy. The concept of molecular evolution and the Molecular Clock hypothesis. The microbial species concept. Homology vs. Analogy; Orthologous and Paralogous genes. Advantages and limitations of relying on molecular data over traditional morphological and biochemical traits.                                        |
| Unit-II: <b>Molecular Markers in Microbiology</b><br>(12 hours)             | Concept of molecular chronometers. Ribosomal RNA as an evolutionary marker: 16S rRNA for Bacteria and Archaea; 18S rRNA and ITS (Internal Transcribed Spacer) regions for Fungi. Multi-Locus Sequence Typing (MLST) and housekeeping genes. Transition to the genomic era: Average Nucleotide Identity and digital DNA-DNA Hybridization (dDDH).                              |
| Unit-III:<br><b>Sequence Analysis and Alignment</b><br>(12 hours)           | Biological databases for taxonomic data-NCBI, EMBL, DDBJ, SILVA, RDP. Basic Local Alignment Search Tool (BLAST). Pairwise and Multiple Sequence Alignment (MSA) using tools like Clustal Omega and MUSCLE. Scoring matrices (PAM, BLOSUM). Models of DNA substitution (Jukes-Cantor, Kimura 2-parameter).                                                                     |
| Unit-IV:<br><b>Phylogenetic Tree Construction</b><br>(12 hours)             | Anatomy of a phylogenetic tree (roots, nodes, branches, clades, operational taxonomic units - OTUs). Distance-based methods: UPGMA and Neighbor-Joining. Character-based methods: Maximum Parsimony and Maximum Likelihood (ML). Introduction to Bayesian inference in phylogenetics. Statistical evaluation of trees: Bootstrapping and Jackknifing.                         |
| Unit-V:<br><b>Polyphasic Taxonomy and Applications</b><br>(12 hours)        | Integration of genomic data with phenotypic and chemotaxonomic data- FAME - Fatty Acid Methyl Ester analysis, quinones, peptidoglycan types. The polyphasic approach as the gold standard for describing novel microbial species. Applications of molecular phylogeny in tracking pathogen outbreaks, microbial forensics, and understanding microbiome community structures. |
| Unit-VI: <b>Current Contours</b> (For Continuous Internal Assessment only): | Daily news and research papers on newly discovered microbial taxa. Public awareness of evolutionary biology and emerging pathogens. Computational analysis utilizing MEGA (Molecular Evolutionary Genetics Analysis) software. Downloading raw FASTA sequences from databases to construct, bootstrap, and visualize a simple phylogenetic tree.                              |

**Mapping with Specific Programme Outcomes**

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>C01</b> | S    | S    | M    | S    | S    | M    | S    | S    | M    | L     | L     | S     |
| <b>C02</b> | S    | S    | M    | S    | S    | M    | S    | S    | M    | L     | L     | S     |
| <b>C03</b> | S    | S    | M    | S    | S    | M    | S    | S    | M    | L     | L     | S     |
| <b>C04</b> | S    | S    | M    | S    | S    | M    | S    | S    | M    | L     | L     | S     |
| <b>C05</b> | S    | S    | M    | S    | S    | M    | S    | S    | M    | L     | L     | S     |
| <b>C06</b> | S    | S    | M    | S    | S    | M    | S    | S    | M    | L     | L     | S     |

**Recommended References:**

1. Hall, B. G. (2018). Phylogenetic Trees Made Easy: A How-To Manual, 5th Edition. Sinauer Associates. USA.
2. Nei, M., and Kumar, S. (2000). Molecular Evolution and Phylogenetics. Oxford University Press. UK.
3. Page, R. D. M., and Holmes, E. C. (1998). Molecular Evolution: A Phylogenetic Approach. Wiley-Blackwell. USA.
4. Lemey, P., Salemi, M., and Vandamme, A. M. (2009). The Phylogenetic Handbook: A Practical Approach to Phylogenetic Analysis and Hypothesis Testing, 2nd Edition. Cambridge University Press. UK
5. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., and Stahl, D. A. (2020). Brock Biology of Microorganisms, 16th Edition. Pearson. USA

**Related Online Contents:**

1. <https://www.megasoftware.net/> (MEGA Software and Tutorials)
2. <https://www.ncbi.nlm.nih.gov/taxonomy> (NCBI Taxonomy Browser)
3. <https://arb-silva.de/> (SILVA ribosomal RNA database project)

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**SEMESTER – II****1. NEXT GENERATION MICROBIOLOGY**

| Course Code          | GEC-2                                                                                                                                     | Course Type | Core | L<br>4 | T<br>- | P<br>- | C<br>3 | Syllabus version | 2026-2027 |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Knowledge of single-cell analysis, next-generation technologies and understand the integration of artificial intelligence in microbiology |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the principles of synthetic biology, genome editing, and the creation of designer microbes.
- ✓ Address challenges in single-cell analysis and strategies for cultivating the "unculturable" microbial dark matter.
- ✓ Become a creative problem solver in applying next-generation technologies to human health, environmental sustainability, and industrial biomanufacturing.
- ✓ Understand the integration of artificial intelligence in microbiology, as well as the ethical, regulatory, and biosafety implications of engineered biological systems.
- ✓ Understand the role of AI and Machine Learning in predicting antimicrobial resistance, predicting protein structure folding

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES                                                                                                          | KNOWLEDGE LEVEL |
|-----|--------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1 | Exploring the concepts of synthetic biology, minimal genomes, and the design of microbial chassis.                       | K1, K2          |
| CO2 | To learn about CRISPR-Cas applications, base editing, and advanced genome recombineering.                                | K2, K4, K5      |
| CO3 | To characterize microbial populations at the single-cell level using transcriptomics and super-resolution imaging.       | K3, K4          |
| CO4 | Exploring high-throughput culturomics and strategies for discovering novel antimicrobials from uncultured soil microbes. | K3, K4          |
| CO5 | Understanding the importance of next-generation live biotherapeutics, engineered probiotics, and phage therapy.          | K1, K2, K4      |
| CO6 | To demonstrate knowledge of future frontiers like AI-driven microbiology, space microbiology, and bioethics.             | K5, K6          |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

**Unit-I: Synthetic Biology and Genome Engineering**  
(12 hours)

Introduction to synthetic biology. The Design-Build-Test-Learn cycle. The concept of minimal genomes and synthetic cells (e.g., *Mycoplasma laboratorium*). Standardized biological parts (BioBricks) and genetic circuits (toggle switches, oscillators). CRISPR-Cas systems: beyond traditional gene knockout (CRISPR interference, CRISPR activation, and base

editing). Engineering microbial chassis for industrial scale-up.

**Unit-II: Single-Cell Microbiology and Advanced Imaging**  
(12 hours)

The shift from bulk population analysis to single-cell resolution. Single-cell genomics and transcriptomics (scRNA-Seq) in microbiology. The use of Fluorescence-Activated Cell Sorting and microfluidics for microbial isolation. Advanced imaging technologies: Super-resolution microscopy. Cryo-Electron Microscopy and Cryo-Electron Tomography for resolving sub-cellular microbial architecture and macromolecular complexes in native states.

**Unit-III: Microbial Dark Matter and Culturomics**  
(12 hours)

Exploring the "unculturable majority." Metagenomic discovery of novel branches on the Tree of Life (e.g., Candidate Phyla Radiation and DPANN superphyla). High-throughput culturomics approaches: mimicking natural environments, iChip technology, and microdroplet cultivation. Bioprospecting the dark matter: discovery of novel antibiotic classes- Teixobactin from previously uncultivable soil microorganisms.

**Unit-IV: Next-Generation Therapeutics and Microbiome Engineering**  
(12 hours)

Moving beyond traditional broad-spectrum antibiotics. Advanced phage therapy: engineered bacteriophages and phage cocktails for combating multidrug-resistant infections. Live Biotherapeutic Products and next-generation probiotics. Precision microbiome editing. Engineered probiotics/bacteria for targeted drug delivery, tumor targeting, and metabolic disease management.

**Unit-V: Digital Microbiology and Future Frontiers**  
(12 hours)

The intersection of microbiology and computer science. The role of AI and Machine Learning in predicting antimicrobial resistance, predicting protein structure folding (e.g., AlphaFold), and accelerating novel drug discovery. Space microbiology: microbial survival in spaceflight, biofilm formation on spacecraft (e.g., International Space Station), and astrobiology. Bioethics, biosecurity, and Dual-Use Research of Concern regarding synthetic life.

**Unit-VI: Current Contours** (For Continuous Internal Assessment only):

Daily news and research papers on synthetic biology breakthroughs, CRISPR therapies, and AI in life sciences. Public awareness of synthetic life, engineered pandemics, and global biosafety protocols. Computational analysis of a single-cell RNA-Seq dataset or utilizing synthetic biology software tools (e.g., Benchling) to design a simple genetic circuit or CRISPR guide RNA.

## Mapping with Specific Programme Outcomes

|             | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|-------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>CO 1</b> | S    | S    | M    | S    | S    | M    | S    | S    | M    | L     | L     | S     |
| <b>CO 2</b> | S    | S    | M    | S    | S    | M    | S    | S    | M    | L     | L     | S     |
| <b>CO 3</b> | S    | S    | M    | S    | S    | M    | S    | S    | M    | L     | L     | S     |
| <b>CO 4</b> | S    | S    | M    | S    | S    | M    | S    | S    | M    | L     | L     | S     |
| <b>CO 5</b> | S    | S    | M    | S    | S    | M    | S    | S    | M    | L     | L     | S     |
| <b>CO 6</b> | S    | S    | M    | S    | S    | M    | S    | S    | M    | L     | L     | S     |

### Recommended References:

1. Voigt, C. (2011). Synthetic Biology: Parts, Devices and Applications. Wiley-VCH. USA.
2. Doudna, J. A., and Sternberg, S. H. (2017). A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution. Houghton Mifflin Harcourt. USA.
3. Zhao, H. (Ed.). (2013). Synthetic Biology: Tools and Applications. Academic Press. USA.
4. Cossart, Pascale. 2020. The New Microbiology: From microbiomes to CRISPR. John Wiley & Sons. USA.

### Related Online Contents:

1. <https://igem.org/>
2. <https://www.addgene.org/guides/crispr/>
3. <https://www.nature.com/nrmicro/>

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**SEMESTER – II****2. HERBAL TECHNOLOGY AND COSMETIC MICROBIOLOGY**

| Course Code          | GEC-2                                                                                                                             | Course Type | Core | L<br>4 | T<br>- | P<br>- | C<br>3 | Syllabus version | 2026-2027 |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Knowledge of Indian medicinal plants against infectious diseases and apply cosmetic preservative efficacy, pharmacopoeia testing. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Explain the scope, principles, and traditional systems of Indian medicinal plants against infectious diseases.
- ✓ Describe collection, authentication, and extract/stock solution preparation using hot and cold methods for key Indian medicinal plants.
- ✓ Evaluate in vitro antibacterial, antifungal and antiviral activities of selected medicinal plants.
- ✓ Discuss the need, microbial roles, preservation, natural antimicrobials, and HACCP sanitary practices in cosmetic microbiology.
- ✓ Apply cosmetic preservative efficacy, bioburden/pharmacopoeia testing, and interpret regulatory toxicological aspects and emerging trends.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                            | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Find out the applications of Indian medicinal plants in Treating diseases.                 | K1, K2          |
| CO2                                                                                                                    | Identification and authentication of herbal plants                                         | K4              |
| CO3                                                                                                                    | Analyze the antimicrobial activity of medicinal plants                                     | K3, K4          |
| CO4                                                                                                                    | Evaluate the role of microorganisms and their metabolites in the preparation of cosmetics. | K3, K4          |
| CO5                                                                                                                    | Assess the procedures and biosafety measures in the mass Production of cosmetics           | K1 – K5         |
| CO6                                                                                                                    | Assess the role of medicinal plant in cosmetic technology                                  | K2 – K4         |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation</b> |                                                                                            |                 |

**Unit-I: Herbal medicine – Indian medicinal plants**  
(12 hours)

Scope and Applications of Indian medicinal plants in treating bacterial, Fungal and viral diseases. Basic principles involved in Ayurvedha, Sidha, Unani and Homeopathy.

**Unit-II: Collection and authentication of selected**

*Emblca officinalis, Withania somnifera, Phyllanthus amarus, Tinospora cordifolia, Andrographis paniculata, Piper longum, Ocimum sanctum, Azardirchata indica, Terminalia chebula, Alliumsativum.* Preparation of extracts-Hot and cold methods.

**Indian medicinal plants** Preparation of stock solutions.  
(12 hours)

Unit-III: **Antimicrobial activity of selected Indian medicinal Plants** In vitro determination of antibacterial and fungal activity of selected whole medicinal plants / parts – well-diffusion methods. MIC - Macro and micro dilution techniques. Antiviral activity – cell lines - cytotoxicity, cytopathic and non – cytopathic effect.  
(12 hours)

Unit-IV: **History of Cosmetic Microbiology** Need for cosmetic microbiology, Scope of cosmetic microbiology - Role of microbes in cosmetic preparation. Preservation of cosmetics. Antimicrobial properties of natural cosmetic products – Garlic, neem, turmeric, aloe vera and tulsi. Sanitary practices in cosmetic manufacturing-HACCP protocols in cosmetic microbiology.  
(12 hours)

Unit-V: **Cosmetic microbiology test methods** Antimicrobial preservative efficacy, microbial content testing and biological toxicological testing. Validation methods – bioburden and Pharmacopeial microbial assays. Preservatives of cosmetics-Global regulatory and Toxicological aspect of cosmetic preservatives.  
(12 hours)

Unit-VI: **Current Contours** (For Continuous Internal Assessment only): Daily news and research papers on cosmetic biology breakthroughs, and advances in cosmetic microbiology methods.

### Mapping with Specific Programme Outcomes

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>CO1</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| <b>CO2</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| <b>CO3</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| <b>CO4</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| <b>CO5</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |

### Recommended References:

1. Panda H. (2004). Hand book on herbal medicines. Asia Pacific Business Press Inc. India.
2. Ayurvedic Formulary of India. (2011). Pharmacopoeia Commission for Indian Medicine and Homeopathy. India,
3. Geis P.A. (2020). Cosmetic Microbiology: A Practical Approach. (3rd Edition). CRC Press. USA.
4. Liu, Willow JH, ed. 2011. Traditional herbal medicine research methods: identification, analysis, bioassay, and pharmaceutical and clinical studies. John Wiley & Sons. USA.

5. Baki, G., 2022. Introduction to cosmetic formulation and technology. John Wiley & Sons. USA.

**Related Online Contents:**

1.[https://www.academia.edu/50236711/Modern\\_Extraction\\_Methods\\_for\\_Preparation\\_of\\_Bioactive\\_Plant\\_Extracts](https://www.academia.edu/50236711/Modern_Extraction_Methods_for_Preparation_of_Bioactive_Plant_Extracts).

2.<https://www.fda.gov/cosmetics/potential-contaminants-cosmetics/microbiological-safety-and-cosmetics>

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**SEMESTER – II****FOOD PROCESSING TECHNOLOGY**

| Course Code          | SEC-2                                                                   | Course Type | Core | L<br>2 | T<br>- | P<br>- | C<br>2 | Syllabus version | 2026-2027 |
|----------------------|-------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Knowledge of food microbiology, and fundamental biochemical principles. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the fundamental principles of food spoilage, preservation, and shelf-life extension.
- ✓ Address challenges in traditional and modern thermal and non-thermal food processing technologies.
- ✓ Become a creative problem solver in designing appropriate packaging systems and bioprocessing methods for various food products.
- ✓ Understand the quality control parameters, regulatory frameworks, and waste management strategies in the food industry.
- ✓ Address the food safety management and implementation.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                              | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Exploring the intrinsic and extrinsic factors causing food spoilage and the principles of Hurdle Technology. | K1, K2          |
| CO2                                                                                                                    | To learn about thermal processing kinetics and emerging non-thermal preservation techniques.                 | K1, K2          |
| CO3                                                                                                                    | To characterize dehydration, freezing, and moisture control mechanisms in food preservation.                 | K1 - K3         |
| CO4                                                                                                                    | Exploring industrial bioprocessing, fermentation technology, and the production of value-added foods.        | K3, K4          |
| CO5                                                                                                                    | Understanding the importance of active packaging, modified atmosphere, and smart labelling.                  | K1, K2          |
| CO6                                                                                                                    | To demonstrate knowledge of food safety standards, regulations, and sustainability in food processing.       | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                              |                 |

Unit-I:  
**Fundamentals of Food Preservation**  
(6 hours)

Introduction to food processing and its historical development. Mechanisms of food spoilage. Intrinsic and extrinsic factors affecting microbial growth in foods.

Unit-II:  
**Thermal and Non-Thermal Processing**  
(6 hours)

Food Preservation - Thermal processing: Blanching, pasteurization, sterilization, and commercial canning. Thermal death kinetics -D-value, Z-value, F-value. Ultra-High Temperature processing and aseptic packaging. Emerging non-thermal technologies: High-Pressure

Processing, and food irradiation- gamma rays, electron beams.

|                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Unit-III: Moisture Control and Low-Temperature Processing</b><br>(6 hours) | Principles of dehydration and drying kinetics. Drying equipment: spray dryers, drum dryers, tray dryers, and fluidized bed dryers. Advanced drying: Freeze-drying. Low-temperature preservation: Chilling and freezing, cryogenic freezing.                                                                                                                                                    |
| <b>Unit-IV: Fermentation Technology</b><br>(6 hours)                          | Role of beneficial microbes in food processing. Dairy processing: pasteurized milk, cheese, yogurt, and butter manufacturing. Cereal and baking technology: role of yeast and sourdough fermentation. Brewing - wine production. Production of fermented vegetables sauerkraut, kimchi and soy products- soy sauce, tempeh. Production of Single Cell Protein and functional food ingredients. |
| <b>Unit-V: Food Packaging and Quality Management</b><br>(6 hours)             | Functions of food packaging. Packaging materials: glass, metals, plastics, and eco-friendly/biodegradable polymers. Advanced packaging systems: Modified Atmosphere Packaging, Controlled Atmosphere Packaging, Active packaging and Smart/Intelligent packaging. Food safety management: HACCP implementation, GMP, and regulatory compliance.                                                |
| <b>Unit-VI: Current Contours</b> (For Continuous Internal Assessment only):   | Daily news and research papers on food tech innovations. Public awareness of alternative proteins (plant-based meats, precision fermentation, lab-grown cultured meat) and 3D food printing. Computational analysis of thermal death time data using spreadsheets. Drafting a flow chart for a sustainable, zero-waste food processing facility.                                               |

#### Mapping with Specific Programme Outcomes

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>C01</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | L     | L     | S     |
| <b>C02</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | L     | L     | S     |
| <b>C03</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | L     | L     | S     |
| <b>C04</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | L     | L     | S     |
| <b>C05</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | L     | L     | S     |
| <b>C06</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | L     | L     | S     |

#### Recommended References:

1. Fellows, P. J. (2017). *Food Processing Technology: Principles and Practice*, 4th Edition. Woodhead Publishing, USA.
2. Potter, N. N., and Hotchkiss, J. H. (1998). *Food Science*, 5th Edition. Springer, USA.
3. Frazier, W. C., and Westhoff, D. C. (2013). *Food Microbiology*, 5th Edition. McGraw Hill Education, USA.
4. Singh, R. P., and Heldman, D. R. (2014). *Introduction to Food Engineering*, 5th Edition. Academic Press, UK.

5. Robertson, G. L. (2012). *Food Packaging: Principles and Practice*, 3rd Edition. CRC Press, UK.

**Related Online Contents:**

1. <https://www.fao.org/food-safety/en/>
2. <https://fssai.gov.in/>

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**SEMESTER – II****HUMAN AND MICROBES**

| <b>Course Code</b>   | <b>NMEC-1</b>                                                                                   | <b>Course Type</b> | <b>Core</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>C</b> | <b>Syllabus version</b> | <b>2026-2027</b> |
|----------------------|-------------------------------------------------------------------------------------------------|--------------------|-------------|----------|----------|----------|----------|-------------------------|------------------|
| <b>Pre-requisite</b> | Basic knowledge of microbes and a general curiosity about health, hygiene, and the environment. |                    |             |          |          |          |          |                         |                  |

**Course Objectives:**

- ✓ Understand the omnipresence of microorganisms and dismantle the myth that all microbes are harmful "germs."
- ✓ Address challenges in identifying common modes of disease transmission and everyday preventive measures.
- ✓ Become a creative problem solver in practicing personal hygiene, understanding food safety, and interpreting health-related news.
- ✓ Understand the beneficial roles of microbes in household fermentation, human gut health, and global ecology.
- ✓ Awareness about vaccines types and vaccination schedule.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| <b>COs</b>                                                                                                             | <b>COURSE OUTCOMES</b>                                                                                              | <b>KNOWLEDGE LEVEL</b> |
|------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|------------------------|
| CO1                                                                                                                    | Exploring the types of microbes and their historical impact on human civilization.                                  | K1, K2                 |
| CO2                                                                                                                    | To learn about the essential roles of microbes in producing daily foods and beverages.                              | K1 - K4                |
| CO3                                                                                                                    | To characterize the human microbiome and understand the importance of beneficial gut bacteria.                      | K1 - K3                |
| CO4                                                                                                                    | Exploring common infectious diseases, their symptoms, and how they spread through populations.                      | K1 - K3                |
| CO5                                                                                                                    | Understanding the basic mechanism of vaccines, standard hygiene protocols, and the safe use of antibiotics.         | K1, K2                 |
| CO6                                                                                                                    | To demonstrate an awareness of microbial safety in daily habits, household waste management, and consumer products. | K5, K6                 |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                     |                        |

Unit-I:

**Microbes Around Us**

(6 hours)

Introduction to the microbial world. Differences between Bacteria, Viruses, Fungi, and Protozoa, Microbes in the air, water, soil, and extreme environments. History of human-microbe discovery: Hooke, Antony van Leeuwenhoek, Louis Pasteur, and Alexander Fleming.

|                                                                             |                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-II:<br><b>Microbes in the Daily Food</b><br>(6 hours)                  | Fermentation-Production of traditional fermented foods: curd (yogurt), bread, cheese, idly, dosa batter, and pickles. Fermented beverages- beer, and wine. Food spoilage, preservation methods.                                                                                                                                                                                           |
| Unit-III:<br><b>Human Microbiome</b><br>(6 hours)                           | The human body as a walking ecosystem. Human Microbiome-skin, mouth, gut. Gut microbes' role human health. Probiotics and Prebiotics. Impact of modern processed diets versus traditional high-fiber diets on the microbiome.                                                                                                                                                             |
| Unit-IV: <b>Common Infectious Diseases</b><br>(6 hours)                     | Understanding pathogens. Air-borne- common cold, influenza, tuberculosis), Water-borne, Food-borne - cholera, typhoid, amoebiasis, food poisoning, Vector-borne- malaria, dengue via mosquitoes, and Contact-borne- fungal skin infections, conjunctivitis.                                                                                                                               |
| Unit-V:<br><b>Protection, Hygiene, and Medicine</b><br>(6 hours)            | The human immune system, Vaccines-types, schedules. Antibiotics for microbial diseases treatment. Personal hygiene: the science of proper handwashing, food safety keys, and sanitation.                                                                                                                                                                                                  |
| Unit-VI: <b>Current Contours</b> (For Continuous Internal Assessment only): | Daily news and social media trends related to health outbreaks, nutrition, and wellness. Reading and evaluating nutritional labels on commercial probiotic drinks or supplements. Simple home experiments like observing milk turning into curd or baking yeast bread. Creating awareness posters/campaigns on proper hand hygiene or water purification methods for the local community. |

#### Mapping with Specific Programme Outcomes

|     | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| CO1 | S    | S    | L    | S    | S    | S    | S    | S    | M    | L     | L     | S     |
| CO2 | S    | S    | L    | S    | S    | S    | S    | S    | M    | L     | L     | S     |
| CO3 | S    | S    | L    | S    | S    | S    | S    | S    | M    | L     | L     | S     |
| CO4 | S    | S    | L    | S    | S    | S    | S    | S    | M    | L     | L     | S     |
| CO5 | S    | S    | L    | S    | S    | S    | S    | S    | M    | L     | L     | S     |
| CO6 | S    | S    | L    | S    | S    | S    | S    | S    | M    | L     | L     | S     |

#### Recommended References:

1. Tortora, G. J., Funke, B. R., and Case, C. L. (2016). *Microbiology: An Introduction*, 12th Edition. Pearson, USA.
2. Alcamo, I. E. (2001). *Fundamentals of Microbiology*. Jones and Bartlett Publishers, UK.
3. Colen, D. (2016). *The Good Gut: Taking Control of Your Weight, Your Mood, and Your Long-term Health*. Penguin Books, UK.
4. De Kruif, P. (1926). *Microbe Hunters*. Harcourt, Brace & Co, UK.

**Related Online Contents:**

1. <https://www.cdc.gov/handwashing/>
2. <https://www.who.int/news-room/fact-sheets/detail/food-safety>
3. <https://www.coursera.org/learn/microbiome>

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**SEMESTER – III****IMMUNOLOGY**

| Course Code          | CC - 5                                                                                                 | Course Type | Core | L<br>6 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|----------------------|--------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Basic understanding of immunity, antigen, antibody, antigen-antibody interactions and diagnostic tests |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Impart knowledge on antigen, antibody, cytokine, chemokine, innate, adaptive and identify the major organs, tissues, and cell types of the immune system.
- ✓ Explain the stages of an immune response, from pathogen recognition to memory formation and describe the mechanisms of antigen presentation and MHC restriction.
- ✓ Applying the knowledge of antibody-antigen interactions to understand diagnostic tests and predict the outcome of immunological scenarios, such as vaccination or allergic reactions.
- ✓ Differentiation of innate and adaptive immune mechanisms and their integration and analyse the roles of cytokines and cell signalling in inflammation and disease.
- ✓ Evaluate experimental data to draw conclusions about immunological mechanisms and assess the role of immune dysfunction in autoimmunity, immunodeficiency, and cancer
- ✓ Develop strategies for manipulating the immune system for vaccines or therapies

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES                                                                                                                                                                                            | KNOWLEDGE LEVEL |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1 | Define key terminology: antigen, antibody, cytokine, chemokine, innate, adaptive and identify the major organs, tissues, and cell types of the immune system.                                              | K1              |
| CO2 | Explain the stages of an immune response, from pathogen recognition to memory formation and describe the mechanisms of antigen presentation and MHC restriction.                                           | K1, K2          |
| CO3 | Use knowledge of antibody-antigen interactions to understand diagnostic tests (e.g., ELISA, flow cytometry) and predict the outcome of immunological scenarios, such as vaccination or allergic reactions. | K1 - K3         |
| CO4 | Differentiate between innate and adaptive immune mechanisms and their integration and analyze the roles of cytokines and cell signaling in inflammation and disease.                                       | K1 - K4         |
| CO5 | Assess the role of immune dysfunction in autoimmunity, immunodeficiency, and cancer and evaluate experimental data to draw conclusions about immunological mechanisms.                                     | K1 - K5         |
| CO6 | Develop strategies for manipulating the immune system                                                                                                                                                      | K1 - K6         |

|                                                                                                                        |                           |  |
|------------------------------------------------------------------------------------------------------------------------|---------------------------|--|
|                                                                                                                        | for vaccines or therapies |  |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                           |  |

|                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-I:<br><b>Immunity and Immune system</b><br>(18 hours)            | Historical perspective, Discovery of humoral and cellular immunity, Types of Immunity - Innate and Acquired immunity, Innate immunity components-physical, physiological defences; – complement, acute phase proteins. Acquired immunity: natural, artificial, active and passive immunity. Inflammatory response, Haematopoiesis, Cells - T cell, B cell, macrophages, neutrophils, Natural killer cells, mast cells, basophils, and eosinophils and organs of Immune system - Thymus, Bone marrow, lymph node, spleen, MALT, GALT, BALT. |
| Unit-II: <b>Antigens and Antibodies</b><br>(18 hours)                 | Immunogenicity versus Antigenicity, Nature and types of antigens, factors influencing immunogenicity, Epitopes, Haptens, Superantigen, Mitogen, Adjuvants. Vaccines. Antibody-structure and functions-subtypes; structural basis of Antibody diversity; Theories of Antibody formation. Genetic basis of antibody diversity-somatic hyper mutation recombination, class switching and clonal selection. Production of monoclonal antibodies and their applications.                                                                        |
| Unit-III:<br><b>T and B cell Biology</b><br>(18 hours)                | T Cell and B cell Biology: MHC restriction-antigen presentation - Organisation and inheritance of MHC, MHC molecules and genes. Role of Antigen presenting cells, Antigen processing and presentation pathways, T cells subsets, T cell maturation, activation and differentiation, B cells subsets, B cell generation, activation and differentiation. Complement pathways. Transplantation immunology                                                                                                                                    |
| Unit-IV: <b>Immunity in Health and Diseases:</b><br>(18 hours)        | Infection-Immunity and signal transduction pathways, Immune system Disorders - Hypersensitivity Type-I to Type - IV. Immunodeficiency diseases - Primary and secondary immunodeficiencies. Auto immune diseases - organ specific and systemic. Prevention and therapy -Vaccine, cell therapy, cytokine and antibody therapy. Tumor immunology                                                                                                                                                                                              |
| Unit-V:<br><b>Immunotechniques and Immunodiagnosis:</b><br>(18 hours) | Agglutination, Immunoprecipitation, Radioimmunoassay, ELISA and Immuno Blotting, Immune cell culture, CHIP assay, Nanopro Immunoassay, Flowcytometry, Immunofluorescence, FACS analysis, Antibody Array, cytokine RT-PCR array, whole animal imaging. <i>In vivo</i> immune tests for hypersensitivity reactions                                                                                                                                                                                                                           |

Unit-VI: **Current Contours** (For Continuous Internal Assessment only): Review and debate on latest discovery on immunology like Spatial Immune Mapping through transcriptomics, Regulatory Immune Cells (Tregs) as therapy for autoimmunity, AI and Imaging for automated segmentation of 3D structure during infection and next generation vaccine design. Seminar on immune responses against SARS-CoV2 and vaccination for COVID19.

#### Mapping with Specific Programme Outcomes

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>CO1</b> | S    | S    | M    | S    | S    | S    | S    | S    | M    | L     | L     | S     |
| <b>CO2</b> | S    | S    | M    | S    | S    | S    | S    | S    | M    | L     | L     | S     |
| <b>CO3</b> | S    | S    | M    | S    | S    | S    | S    | S    | M    | L     | L     | S     |
| <b>CO4</b> | S    | S    | M    | S    | S    | S    | S    | S    | M    | L     | L     | S     |
| <b>CO5</b> | S    | S    | M    | S    | S    | S    | S    | S    | M    | L     | L     | S     |
| <b>CO6</b> | S    | S    | M    | S    | S    | S    | S    | S    | M    | L     | L     | S     |

#### RECOMMENDED REFERENCES:

1. Kuby, J. (2006). Immunology 2nd edn. W.H.Freeman and company. New York.
2. Janeway C, Travers P, Walport M, Sholmchik M. (2004). Immunobiology 6th edn. Gerald Science. USA.
3. Roitt R.I.M(2001). Essential Immunology.10th edn. Blackwell Scientific Publishers. USA.
4. Stites D.P.,Abba I.Terr, Parslow T.G.(1997). Medical Immunology. 9<sup>th</sup> edn, Prentice-Hall Inc. UK.
5. Tizard, R.I. (2000) Immunology- An Introduction. 4th edn. Saunders College Publishing, Philadelphia.
6. Nairn, R., and Helbert, M. (2006). Immunology for Medical Students. 2nd edn. Mosby International limited. USA.
7. Humphrey, J.H. and White, R.G. (1995). Immunology for Students of Medicine, 5th edn. ELBS, London
8. Ananthanarayanan, R, and Panicker, C.K.J. (2013). Textbook of Microbiology. Orient Longman. India.

#### Related Online Contents:

1. <https://doi.org/10.1016/j.immuni.2020.05.002>
2. <https://doi.org/10.1038/s41577-020-0311-8>
3. <https://www.immunopaedia.org.za/immunology/>
4. [http://cshprotocols.cshlp.org/site/Taxonomy/immunology\\_11.xhtml](http://cshprotocols.cshlp.org/site/Taxonomy/immunology_11.xhtml)

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**SEMESTER – III****MEDICAL MICROBIOLOGY**

| Course Code          | CC-6                                                                                                                                                                                                 | Course Type | Core | L<br>6 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Basic understanding and awareness of basic concepts in immunity, disease processes, and microbial infections. Introductory understanding of laboratory techniques and scientific observation skills. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ To make the students understand various attributes which make the microbes pathogenic or disease-causing, the emergence of newer pathogens with relevance to India and various routes of local or global spread
- ✓ To learn the mechanisms of resistance of bacteria to antibiotics and role of newer vaccines in controlling infectious diseases
- ✓ To describe the molecular diagnostic methods and automated equipment's used for diagnosis of diseases caused by microorganisms
- ✓ To understand the common infections and diseases of medical importance, their microbial causes and pathogenic action
- ✓ To understand the fungal and protozoan diseases and their preventive measures

**Expected Course Outcomes:**

**On the completion of the course, the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                                                                                       | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Understand classical and molecular determinants of disease-causing microbes                                                                                                           | K1, K2          |
| CO2                                                                                                                    | Describe the characteristics of new disease-causing bacteria and viruses                                                                                                              | K1- K4          |
| CO3                                                                                                                    | Operate and critique the various molecular tools available to work on the molecular epidemiology of disease-causing microorganisms                                                    | K1 - K3         |
| CO4                                                                                                                    | Evaluate mechanisms underlying resistance of bacteria to antibiotics, spread of resistance and the use of newer vaccines to control infectious diseases                               | K6              |
| CO5                                                                                                                    | Understand how the infectious diseases are diagnosed using newer diagnostic tools and what automated equipment are available for use in diagnostic microbiology laboratories          | K1, K2          |
| CO6                                                                                                                    | Apply knowledge of medical microbiology to analyze case studies, perform diagnostic interpretations, and communicate recent advances through presentations and scientific activities. | K3, K4          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                                                                                       |                 |

|                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-I:<br><b>Medical Microbiology-An outline</b><br>(18 hours) | Microbiology in Medicine. Koch Postulates. Classification of medically important microbes - Normal microbial flora of the human body-Host-microbe interactions – Transmission, attachment, entry mechanisms, microbial pathogenicity. Virulence factors of bacteria. Quantitative measures of pathogenicity: minimal lethal dose. Nosocomial and community acquired infections -investigation of epidemic diseases. Role of biofilms and quorum sensing in microbial pathogenicity.                                                                                                                                                                                                                                                                     |
| Unit-II:<br><b>Medical Bacteriology</b><br>(18 hours)           | Morphological, cultural and biochemical characteristics, epidemiology, pathogenesis, laboratory diagnosis, prophylaxis and control of medically important diseases caused by <i>Staphylococcus aureus</i> , <i>Streptococcus pyogenes</i> , <i>Corynebacterium diphtheriae</i> , <i>Clostridium tetani</i> , <i>Bacillus anthracis</i> , <i>Leptospira</i> , <i>Treponema pallidum</i> , <i>Mycobacterium tuberculosis</i> , <i>Escherichia coli</i> , <i>Vibrio cholerae</i> , <i>Neisseriae gonorrhoeae</i> , <i>Haemophilus</i> , <i>Helicobacter pylori</i> , <i>Pseudomonas</i> and <i>Salmonella</i> . Zoonotic bacterial pathogens, Antibiotic susceptibility test: Kirby – Bauer disk diffusion method. General methods of Bacterial diagnosis. |
| Unit-III:<br><b>Medical Mycology</b><br>(18 hours)              | Morphological, cultural characteristics, epidemiology, mechanism of fungal pathogenesis, laboratory diagnosis and treatment of medically important diseases caused by: Superficial mycosis – <i>Tinea versicolor</i> . Cutaneous mycoses: <i>Microsporum</i> , <i>Trichophyton</i> , <i>Epidermophyton</i> . Subcutaneous mycoses. Systemic Mycoses – <i>Histoplasma capsulatum</i> , <i>Blastomyces dermatitidis</i> , <i>Cryptococcus neoformans</i> . Opportunistic mycoses: Candidiasis, Cryptococcosis and Aspergillosis Zygomycosis. Antifungal susceptibility testing.                                                                                                                                                                           |
| Unit-IV:<br><b>Medical Virology</b><br>(18 hours)               | General properties, epidemiology, pathogenesis, laboratory diagnosis and treatment of medically important viral diseases - Influenza, Measles, Mumps, Rubella, monkey pox, Chicken Pox, Poliomyelitis, HIV, Rabies, Yellow fever, Dengue, Covid-19, Japanese Encephalitis and oncogenic viruses. Emerging viral diseases, Antiviral drugs, Antiviral vaccines.                                                                                                                                                                                                                                                                                                                                                                                          |
| Unit-V:<br><b>Medical Parasitology</b><br>(18 hours)            | Morphology, pathogenesis, laboratory diagnosis and treatment of medically important protozoan diseases caused by: <i>Entamoeba histolytica</i> , <i>Giardia lamblia</i> , <i>Trichomonas vaginalis</i> , <i>Plasmodium vivax</i> , <i>Leishmania donovani</i> , <i>Taenia solium</i> , <i>Ascaris lumbricoides</i> , <i>Ancylostoma duodenale</i> and <i>Wuchereria bancrofti</i> . Diagnosis of parasitic infection using clinical samples. Role of Nucleic acid probes in diagnostic microbiology.                                                                                                                                                                                                                                                    |
| Unit-VI: <b>Current Contours</b> (For                           | Chart preparation on mechanisms of microbial pathogenicity, virulence factors, and host-pathogen                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

Continuous Internal Assessment only): interactions; case studies on major bacterial, viral, fungal, and parasitic diseases; demonstration and interpretation of antibiotic susceptibility testing (Kirby–Bauer method); preparation of reports on emerging infectious diseases and antimicrobial resistance; quiz sessions and short seminar presentations on recent advances in medical microbiology.

### Mapping with Specific Programme Outcomes

|      | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 | PSO 9 | PSO10 | PSO1 1 | PSO1 2 |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|
| CO 1 | S     | S     | L     | S     | S     | S     | S     | S     | M     | L     | L      | S      |
| CO 2 | S     | S     | L     | S     | S     | S     | S     | S     | M     | L     | L      | S      |
| CO 3 | S     | S     | L     | S     | S     | S     | S     | S     | M     | L     | L      | S      |
| CO 4 | S     | S     | L     | S     | S     | S     | S     | S     | M     | L     | L      | S      |
| CO 5 | S     | S     | L     | S     | S     | S     | S     | S     | M     | L     | L      | S      |
| CO 6 | S     | S     | L     | S     | S     | S     | S     | S     | M     | L     | L      | S      |

### Recommended References:

1. Aejaz Iqbal and Zafar Nowshad. 2020. Medical Microbiology: Millennium Edition. Notion Press, Chennai.
2. Jawetz, Melnick, and Adelberg's. 2016. Medical Microbiology by Carroll KC, Hobdon JA, Miller S, Morse SA, Mietzner TA. 27<sup>th</sup> edition. Lange Publication, New York.
3. Wilson BA, Salyers AA, Whitt DD, Winkler ME. 2011. Bacterial Pathogenesis: A molecular approach. 3<sup>rd</sup> edition. American Society for Microbiology Press, Washington, DC USA.
4. Loch C, Simonet M, and Caister. 2012. Bacterial Pathogenesis: Molecular and Cellular Mechanisms by Academic Press, USA.
5. Persing DH, Tenover FC, Hayden R, Leven M, Miller MB, Nolte FS, Tang YW, Belkum AAV. 2016. Molecular Microbiology: Diagnostic Principles and Practice, 3<sup>rd</sup> edition. Washington, American Society for Microbiology Press. USA.
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7. Cary Engleberg ,N, Victor ,J, DiRita, Michale J.Imperiale, Schaechter's Mechanisms of Microbial Disease, 6<sup>th</sup> edition ,Williams and Wilkins., Baltimore. USA.
8. Collee JC, Duguid JP, Fraser AC ,Marimon BP. Mackie and Mc Carteny, 1989. Practical Medical Microbiology, 13<sup>th</sup> edition, Churchill Livingstone, London.
9. David Greenwood, Mike Barer, Richard Slack and Will Irving. 2012. Medical Microbiology. A Guide to Microbial Infections: Pathogenesis, immunity, Laboratory investigation and Control, 18<sup>th</sup> edition, Churchill Livingstone. London.

10. Dimmock, N.J., Easton, A.J. and Lappard, K.N. 2009. Introduction to Modern Virology. Wiley Blackwell ,USA
11. Hugo W.B and Russell A.D. 1989. Pharmaceutical Microbiology, 4<sup>th</sup> edition, Blackwell Scientific Publications, Oxford, United Kingdom.
12. Errol Reiss, Jean Shadomy, H. and Marshall Lyon, G. 2011. Fundamental Medical Mycology. 1<sup>st</sup> edition, Wiley Blackwell. United States.
13. Flint, S.J., Enquist L.W., Racaniello, V.R. and Skalka, A.M. 2009. Principles of Virology: Molecular Biology, 3<sup>rd</sup> edition. ASM Press, Washington.
14. Stefan Riedal, Stephan A.Morse, Timothy Mietzner and Steve Miller, 2001. Jawetz, Melnick and Adelberg's Medical Microbiology, 28<sup>th</sup> edition, McGraw Hill Medical Publication division, New York
15. Joan stokes E, Ridgway G.L and Wren M.W.D. 1993. Clinical Microbiology 7<sup>th</sup> edition, Edward Arnold, London
16. Kenneth j. Ryan, C. George Ray. 2014. Sherris Medical Microbiology, 4<sup>th</sup> edition. McGraw-Hill Medical Publishing Division. New York.
17. Morag, C. and Timbury, M.C. 1994. Medical Virology, 10<sup>th</sup> edition. Churchill Livingston, London.
18. Topley and Wilson 1995. Principles of Bacteriology, Virology and Immunity, 9<sup>th</sup> edition. Edward Arnold, London.

**Related Online Contents:**

1. <https://www.aspergillus.org.uk/mycology-courses?page=5>
2. <https://www.mooc-list.com/tags/human-parasitology>
3. <https://www.mooc-list.com/tags/tropical-parasitology>

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**SEMESTER – III****IMMUNOLOGY, MEDICAL AND INDUSTRIAL MICROBIOLOGY (P)**

| Course Code          | CP-3                                                                                                                                                                                       | Course Type | Core Practical | L | T | P | C | Syllabus version | 2026-2027 |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------|---|---|---|---|------------------|-----------|
| <b>Pre-requisite</b> | Basic theoretical understanding of immune system components, human pathogens, fermentation principles, and proficiency in general aseptic and isolation techniques of microbial pathogens. |             |                |   |   |   |   |                  |           |

**Course Objectives:**

- ✓ Acquire hands-on skills in performing immunological assays, blood typing, and serological disease diagnosis.
- ✓ Address challenges in the safe handling, isolation, and biochemical identification of clinical pathogens from biological samples.
- ✓ Become a creative problem solver in designing lab-scale industrial fermentations, cell immobilization, and downstream product recovery.
- ✓ Understand the practical methodologies for evaluating antimicrobial susceptibility and identifying drug resistance.
- ✓ Understand lab-scale production and estimation of industrial bioproducts.

**Expected Course Outcomes:**

**On the completion of the course, the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                      | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Perform in vitro antigen-antibody interactions including agglutination and precipitation tests.                      | K3              |
| CO2                                                                                                                    | Execute advanced immunodiagnostic techniques such as double diffusion and ELISA.                                     | K3 – K6         |
| CO3                                                                                                                    | Isolate and identify pathogenic bacteria from simulated clinical specimens using selective and differential media.   | K3 – K6         |
| CO4                                                                                                                    | Evaluate antimicrobial susceptibility using standard disc diffusion and minimal inhibitory concentration methods.    | K3 – K6         |
| CO5                                                                                                                    | Demonstrate the lab-scale production and estimation of industrial products like alcohol, organic acids, and enzymes. | K3 – K6         |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                      |                 |

**EXPERIMENTS****IMMUNOLOGY**

1. ABO Blood grouping and Rh typing (Haemagglutination).
2. Widal test (slide agglutination) for the serodiagnosis of Typhoid.
3. Rapid Plasma Reagin (RPR) or VDRL test for the serodiagnosis of Syphilis.
4. Ouchterlony Double Immuno-diffusion technique, Radial Immunodiffusion for antigen quantitation. Demonstration of Immunoelectrophoresis.
5. Direct or indirect Enzyme-Linked Immunosorbent Assay (ELISA).

## MEDICAL MICROBIOLOGY

1. Collection and transport methods for clinical specimens (throat swab, urine, pus, stool).
2. Culturing and identifying the normal microbial flora of the throat and skin.
3. Isolation and identification of pathogens from Urine samples.
4. Isolation and identification of pathogens from Pus/Wound samples.
5. Isolation and identification of enteric pathogens from Stool samples.
6. Preparation of McFarland turbidity standards for inoculum standardization.
7. Performing the Kirby-Bauer disk diffusion susceptibility test on Mueller-Hinton agar.
8. Determination of the Minimum Inhibitory Concentration (MIC) of an antibiotic using the broth microdilution or tube dilution method.

## INDUSTRIAL MICROBIOLOGY

1. Lab-scale fermentation of fruit juice into wine using *Saccharomyces cerevisiae*; estimation of alcohol content and titratable acidity.
2. Solid-state fermentation for the production of amylase using *Aspergillus* or *Bacillus* species.
3. Submerged fermentation for the production of citric acid using *Aspergillus niger*.
4. Whole-cell immobilization technique: Entrapment of yeast cells.
5. Isolation, mass cultivation of *Rhizobium*, Cyanobacterial Biofertilizer.
6. Milk quality assessment using dye reduction test.
7. Air and water quality assessment methods.

### Mapping with Specific Programme Outcomes

|     | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| CO1 | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| CO2 | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| CO3 | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| CO4 | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| CO5 | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |
| CO6 | S    | S    | S    | S    | S    | S    | S    | S    | S    | L     | L     | S     |

## RECOMMENDED REFERENCES

1. Cappuccino, J. G., and Welsh, C. (2017). *Microbiology: A Laboratory Manual*, 11th Edition. Pearson. USA.
2. Collee, J. G., Fraser, A. G., Marmion, B. P., & Simmons, A. (Eds.). (1996). *Mackie & McCartney Practical Medical Microbiology*, 14th Edition. Churchill Livingstone. UK.
3. Hay, F. C., & Westwood, O. M. (2002). *Practical Immunology*, 4th Edition. Wiley-Blackwell. USA.
4. Patel, A. H. (2011). *Industrial Microbiology*. Macmillan Publishers India.
5. CLSI (Clinical and Laboratory Standards Institute) Performance Standards for Antimicrobial Susceptibility Testing.

**Related Online Contents**

1. <https://www.cdc.gov/laboratory/>
2. <https://vlab.amrita.edu/?sub=3&brch=69>
3. <https://www.who.int/teams/health-product-policy-and-standards/standards-and-specifications/vaccine-standardization/immunological-assays>

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**SEMESTER – III****1. RESEARCH METHODOLOGY AND BIOETHICS**

| Course Code          | DCEC - 3                                                                   | Course Type | Discipline Centric Elective | L | T | P | C | Syllabus version | 2026-2027 |
|----------------------|----------------------------------------------------------------------------|-------------|-----------------------------|---|---|---|---|------------------|-----------|
|                      |                                                                            |             |                             | 5 | - | - | 4 |                  |           |
| <b>Pre-requisite</b> | A basic understanding of the research, publication, ethics and statistics. |             |                             |   |   |   |   |                  |           |

**Course Objectives:**

- ✓ Define and explain the fundamental concepts, principles, and stages of philosophy, scientific research methodology, research ethics and bioethics.
- ✓ Identify and apply appropriate research designs, data collection tools, and analytical techniques for a specific research problem
- ✓ Analyze and apply core ethical principles (beneficence, autonomy, justice) to human and animal studies.
- ✓ Evaluate scientific literature and research proposals for methodological soundness and ethical compliance.
- ✓ Develop a well-structured, ethically sound research proposal, including necessary consent forms and risk assessments

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                                                | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | State the key principles of bioethics (e.g., Belmont Report) and define foundational research terms (e.g., variable, hypothesis, bias).        | K1              |
| CO2                                                                                                                    | Explain the purpose of IRB (Institutional Review Board) approval, informed consent, and data management in research.                           | K1, K2          |
| CO3                                                                                                                    | Implement appropriate statistical tools and data collection techniques to analyze experimental data.                                           | K1- K3          |
| CO4                                                                                                                    | Differentiate between quantitative and qualitative methodologies and identify potential ethical dilemmas in study designs.                     | K1 - K4         |
| CO5                                                                                                                    | Critically judge the validity, reliability, and ethical integrity of published research papers and proposed studies.                           | K1 - K5         |
| CO6                                                                                                                    | Generate a research proposal with a clear methodology and a completed ethical clearance application, ensuring protection of research subjects. | K1 - K6         |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                                                |                 |

|                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-I:<br><b>Philosophy and ethics in science</b><br>(15 hours)                             | Philosophy- nature and scope, concept, branches. Ethics: moral philosophy, nature of moral judgements and reactions. Ethics in science research. Intellectual honesty and research integrity. Scientific misconducts: falsification, fabrication and plagiarism. Redundant Publications: duplicate and overlapping publications, salami slicing. Selective reporting and misrepresentation of data. Publication Ethics: Best practices/standards setting initiatives and guidelines. Conflicts of interest. Publication Misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types. Violation of publication ethics, authorship and contributor ship. Identification of publication misconduct, complaints and appeals. Predatory publishers and journals. |
| Unit-II: <b>Design, plan of experiments and analysis, presentation of data</b><br>(15 hours) | Design and planning of Experiments: Aims and objectives, expected outcome, methodology to be adopted. Interpolation, Extrapolation, Types of errors, Error analysis and statistical principles. Objectives and basic principles of designs of experiments. Analysis and presentation data: using graphs, presenting data in tables, schemes and figures. Statistical tests, software for drawing, statistical analyses, bibliography using Mendeley and endnote. Software used in Science. Familiarization of Spreadsheet Tools, Presentation Tools and Writing Tools. Presentation of Tables and Figures. Use and Format of Appendices, Indexing.                                                                                                                                              |
| Unit-III:<br><b>Databases and Research Metrics</b><br>(15 hours)                             | Databases – Indexing databases, Citation databases: Web of Science, Scopus, etc. Research Metrics, Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score. Metrics: h-index, g-index, i10 index, altmetrics. Open access publications and initiatives. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies. Software tool to identify predatory publications. Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc. Predatory publishers and journals.                                                                                                                                                                                                                      |
| Unit-IV: <b>Research publication</b><br>(15 hours)                                           | General aspects of scientific writing, reporting practical and project work, writing literature survey and reviews, organizing a poster display, oral presentation. Guidelines for writing the abstract, introduction, methodology, results and discussion, and conclusion of a manuscript. References, Citation and listing system of documents. Developing a Research Proposal – Thesis proposal. Format of research proposal. Research Report: Format of the research report, style of writing the report, references and bibliography.                                                                                                                                                                                                                                                      |

Unit-V: **Bioethics** (15 hours) Bioethics: ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Genetically engineered food, environmental risk, labeling and public opinion. Protection of environment and biodiversity – biopiracy.

Unit-VI: **Current Contours** (For Continuous Internal Assessment only): Discussion and assignment on Open Science and Transparency, Design Bioethics, Relational and Situational Ethics, Reconciling Data Privacy with Openness, Balancing Autonomy and Safety, Conflicts of Interest

### Mapping with Specific Programme Outcomes

|            | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 | PSO 9 | PSO10 | PSO11 | PSO12 |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>CO1</b> | S     | S     | M     | S     | S     | M     | S     | S     | M     | L     | L     | S     |
| <b>CO2</b> | S     | S     | M     | S     | S     | M     | S     | S     | M     | L     | L     | S     |
| <b>CO3</b> | S     | S     | M     | S     | S     | M     | S     | S     | M     | L     | L     | S     |
| <b>CO4</b> | S     | S     | M     | S     | S     | M     | S     | S     | M     | L     | L     | S     |
| <b>CO5</b> | S     | S     | M     | S     | S     | M     | S     | S     | M     | L     | L     | S     |
| <b>CO6</b> | S     | S     | M     | S     | S     | M     | S     | S     | M     | L     | L     | S     |

### RECOMMENDED REFERENCES:

1. Kothari, C.R, 1985. "Research Methodology- Methods and Techniques", Wiley Eastern Limited. New Delhi.
2. Petter Laake, Haakon Breien Benestad and Bjorn Reino Olsen, 2007. "Research methodology in the medical and biological sciences" 1st Ed, Academic Press, USA.
3. Ranjit Kumar, 2005. "Research Methodology- A step-by-step Guide for beginners", 3rd Ed, Sage publications, India.
4. Gurumani N, 2006. Research Methodology for Biological sciences, MJP publishers, Chennai.
5. Anderson J.B. and Poole M. (2011). Assignment and Thesis Writing. 4th edn. Wiley India Private Limited. India.
6. M.K. Sateesh, 2010. Bioethics and Biosafety, IK International Publishing, India.
7. Lewis Vaughn. Bioethics: Principles, Issues and Cases, 2nd Edition. Oxford University Press, UK.
8. Deepa Goel, Shomini Parashar. (2013). IPR, Biosafety and Bioethics. Pearson. India.
9. Felix Thiele, Richard E. Ashcroft (2005). Bioethics in a Small World. Springer. USA.
10. John Bryant (2002) Bioethics for Scientists. John Wiley and Sons Publisher. USA.

## **Related Online Contents**

1. UCMerced Research Methods Tutorials:  
<https://libguides.ucmerced.edu/research-methods>
2. Elsevier Researcher Academy - <https://researcheracademy.elsevier.com/>
3. NIH eSource - <https://obssr.od.nih.gov/training/online-training-resources/esource>
4. Bioethics.com - <https://bioethics.com/>
5. BioethicsBytes - <https://bioethicsbytes.wordpress.com/>
6. ELSI Research Portal - <https://elsihub.org/>

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**SEMESTER – III****2. MICROBIOME BIOLOGY**

| Course Code          | DCEC-3                                                                                                                                     | Course Type | Core | L<br>5 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Knowledge on microbiome types, analysis and modulation microbiome in plant, animal and human system through diet and environmental factors |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the importance of Microbiome in Poultry health, Pig, ruminants
- ✓ Addresses challenges in Microbiome for Cancer therapy
- ✓ Creative problem solver of Rhizosphere microbiome and In Situ Phytomicrobiome
- ✓ Understanding the Probiotic Microbiome and human health.
- ✓ Understand the importance of Microbiome in Poultry health, Pig, ruminants

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                           | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Exploring the metagenomics and its application in microbiome research                                     | K1, K2          |
| CO2                                                                                                                    | To learn about the computational techniques in Microbiome Data analysis                                   | K1, K2          |
| CO3                                                                                                                    | To characterize human microbiome under healthy and disease condition                                      | K1- K4          |
| CO4                                                                                                                    | Exploring microbiome under distinct climatic conditions, diet and geography.                              | K3, K4          |
| CO5                                                                                                                    | Understanding the Importance of the plant microbiome in rhizosphere, drought                              | K1, K2          |
| CO6                                                                                                                    | To demonstrate microbiome in animal health improvement and modification microbiome by probiotics and diet | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                           |                 |

Unit-I:  
**Microbiome- An overview**  
(15 hours)

Microbiome- Types of Microbiomes- Human, Gut, Animal, Plant microbiomes, Root, Environmental microbiomes, Microbiome - Natural and artificial microbiome - climatic conditions, Microbiome modification in plants, animals and human system-diet, life style factor and geography.

Unit-II:  
**Metagenomics**  
(15 hours)

Metagenomics work flow- sample collection and processing, Metagenomic DNA isolation methods, Targeted, Shotgun Metagenomics, amplicon sequencing, -Illumina Genome Analyzer, Genome assembly annotation-Genome analysis tools -QIIME pipeline.

|                                                                             |                                                                                                                                                                                                                                                                                                                                   |
|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-III:<br><b>Plant microbiome</b><br>(15 hours)                          | Rhizosphere microbiome engineering In Situ Phytomicrobiome, Microbiome for Plant Growth and Improvement, Plant Microbiome Engineering to Improve Drought Stress Tolerance                                                                                                                                                         |
| Unit-IV:<br><b>Animal Microbiome</b><br>(15 hours)                          | Microbiome to improve Animal health, Gastro intestinal Microbiome in Poultry health, Gastro intestinal Microbiome in Pig, ruminants                                                                                                                                                                                               |
| Unit-V:<br><b>Human microbiome</b><br>(15 hours)                            | Dietary habitat in Human health enhancement, Skin Microbiome: A therapeutic approach, Microbiome therapy for Human health, Microbiome Engineering for Cancer therapy, Orthopedic biomechanics, Probiotic engineered Microbiome and human health.                                                                                  |
| <b>Unit-VI: Current Contours</b> (For Continuous Internal Assessment only): | Daily news and research paper on Microbiome. Public awareness of microbiome importance in human and animal health. Scientific model on plant, animal, human microbiome concept. Computational analysis microbiome data, metagenomic data from Web Resources. Collection metadata about samples and creation mapping file for OTUS |

#### Mapping with Specific Programme Outcomes

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>C01</b> | S    | S    | M    | S    | S    | M    | S    | S    | L    | L     | L     | S     |
| <b>C02</b> | S    | S    | M    | S    | S    | M    | S    | S    | L    | L     | L     | S     |
| <b>C03</b> | S    | S    | M    | S    | S    | M    | S    | S    | L    | L     | L     | S     |
| <b>C04</b> | S    | S    | M    | S    | S    | M    | S    | S    | L    | L     | L     | S     |
| <b>C05</b> | S    | S    | M    | S    | S    | M    | S    | S    | L    | L     | L     | S     |
| <b>C06</b> | S    | S    | M    | S    | S    | M    | S    | S    | L    | L     | L     | S     |

#### Recommended References:

1. Angela E. Douglas. 2018. Fundamentals of Microbiome Science: How Microbes Shape Animal Biology, Princeton University Press, New Jersey, USA
- 2) Rodriguez R and Durán P (2020) Natural Holobiome Engineering by Using Native Extreme Microbiome to Counteract the Climate Change Effects. *Front. Bioeng. Biotechnol.* 8:568.
- 3) Broberg. 2018. McDonald. Integrated multi-omic analysis of hostmicrobiota interactions in acute oak decline. *Microbiome*, 6:21
- 4) Bordenstein SR, Theis KR (2015) Host Biology in Light of the Microbiome: Ten Principles of Holobionts and Hologenomes. *PLoS Biol* 13(8): e1002226.
- 5) Dhanasekaran D. Paul D, Amaresan N, Sankaranarayanan A, Shouche Y (2022) Microbiome-Host interactions. CRC press Taylor & Francis group, Baco raton, New York, USA.
- 6) Dhanasekaran, D and A. Sankara Narayanan. 2024. Plant Microbiome Engineering, Springer Protocols, Humana New York.

7). Dhanasekaran D, A. Sankaranarayanan, Priyanka Sarkar. 2024. Human and Animal Microbiome Engineering, Elsevier. USA.

**Related Online Contents:**

1. <http://qiime.org/tutorials/index.html>
2. <https://www.coursera.org/learn/microbiome>
3. <https://fn.academy/microbiome-course/>

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**SEMESTER – III****1. INDUSTRIAL AND PHARMACEUTICAL MICROBIOLOGY**

| Course Code          | GEC-3                                                                           | Course Type | Core | L<br>5 | T<br>- | P<br>- | C<br>3 | Syllabus version | 2026-2027 |
|----------------------|---------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Knowledge on fermentation, fermenter, antibiotics, vaccines, sterility testing. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the fundamental principles of industrial strain development, fermentation technology, and media formulation.
- ✓ Address challenges in the scale-up of bioprocesses and the downstream processing/purification of microbial products.
- ✓ Become a creative problem solver in the commercial production of primary and secondary metabolites, including antibiotics and recombinant therapeutics.
- ✓ Understanding the Probiotic engineered Microbiome and human health.
- ✓ Understand the rigorous quality assurance, sterility testing, and regulatory frameworks governing the pharmaceutical industry.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES                                                                                                         | KNOWLEDGE LEVEL |
|-----|-------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1 | Exploring the isolation, screening, and genetic improvement of industrially important microbial strains.                | K1, K2          |
| CO2 | To learn about bioreactor design, fermentation systems, and the control of bioprocess parameters.                       | K1, K2, K3      |
| CO3 | To characterize the steps involved in downstream processing and product recovery.                                       | K1 – K4         |
| CO4 | Exploring the large-scale production of industrial enzymes, organic acids, and biofuels.                                | K3, K4          |
| CO5 | Understanding the importance of pharmaceutical microbiology in antibiotic, vaccine, and therapeutic protein production. | K1, K2          |
| CO6 | To demonstrate knowledge of Good Manufacturing Practices (cGMP), sterility testing, and pharmacopeial standards.        | K5, K6          |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation**

**Unit-I: Basics of Industrial Microbiology**  
(15 hours)

Introduction and scope of industrial microbiology. Isolation, primary and secondary screening of industrially important microbes from natural sources. Preservation and maintenance of microbial cultures. Strain improvement strategies: mutagenesis, protoplast fusion, and recombinant DNA technology. Formulation of fermentation media: carbon

sources, nitrogen sources, precursors, inducers, and antifoaming agents.

Unit-II:  
**Fermentation Technology and Bioreactors**  
(15 hours)

Principles of microbial growth in batch, fed-batch, and continuous cultures. Basic design and components of a standard bioreactor. Types of bioreactors. Online and offline measurement/control of bioprocess parameters - pH, temperature, dissolved oxygen, agitation. Solid-state fermentation vs. submerged fermentation. Scale-up of fermentation processes.

Unit-III:  
**Downstream Processing**  
(15 hours)

Downstream processing - Harvesting microbial cells: centrifugation, filtration, and flocculation. Cell disruption methods for intracellular products. Product recovery and purification: liquid-liquid extraction, precipitation, membrane separation, and chromatography. Final product formulation: crystallization and lyophilization.

Unit-IV:  
**Production of Industrial Metabolites**  
(15 hours)

Microbial production of primary metabolites: organic acids - citric acid, lactic acid, and industrial enzymes - amylases, proteases, lipases. Microbial production of bio-solvents and biofuels - bioethanol. Production of fermented foods, beverages, and Single Cell Protein.

Unit-V:  
**Pharmaceutical Microbiology**  
(15 hours)

Classification of antimicrobial agents. Microbial production of secondary metabolites: antibiotics - penicillin, streptomycin, tetracycline) and vitamins (B12, riboflavin. Types of vaccines and their manufacturing principles. Sterility testing, pyrogen testing, and QA/QC under current Good Manufacturing Practices.

Unit-VI: **Current Contours** (For Continuous Internal Assessment only):

Daily news and case studies on biomanufacturing scale-up and pharmaceutical supply chains. Public awareness of antibiotic resistance mechanisms and vaccine efficacy. Computational modeling of fermentation kinetics. Drafting a standard operating procedure (SOP) for batch record management in a simulated GMP bioprocessing facility.

### Mapping with Specific Programme Outcomes

|     | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 | PSO 8 | PSO 9 | PSO10 | PSO11 | PSO12 |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| CO1 | S     | S     | S     | S     | S     | L     | S     | S     | S     | M     | L     | S     |
| CO2 | S     | S     | S     | S     | S     | L     | S     | S     | S     | M     | L     | S     |
| CO3 | S     | S     | S     | S     | S     | L     | S     | S     | S     | M     | L     | S     |
| CO4 | S     | S     | S     | S     | S     | L     | S     | S     | S     | M     | L     | S     |
| CO5 | S     | S     | S     | S     | S     | L     | S     | S     | S     | M     | L     | S     |
| CO6 | S     | S     | S     | S     | S     | L     | S     | S     | S     | M     | L     | S     |

### **Recommended References:**

1. Stanbury, P. F., Whitaker, A., and Hall, S. J. (2016). *Principles of Fermentation Technology*, 3rd Edition. Butterworth-Heinemann. UK.
2. Crueger, W., and Crueger, A. (1990). *Biotechnology: A Textbook of Industrial Microbiology*. Sinauer Associates. USA.
3. Waites, M. J., Morgan, N. L., Rockey, J. S., and Higton, G. (2001). *Industrial Microbiology: An Introduction*. Wiley-Blackwell. USA.
4. Okafor, N., and Okeke, B. C. (2017). *Modern Industrial Microbiology and Biotechnology*, 2nd Edition. CRC Press. USA.
5. Casida, L.E., 2018. *Industrial microbiology*. New Age International Publishers. India
6. Patel, A.H., 2012. *Industrial microbiology*. Trinity press. India.
7. Hugo, W. B., and Russell, A. D. (2011). *Pharmaceutical Microbiology*, 8th Edition. Wiley-Blackwell. USA

### **Related Online Contents:**

1. <https://nptel.ac.in/courses/102105058>
2. <https://www.fda.gov/drugs/pharmaceutical-quality-resources>
3. <https://www.coursera.org/learn/industrial-biotechnology>

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**SEMESTER – III****2. LIFE SCIENCE FOR COMPETITIVE EXAMINATIONS**

| Course Code          | GEC-3                                                                                                                                   | Course Type | Core | L<br>5 | T<br>- | P<br>- | C<br>3 | Syllabus version | 2026-2027 |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Currently pursuing or completed a M.Sc. in any branch of Life Sciences, with a basic understanding of general academic study practices. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the structural frameworks, syllabi variations, and marking schemes of major Indian Life Science competitive exams.
- ✓ Address challenges in time management, macro/micro study planning, and resource optimization.
- ✓ Become a creative problem solver in tackling analytical, data-based questions and General Aptitude sections.
- ✓ Understand the psychological aspects of high-stakes testing, including stress management and performance analysis through mock tests.
- ✓ Understand the conceptual gaps and recalibrating study plans test metrics.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES                                                                                                      | KNOWLEDGE LEVEL |
|-----|----------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1 | Exploring the landscape, eligibility criteria, and exam patterns of CSIR-NET, GATE, DBT, and ICMR.                   | K1, K2          |
| CO2 | To learn about creating dynamic, prioritized study schedules and effective note-making strategies.                   | K1, K2          |
| CO3 | To characterize evidence-based learning techniques like active recall and spaced repetition.                         | K1 - K3         |
| CO4 | Exploring strategic approaches for solving General Aptitude (Part A) and experimental data-based questions (Part C). | K3, K4          |
| CO5 | Understanding the importance of exam psychology, stress mitigation, and avoiding negative marking traps.             | K1, K2          |
| CO6 | To demonstrate the ability to analyze previous year question papers (PYQs) and mock test performance metrics.        | K5, K6          |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation**

**Unit-I: Landscape of Indian Competitive Exams**  
(15 hours)

Overview of national-level life science examinations: CSIR-UGC NET (JRF/LS), GATE (Life Sciences - XL, Ecology and Evolution - EY), DBT-BET, ICMR-JRF, and state-level SETs. Comparative analysis of exam patterns: computer-based testing interfaces, section-wise weightage, marking schemes, and the mathematics of negative marking. Analyzing

standard syllabi frameworks and identifying overlapping high-yield core topics.

**Unit-II: Strategic Planning and Resource Optimization**  
(15 hours)

The transition from university-level subjective writing to objective MCQ-based testing. Time management frameworks: macro-planning vs. micro-planning. Prioritization of topics based on historical question trends. Resource selection: identifying standard international reference books vs. coaching materials. Effective note-making methodologies: Cornell method, mind mapping, and creating rapid-revision flashcards.

**Unit-III: Advanced Learning Methodologies**  
(15 hours)

The cognitive science of learning. Transitioning from passive reading to active learning. Implementing the Spaced Repetition System for retaining massive amounts of factual data. The Feynman Technique for conceptual clarity. Overcoming the "illusion of competence." Structuring effective revision cycles.

**Unit-IV: Tackling Analytical Reasoning and General Aptitude**  
(15 hours)

Decoding the General Aptitude section (Part A of CSIR-NET / General Aptitude in GATE). Strategies for numerical ability, logical reasoning, data interpretation, and graphical analysis without heavy mathematical backgrounds. Frameworks for tackling high-order thinking skills and experimental design questions. The art of intelligent guessing and the "elimination of options" strategy.

**Unit-V: Test-Taking Strategies and Exam Psychology**  
(15 hours)

Psychological readiness for high-stakes exams. Managing test anxiety, imposter syndrome, and burnout during prolonged preparation. The biology of stress and cognitive performance. Simulating exam conditions: the importance of full-length mock tests. Post-test analysis: maintaining an "error log," identifying conceptual gaps versus silly mistakes, and recalibrating study plans based on mock test metrics.

**Unit-VI: Current Contours** (For Continuous Internal Assessment only):

Daily tracking of notifications from major testing agencies (NTA, CSIR HRDG, IITs). Group discussions on optimizing the PhD interview process and writing Statements of Purpose. Computational analysis of personal mock test data to map accuracy rates and time spent per section. Live solving of Previous Year Question papers under timed conditions.

**Mapping with Specific Programme Outcomes**

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>C01</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | M     | L     | S     |
| <b>C02</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | M     | L     | S     |
| <b>C03</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | M     | L     | S     |
| <b>C04</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | M     | L     | S     |
| <b>C05</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | M     | L     | S     |
| <b>C06</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | M     | L     | S     |

**Recommended References:**

1. Brown, P. C., Roediger III, H. L., & McDaniel, M. A. (2014). Make It Stick: The Science of Successful Learning. Harvard University Press. UK.
2. Clear, J. (2018). Atomic Habits: An Easy & Proven Way to Build Good Habits & Break Bad Ones. Avery. USA.
3. Agarwal, R. S. A Modern Approach to Logical Reasoning. S. Chand Publishing. India
4. Newport, C. (2006). How to Become a Straight-A Student: The Unconventional Strategies Real College Students Use to Score High While Studying Less. Crown. India.

**Related Online Contents:**

1. <https://csirhrdg.res.in/>
2. <https://nta.ac.in/>
3. <https://gate.iitk.ac.in/>

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**SEMESTER – III****PUBLIC HEALTH MICROBIOLOGY**

| Course Code          | NMEC-2                                                                                                             | Course Type | Core | L<br>2 | T<br>- | P<br>- | C<br>2 | Syllabus version | 2026-2027 |
|----------------------|--------------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | A general awareness of societal health issues, basic high school science, and an interest in community well-being. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the core concepts of public health, epidemiology, and how microorganisms impact human populations.
- ✓ Address challenges in community sanitation, safe drinking water, and the prevention of vector-borne diseases.
- ✓ Become a creative problem solver in promoting community hygiene, understanding outbreak dynamics, and debunking health misinformation.
- ✓ Understand the role of global health interventions, vaccination programs, and the societal threat of antibiotic resistance.
- ✓ Understand the immunization and vaccines.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                       | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Exploring the foundational concepts of public health, epidemiology, and the history of disease tracking.              | K1, K2          |
| CO2                                                                                                                    | To learn about water and food safety protocols, including municipal water purification and sanitation.                | K1, K2          |
| CO3                                                                                                                    | To characterize the spread of air-borne and vector-borne diseases within communities.                                 | K1- K4          |
| CO4                                                                                                                    | Exploring the dynamics of disease outbreaks, distinguishing between endemics, epidemics, and pandemics.               | K1 - K4         |
| CO5                                                                                                                    | Understanding the importance of herd immunity, national vaccination schedules, and the rise of "superbugs."           | K1, K2          |
| CO6                                                                                                                    | To demonstrate the ability to analyze public health campaigns and communicate basic health literacy to the community. | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                       |                 |

Unit-I:  
**Public Health and Epidemiology**  
(6 hours)

Public health - individual medicine to community health. The Epidemiological Triad. Role of major health organizations: WHO, CDC, and the Ministry of Health and Family Welfare in India.

Unit-II: **Water, Sanitation, and**

Clean water and community health. Municipal water treatment methods and water safety test. Common water-

|                                                                             |                                                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Hygiene</b><br>(6 hours)                                                 | borne diseases-Cholera, Typhoid, Giardia. Food safety in public spaces: street food hygiene, food handler protocols, and preventing mass food poisoning events.                                                                                                                            |
| <b>Unit-III: Air-borne and Vector-borne Diseases</b><br>(6 hours)           | Air borne diseases: droplets vs. aerosols. The mechanics of respiratory infections-Tuberculosis, Influenza. Vector-borne diseases: lifecycle and control of disease-carrying mosquitoes - Malaria, Dengue, and Chikungunya. Community-level vector control strategies.                     |
| <b>Unit-IV: Tracking Outbreaks and Pandemics</b><br>(6 hours)               | Endemic, Epidemic, and Pandemic. The basics of contact tracing, quarantine, and isolation. Case studies of modern pandemics: the 1918 Flu, HIV/AIDS, and the COVID-19 pandemic. The socio-economic impact of lockdowns and public health emergencies on society.                           |
| <b>Unit-V: Vaccines and Drug Resistance</b><br>(6 hours)                    | Immunization-concept of "Herd Immunity." Understanding the Universal Immunization Programme and routine childhood vaccines. The growing global crisis of Antimicrobial Resistance. How agricultural practices, over-the-counter antibiotic.                                                |
| <b>Unit-VI: Current Contours</b> (For Continuous Internal Assessment only): | Daily news on local disease outbreaks or seasonal health advisories. Public awareness regarding health misinformation and "fake news" on social media. Drafting a public health poster or designing a simple community awareness campaign addressing a local hygiene or vaccination issue. |

#### Mapping with Specific Programme Outcomes

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>C01</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | M     | L     | S     |
| <b>C02</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | M     | L     | S     |
| <b>C03</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | M     | L     | S     |
| <b>C04</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | M     | L     | S     |
| <b>C05</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | M     | L     | S     |
| <b>C06</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | M     | L     | S     |

#### Recommended References:

1. Turnock, B. J. (2015). *Public Health: What It Is and How It Works*, 6th Edition. Jones & Bartlett Learning. USA.
2. Engelkirk, P. G., and Duben-Engelkirk, J. (2014). *Burton's Microbiology for the Health Sciences*, 10th Edition. Wolters Kluwer. Netherlands.
3. Johnson, S. (2006). *The Ghost Map: The Story of London's Most Terrifying Epidemic—and How It Changed Science, Cities, and the Modern World*. Riverhead Books. New York.

#### Related Online Contents:

1. <https://www.who.int/health-topics/public-health>
2. <https://www.cdc.gov/publichealth101/index.html>
3. <https://www.coursera.org/learn/epidemiology>

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**SEMESTER – IV****ENVIRONMENT AND AGRICULTURAL MICROBIOLOGY**

| Course Code   | CC-7                                                                                                           | Course Type | Core | L<br>6 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|---------------|----------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| Pre-requisite | Understand the microbial diversity in soil, air, water and explore the microbial role in biogeochemical cycles |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the diversity and characters of microorganisms in different environments.
- ✓ Explore the community of microflora present in air and aquatic ecosystem with associated factors of growth.
- ✓ Analyze principle and types of biodegradations and bioremediations.
- ✓ Comprehend different biological interaction in plant and soil.
- ✓ Modern agricultural practices and its application to the agro-food safety

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs | COURSE OUTCOMES                                                                                                                                                                                                    | KNOWLEDGE LEVEL |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1 | Understand the diversity and characters of microorganisms in different environments, relate microbial role in functioning of ecosystem Predict microbial adaptation in natural and extreme environmental condition | K1 – K3         |
| CO2 | Explore the community of microflora present in air and aquatic ecosystem with associated factors of growth. Understand airborne diseases and assessment of air quality                                             | K1, K2          |
| CO3 | Describe principle and types of bioremediation. Examine microbial degradation of polymers, xenobiotics, domestic and industrial waste, biosorption of industrial waste                                             | K3, K4          |
| CO4 | Explicate different biological interaction in plant and soil and explore the microbial role in biogeochemical cycles                                                                                               | K3, K4          |
| CO5 | Understand assessment, management and conservation of agrobiodiversity                                                                                                                                             | K1, K2          |
| CO6 | Elaborate the role of modern agriculture practices in ensuring agro-food safety and agromedicine                                                                                                                   | K5, K6          |

**K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation**

Unit-I:  
**Microbial Diversity in Natural and Extreme Condition**  
(18 hours)

Edaphic and climatic factors dependent microorganisms in different environments of atmosphere, hydrosphere, lithosphere and biosphere. Characteristic features of environmental micro flora and their role in ecosystem functions. Microorganisms impact in Climate change. Exploring of site-specific microbiomes and metagenomics.

**Unit-II: Aero and Aquatic Microbiology**  
(18 hours)

Droplet nucleus, aerosols, air borne transmission of microbes and diseases. Air-borne microbial survival and assessment of air quality. Aquatic microbiology: Factors influencing microbial growth in aquatic systems. Occurrence and distribution of microbes in aquatic habitats - fresh water, sea water, hydrothermal vents, salt pans, estuaries, coral reefs and mangroves.

**Unit-III: Biodegradation and Bioremediation of Wastes**  
(18 hours)

Definition and characterization of waste and their types. Bioremediation: Basic principles and types of bioremediations, bio adsorption, bioaccumulation and biomagnifications. Bioleaching and biodegradation. Degradation of polymers: Plastic, polyethylene and polyhydroxyalkanoates. Microbial degradation of xenobiotics: Hydrocarbons, methane alkanes, halogenate, sulfonated compounds, and heavy metals.

**Unit-IV: Microbial Interactions in Biogeochemical cycles**  
(18 hours)

Microbial interactions: Plant and microbe, microbe and microbe interactions. Principles of quorum sensing and quenching mechanisms in microbes and plant interactions. R:S ratio. Impact of genetically modified crops and invasive species. Outline of biogeochemical cycles: transformation, fixation and mobilization of soil nutrients.

**Unit-V: Sustainable Agriculture**  
(18 hours)

Concepts of sustainable agriculture and functioning of traditional agricultural practices, organic farming, integrated agriculture systems, hydroponics and aquaponics. Structure and function of rhizosphere and rhizosphere engineering. Biofertilizers: symbiotic, associative and free-living microorganisms. Biocontrol agents: Microbial herbicides, microbial insecticides and entomopathogenic fungi. Modern agricultural practices and its application to the agro-food safety and agro-medicine.

**Unit-VI: Current Contours (For Continuous Internal Assessment only):**

Assignment was given based on the syllabus and seminar was subjected to students related to their assignment topics individually. A project was assigned in the topic of nodulating plants submission/description of microbial endophytic plants. Mini project in various recent research topics related to subject was given.

**Mapping with Specific Programme Outcomes**

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
|            |      |      |      |      |      |      |      |      |      |       | 1     | 2     |
| <b>C01</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | S     | L     | S     |
| <b>C02</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | S     | L     | S     |
| <b>C03</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | S     | L     | S     |
| <b>C04</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | S     | L     | S     |
| <b>C05</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | S     | L     | S     |
| <b>C06</b> | S    | S    | S    | S    | S    | L    | S    | S    | S    | S     | L     | S     |

### **Recommended References:**

1. Weil, R.R., Brady, N.C. (2017). The Nature and Properties of Soils. 15th edn, Pearson Education. UK.
2. Eldowney. S, Hardman. D.J, Waite. D.J, Waite. S (1993). Pollution: Ecology and Biotreatment, Longman Scientific Technical. UK.
3. Rai, M.K. (2005). Handbook of Microbial biofertilizers. Food Products Press, New York, USA.
4. Rajendran, P and P. Gunasekaran. (2007). Microbial Bioremediation. MJP. Publishers. India.
5. Rao, N.S. (Ed.). (2016). Advances in agricultural microbiology. Elsevier.
6. Van Elsas, J.D., Trevors, J.T., Jansson, J.K and Nannipieri, P. (2006). Modern Soil Microbiology. CRC Press, UK.
7. Dighton, J and White, J.F. (Eds.). (2017). The fungal community: its organization and role in the ecosystem. CRC Press, UK.
8. Pepper, I.L., Gerba, C.P. and Gentry T.J. 2015. Environmental Microbiology. 3rd edn., Academic Press, UK.
9. Maier, R.M., Pepper, I.L. and Gerba, C.P. 2009. Environmental Microbiology. 2nd edn., Academic Press, UK.
10. Palmisano, A.C. and M.A. Barlaz. 1996. Microbiology of Solid Waste. CRC, UK.

### **Related Online Contents:**

1. [https://microbewiki.kenyon.edu/index.php/Agricultural\\_microbiology](https://microbewiki.kenyon.edu/index.php/Agricultural_microbiology)
2. <https://www.pdfdrive.com/environmental-microbiology-e6710301.html>
3. <https://www.pdfdrive.com/agricultural-microbiology-e40856477.html>

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**SEMESTER – IV****FOOD AND DAIRY MICROBIOLOGY**

| Course Code          | CC-8                                                                                                                                                                          | Course Type | Core | L<br>6 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Basic understanding of microbes in food, their beneficial and harmful interaction, food borne infection and intoxication, quality assessment and microbes in food production. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the interaction between microorganisms and food environment; microbial spoilage and food Preservation and food safety and quality management systems
- ✓ Identify the role of pathogen in food borne infections and food poisoning, mycotoxins, viral and parasitic foodborne diseases
- ✓ Analyze the milk borne infection and intoxication, and production of fermented dairy products, probiotics and prebiotics
- ✓ Understand the assessment, management and conservation of agrobiodiversity.
- ✓ Address the food control agencies and its regulations - GMP, HACCP and FSSAI

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                                                                         | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Distinguish intrinsic and extrinsic factors of growth of microbes in food. Analyze microbial spoilage and to design methods for food preservation                       | K2, K4          |
| CO2                                                                                                                    | Implement quality control and represent the standard for quality in food production.                                                                                    | K2, K4          |
| CO3                                                                                                                    | Examine cause and control of food borne infection and food poisoning                                                                                                    | K3, K5          |
| CO4                                                                                                                    | Describe principle and types of bioremediations. Examine microbial degradation of polymers, xenobiotics, domestic and industrial waste, biosorption of industrial waste | K2, K4          |
| CO5                                                                                                                    | Understand assessment, management and conservation of agrobiodiversity                                                                                                  | K1, K2, K5      |
| CO6                                                                                                                    | Assessment of milk borne infection and intoxication and preparation of dairy products yoghurt, cheese, probiotics and prebiotics.                                       | K4, K5, K6      |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                                                                         |                 |

Unit-I:  
**Contamination, Spoilage, Preservation and Safety Standards of Food**

(18 hours)

Introduction- Importance of food microbiology- Factors influencing - intrinsic and extrinsic microbial growth in food. Food preservations: principles- methods of preservations - Physical and chemical methods.

Unit-II: **Food Spoilage and Sanitation**

(18 hours)

Contamination, preservation and spoilage of cereals and cereals products, Vegetables and fruits, meat and meat products, fish and other sea foods, egg and poultry. Food hygiene and control - food sanitation in food manufacture and in the retail trade. Food control agencies and its regulations - GMP, HACCP and FSSAI.

Unit-III: **Food Borne Diseases**

(18 hours)

Food intoxication and food poisoning bacterial and nonbacterial food borne diseases: Staphylococcus spp., Clostridium spp., Escherichia coli and Salmonella spp. Infections. Mycotoxins, Viral and Parasitic food borne diseases, Sea Food toxicants.

Unit-IV: **Dairy Microbiology**

(18 hours)

Micro flora of milk -sources of contamination - methods of minimizing contamination. Milk borne infection-intoxication. Milk preservation methods- pasteurization-sterilization.

Unit – V: **Milk Products**

(18 hours)

Fermented dairy products – microbes involved in fermentation -starter lactic acid cultures - butter milk, cream, yoghurt, kafil, kumiss, acidophilous milk, cheese production and cheese types. Probiotics, prebiotics foods and Postbiotics.

Unit-VI: **Current Contours** (For Continuous Internal Assessment only):

Field trip to dairy, beverage Industry and Food processing research Institutes. Analysis of microbiological quality milk and other food products. Fermented food preparation. Mycotoxin detection in food samples. Public Awareness about the prevention of food contamination and importance of SCP, probiotics and fermented food. Daily news and research paper on food borne out breaks and food preservation.

**Mapping with Specific Programme Outcomes**

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>C01</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>C02</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>C03</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>C04</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>C05</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>C06</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |

### **Recommended References:**

1. Adams M.R. M.O. Moss. 2005. Food Microbiology, 2<sup>nd</sup> edn. The Royal Society of Chemistry, UK.
2. James M. Jay, Martin J. Loesser, David A Golden. 2005. Modern food Microbiology, 7th edn., Springer science, USA.
3. Thomas J. Montville, Karl R. Matthews. 2005. Food Microbiology: an introduction. ASM press. USA.
4. Frazier WC and Westhoff DC. 2014. Food microbiology, TATA McGraw Hill Publishing Company Ltd. 5th edn., New Delhi.
5. Sankaranarayanan, A., Amaresan, N. and D. Dhanasekaran 2020. Fermented Food Products. CRC Press, Taylor and Francis Group, New York, USA,
6. Amaresan,N., D. Dhanasekaran, O. O. Babalola, 2023. Food Microbiology based Entrepreneurship: Making money from microbes. Springier book series 'Microorganisms for Sustainability, Springer, New York, USA.
7. Dhanasekaran,D and A. Sankaranarayanan, 2021. Advances in Probiotics: Microorganisms in Food and Health, Academic Press, Elsevier, Cambridge. UK.
8. Patel, AH. 2011. Industrial Microbiology, Macmillan India, Ltd, 2nd edn.
9. Stanbury, PF, Whitaker, A. (2008). Principles of Fermentation Technology, 2<sup>nd</sup> edition, Pergamon Press, New York.
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### **Related Online Contents:**

1. <http://foodscience.psu.edu/workshops/food-microbiology>
2. <https://www.canr.msu.edu/foodpreservation/>
3. <https://www.pdfdrive.net/food-microbiology-books.html>
4. <http://nuristianah.lecture.ub.ac.id/files/2014/09/fundamental-foodmicrobiology.pdf>

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**SEMESTER – IV**  
**MICROBIAL BIOTECHNOLOGY AND GENETIC ENGINEERING**

| Course Code          | CC-9                                                                                                                 | Course Type | Core | L<br>6 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|----------------------|----------------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Basics of gene cloning, principles of gene manipulative tools and fundamentals of technology in biological scale up. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ To provide the methods of genetic engineering & gene cloning and the essential molecular tools for genetic engineering & cloning.
- ✓ To impart various gene transfer techniques, methods of clones' identification, protein engineering and techniques.
- ✓ To bring out diverse microbial products and their commercialization through biotechnology
- ✓ To present the potential applications of microbial and molecular biotechnology in medicine, agriculture and various other current industrial processes.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                                           | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Elaborate various routes of gene cloning and diversity of molecular tools for gene cloning                                                | K1, K2, K5      |
| CO2                                                                                                                    | Recognize cell expression systems, identify clones and employ various techniques of genetic engineering.                                  | K1, K2, K5      |
| CO3                                                                                                                    | Comprehend economical and societal role of biotechnology in medicine and industry.                                                        | K1, K2, K3      |
| CO4                                                                                                                    | Understand the vast role microbial biotechnology in agricultural blooming.                                                                | K3, K4          |
| CO5                                                                                                                    | Assess the role of microbial biotechnology in plants transgenesis.                                                                        | K1, K2, K3, K4  |
| CO6                                                                                                                    | Create novel scientific ideas of genetic engineering & microbial biotechnology that could lead to next level of enhancement of the field. | K1 through K7   |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                                           |                 |

Unit-I:  
**Gene cloning, enzymes & cloning vectors**  
 (18 hours)

DNA cloning: Steps and methods of DNA cloning - Enzymes for gene manipulation & cloning - DNA polymerases, nucleases, DNA ligases, methylase. - Vectors: types, properties - plasmids vectors for cloning in *E. coli*-pBR322 & derivatives, pUC vectors and pGEM3Z - Bacteriophages vectors-M13 & Lambda, cosmids, phasmids, phagemids and BACs. Eukaryotic vectors - plasmid, YACs, and P elements - animal- retroviruses and

plant vectors-Ti plasmid-based vectors - Cutting, joining and introduction of DNA into living cells: adapters, linkers and homopolymer tailing.

**Unit-II: Gene transfer, screening for clone techniques**  
(18 hours)

Gene expression cell systems: Bacterial, Yeast and Mammalian. Gene transfer techniques: electroporation, microinjection, protoplast fusion and microparticle bombardment. Screening for recombinants: Direct: Insertional inactivation, plaque phenotype and indirect methods: Immunochemical detection, nucleic acid hybridization. Genome mapping: RFLP. PCR – Principles, types and their applications. Sequencing genomes – chain termination and pyrosequencing. Protein engineering - site directed mutagenesis: conventional and PCR-based methods - Design and construction of novel proteins and enzymes. Data analysis - Mass spectrometry-based Proteome analysis, MALDI-TOF and LC-MS platforms – Applications of protein engineering.

**Unit-III: Commercial Biotechnology**  
(18 hours)

Microbial biotechnology and Commercial production -- Pharmaceuticals - interferons, Enzymes: Alginate lyase, Monoclonal antibodies - HIV therapeutic agents. Subunit vaccines: Herpes simplex virus, Peptide vaccines – genetic immunization – vector vaccines. Microbial production of PstI, Dye: Indigo, Synthesis of Novel antibiotics. Biopolymers: PHA. Microbial production of alcohol, lactic acid, streptomycin, lipase and riboflavin.

**Unit-IV: Plant growth promoting bacteria, Microbial herbicides & insecticides**  
(18 hours)

Plant Growth-Promoting Rhizobacteria – Genetic engineering of nitrogenase gene cluster and Nodulation. Mass cultivation of biofertilizers: Cyanobacteria (*Spirulina* sp.), *Azolla* sp. *Rhizobia* sp., and VAM. Biocontrol of pathogens: Siderophores, antibiotics and enzymes. Release of genetically engineered organisms - Ice nucleation and anti-freeze proteins. Microbial herbicides. Microbial insecticides - *Pseudomonas* and *Bacillus thuringiensis*: - genetic engineering of Bt strains – Bt cotton – viral insecticides – entomopathogenic fungi.

**Unit-V: Transgenic plants and Transgenic animals**  
(18 hours)

Plants transgenesis with Ti plasmid vector systems - Development of insect, virus & herbicide resistant plants, stress & senescence tolerant plants, modification of flower nutritional content, sweetening by genetic engineering. Plant as bioreactors. Production of food, colourant and fuel from microalgae. Methods of developing transgenic mice and cattle. In- vivo and ex- vivo human gene therapy. Molecular diagnostics for genetic diseases.

**Unit-VI: Current Contours** (For Continuous Internal

An experimental demonstration for students shall be a part of the course. Assignments - Quiz classes - short seminar presentations using PPT – debates on genetic

Assessment only): engineering, its role in commercialization in the form of biotechnology and human ethics should be taken- up. Internship by students at appropriate places should be encouraged. Swayam- NPTEL courses on Biotechnology vs Genetic engineering should be recommended for higher understanding. Group discussion on recent advances of the course in production should be scheduled.

#### Mapping with Specific Programme Outcomes

|     | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| CO1 | S    | S    | S    | S    | S    | M    | S    | S    | S    | M     | L     | S     |
| CO2 | S    | S    | S    | S    | S    | M    | S    | S    | S    | M     | L     | S     |
| CO3 | S    | S    | S    | S    | S    | M    | S    | S    | S    | M     | L     | S     |
| CO4 | S    | S    | S    | S    | S    | M    | S    | S    | S    | M     | L     | S     |
| CO5 | S    | S    | S    | S    | S    | M    | S    | S    | S    | M     | L     | S     |
| CO6 | S    | S    | S    | S    | S    | M    | S    | S    | S    | M     | L     | S     |

#### Recommended References:

1. Old RW and Primrose SB. (2001) Principles of gene manipulations – An introduction to genetic engineering, 5 ed. University of California Press, USA.
2. Winnacker EL. From Genes to Clones. (2003) Introduction to gene technology. New Delhi Panima publishing corporation, India
3. Glick BR. (2017) Molecular Biotechnology – Principles and applications of recombinant DNA. 5<sup>th</sup> edition, ASM Press, Washington, DC, USA.
4. Nicholl DST (2008). An introduction to genetic engineering. Cambridge University Press, UK.
5. Brown TA. Gene Cloning & DNA analysis. (2016) London; New York: Chapman and Hall, USA.
6. Pinler A. (2001) Genetic engineering of microorganisms. Protein Structure, Stability and Folding by Kenneth P. Murphy. Published by Humana Press Inc., UK.
7. Jeffrey L, Cleland and Charles S Craik. (1996) Protein Engineering Principles and Practice Published by Wiley-Liss Inc., UK.
8. Paul R Carey. (1996) Protein Engineering and Design, Published by Academic Press Inc., UK.
9. Old RW and Primrose SB. Principles of Gene Manipulation - An Introduction to Genetic Engineering. 5<sup>th</sup> edition. Blackwell Scientific Publications, London. 2003, UK.
10. Brown TA. (2012) Genomes. 2<sup>nd</sup> Ed, John Wiley and sons. USA.
11. D.P. Clarke, N. Pazdernik. (2012) Molecular Biology by 2<sup>nd</sup> edition. Academic Press. USA.
12. J. Sambrook, D. Russell. (2012) Molecular Cloning: A laboratory manual by 4<sup>th</sup> edition. Cold Spring Harbor laboratory Press. USA.
13. J. Watson, T. Baker, S. Bell, A. Gann, M. Levine, R. Losick. (2014) Molecular Biology of the Gene by 7<sup>th</sup> edition. Pearson, UK.
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16. Padma Singh. 2009. Recent Trends in Microbial Biotechnology, CBS Publishers and Distributors. India.
17. Swarna Latha, C. D., Bhaskara Rao, D. 2007. Microbial Biotechnology. Discovery Publishing House. India.
18. Ratul Saikia. 2008. Microbial Biotechnology. New India Publishing Agency. India
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20. Puvanakrishnan, R., Sivasubramanian, S., Hemalatha, T. 2021. Microbial Technology, 1<sup>st</sup> edition. MJP publishers. India.
21. Borowitzka, M.A. Borowitzka, L.J. 1989. Microalgal Biotechnology, Cambridge University Press, UK.
22. Glazer, A.N., Nikaido, H. 1994. Microbial Biotechnology – Fundamentals of Applied Microbiology, WH Freeman and Company, New York, USA.

### **Related Online Contents:**

1. [http://www.bio.brandeis.edu/classes/heredity/Lecture%20Powerpoints/Chapter\\_13\\_1.pdf](http://www.bio.brandeis.edu/classes/heredity/Lecture%20Powerpoints/Chapter_13_1.pdf)
2. <https://www.cheric.org/files/education/cyberlecture/e200402/e200402-301.pdf>
3. <https://www.onlinebiologynotes.com/gene-cloning-steps-involved-gene-cloning/>
4. <https://uenf.br/cbb/lbt/files/2014/09/Cloning-vectors.pdf>
5. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6393796/>
6. [http://www.bio.brandeis.edu/classes/heredity/Lecture%20Powerpoints/Chapter\\_13\\_1.pdf](http://www.bio.brandeis.edu/classes/heredity/Lecture%20Powerpoints/Chapter_13_1.pdf)
7. <https://www.cheric.org/files/education/cyberlecture/e200402/e200402-301.pdf>
8. <https://www.onlinebiologynotes.com/gene-cloning-steps-involved-gene-cloning/>
9. <https://uenf.br/cbb/lbt/files/2014/09/Cloning-vectors.pdf>
10. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6393796/>

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**SEMESTER – IV****1. BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS**

| Course Code          | DCEC-4                                                                                                                                           | Course Type | Core | L<br>4 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Knowledge of basic ethics of genetically modified organisms, intellectual property frameworks to protect and commercialize biological inventions |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the principles of biosafety, bioethics, risk assessment, and containment levels in biological research.
- ✓ Address challenges and ecological/ethical dilemmas associated with genetically modified organisms (GMOs) and synthetic biology.
- ✓ Become a creative problem solver in navigating intellectual property frameworks to protect and commercialize biological inventions.
- ✓ Understand international treaties, the criteria for patentability, and the prevention of biopiracy.
- ✓ Patenting of biological inventions and biopiracy.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                     | COURSE OUTCOMES                                                                                              | KNOWLEDGE LEVEL |
|-------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                     | Explore the foundational concepts of biosafety, bioethics, and microbial risk groups.                        | K1, K2, K5      |
| CO2                                                                                                                     | Learn about national and international biosafety guidelines and institutional regulatory committees.         | K1, K2, K5      |
| CO3                                                                                                                     | Characterize the environmental, health, and ethical impacts of transgenic organisms.                         | K1, K2, K3      |
| CO4                                                                                                                     | Explore the fundamentals of Intellectual Property Rights (IPR), patents, copyrights, and trademarks.         | K3, K4          |
| CO5                                                                                                                     | Understand the importance of patenting biological materials, the Budapest Treaty, and traditional knowledge. | K1, K2, K3, K4  |
| CO6                                                                                                                     | Demonstrate the ability to search patent databases and understand technology transfer and commercialization. | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7 - Evaluation</b> |                                                                                                              |                 |

Unit-I:  
**Biosafety and Bioethics**  
(12 hours)

Definition and philosophy of biosafety and bioethics. Historical background and ethical milestones in life sciences. Primary and secondary containment for biohazards. Biosafety Levels-BSL-1, 2, 3, 4. Risk Assessment: criteria for classifying infectious agents into risk groups. Design, types, and operation of Biological Safety Cabinets. Principles of Good Laboratory Practices.

|                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-II:<br><b>Regulatory Frameworks for Biosafety</b><br>(12 hours)          | National and international regulatory guidelines. Role and constitution of institutional and national committees in India: Institutional Biosafety Committee, Review Committee on Genetic Manipulation, and Genetic Engineering Appraisal Committee. The Cartagena Protocol on Biosafety. Safe handling, transport, and disposal protocols for biohazardous and recombinant waste.                                                      |
| Unit-III:<br><b>Biosafety of Genetically Modified Organisms</b><br>(12 hours) | Ecological and health concerns regarding GMOs-transgenic plants, animals, and microbes. Evaluation of horizontal gene transfer, potential allergenicity, and ecological imbalance. Environmental release of GMOs. Bioethics of animal testing, cloning, stem cell research, and synthetic biology. Public perception, media representation, and controversies - Bt Cotton, Golden Rice.                                                 |
| Unit-IV:<br><b>Intellectual Property Rights</b><br>(12 hours)                 | Concept, scope, and types of IPR: Patents, Trademarks, Copyrights, Geographical Indications, Trade Secrets, and Industrial Designs. Evolution of patent laws. Role of the World Intellectual Property Organization. The General Agreement on Tariffs and Trade and the Trade-Related Aspects of Intellectual Property Rights agreement.                                                                                                 |
| Unit-V:<br><b>Patenting in Life Sciences</b><br>(12 hours)                    | Criteria for patentability: novelty, non-obviousness, and industrial application/utility. Patenting of biological inventions: isolated genes, genetically modified organisms, and microbial strains. The Budapest Treaty for the deposit of microorganisms. Protection of Plant Varieties and Farmers' Rights Act. Traditional knowledge and biopiracy - Neem, Turmeric, Basmati rice. Basics of patent drafting and filing procedures. |
| Unit-VI: <b>Current Contours</b> (For Continuous Internal Assessment only):   | Daily news on patent litigations in the pharmaceutical and biotech industries, and recent biosafety protocol updates. Public awareness of biopiracy and ethical scientific conduct. Computational analysis using public patent databases. Drafting a mock patent abstract for a hypothetical biological invention.                                                                                                                      |

#### Mapping with Specific Programme Outcomes

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
|            |      |      |      |      |      |      |      |      |      |       | 1     | 2     |
| <b>C01</b> | S    | S    | S    | S    | S    | M    | S    | S    | S    | S     | L     | S     |
| <b>C02</b> | S    | S    | S    | S    | S    | M    | S    | S    | S    | S     | L     | S     |
| <b>C03</b> | S    | S    | S    | S    | S    | M    | S    | S    | S    | S     | L     | S     |
| <b>C04</b> | S    | S    | S    | S    | S    | M    | S    | S    | S    | S     | L     | S     |
| <b>C05</b> | S    | S    | S    | S    | S    | M    | S    | S    | S    | S     | L     | S     |
| <b>C06</b> | S    | S    | S    | S    | S    | M    | S    | S    | S    | S     | L     | S     |

### **Recommended References:**

1. Goel, D., and Prashar, S. (2013). *IPR, Biosafety and Bioethics*. Pearson Education, India.
2. Fleming, D. O., and Hunt, D. L. (2006). *Biological Safety: Principles and Practices*, 4th Edition. ASM Press, USA.
3. Singh, K. K. (2015). *Biotechnology and Intellectual Property Rights: Legal and Social Implications*. Springer. USA.
4. Sibley, K. (Ed.). (2001). *The Law and Strategy of Biotechnology Patents*. Butterworth-Heinemann. USA.
5. Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy*. Tata McGraw-Hill, USA.

### **Related Online Contents:**

1. <https://www.wipo.int/>
2. <https://ipindia.gov.in/>
3. <https://geacindia.gov.in/>

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**SEMESTER – IV****2. CLINICAL RESEARCH AND CLINICAL TRIALS**

| Course Code          | DCEC-4                                                                                     | Course Type | Core | L<br>4 | T<br>- | P<br>- | C<br>4 | Syllabus version | 2026-2027 |
|----------------------|--------------------------------------------------------------------------------------------|-------------|------|--------|--------|--------|--------|------------------|-----------|
| <b>Pre-requisite</b> | Knowledge of basic pharmacology, human anatomy and physiology, and fundamental statistics. |             |      |        |        |        |        |                  |           |

**Course Objectives:**

- ✓ Understand the fundamental concepts of drug discovery, pre-clinical testing, and the sequential phases of clinical trials.
- ✓ Address challenges in ensuring patient safety, maintaining data integrity, and strictly adhering to ethical guidelines.
- ✓ Become a creative problem solver in clinical trial protocol designing, subject recruitment, and clinical data management.
- ✓ Understand the importance of Clinical Data Management and Pharmacovigilance.
- ✓ Understand the international and national regulatory frameworks governing clinical research and pharmacovigilance.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                     | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Explore the drug development lifecycle and the objectives of Phase I, II, III, and IV clinical trials.              | K1, K2, K5      |
| CO2                                                                                                                    | Learn about the historical evolution of medical ethics and the function of Ethics Committees.                       | K1, K2          |
| CO3                                                                                                                    | Characterize the essential documents required for clinical trials, including Protocols and Informed Consent Forms.  | K1, K2, K3      |
| CO4                                                                                                                    | Explore the principles of Good Clinical Practice (ICH-GCP) and the roles of various trial stakeholders.             | K1 – K3         |
| CO5                                                                                                                    | Understand the importance of Clinical Data Management (CDM) and Pharmacovigilance (safety reporting).               | K1, K2          |
| CO6                                                                                                                    | Demonstrate the ability to navigate trial registries and conceptualize a mock trial protocol for a new therapeutic. | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                     |                 |

Unit-I:  
**Drug Development and Clinical Trials**  
(12 hours)

The drug discovery and development process. Pre-clinical testing. Definition and scope of clinical research. Detailed overview of Clinical Trial Phases: Phase I - Human Pharmacology, Phase II - Therapeutic Exploratory, Phase III - Therapeutic Confirmatory, and Phase IV - Post-Marketing Surveillance. Key stakeholders: Sponsor, Principal Investigator, Contract Research Organization, Site Management Organization, and Clinical Research Associate.

**Unit-II: Ethics in Clinical Research**  
(12 hours)

Historical perspective and ethical milestones: The Nuremberg Code, The Declaration of Helsinki, and the Belmont Report. Core ethical principles: Respect for persons, Beneficence, and Justice. Composition, roles, and responsibilities of Institutional Review Boards and Independent Ethics Committees. The Informed Consent Process: designing the Informed Consent Form and considerations for vulnerable populations.

**Unit-III: Good Clinical Practice and Regulatory Authorities**  
(12 hours)

Introduction to the International Council for Harmonisation. The 13 core principles of ICH-GCP and their implementation. Overview of global and national regulatory bodies: US-FDA, EMA, and CDSCO. Investigational New Drug and New Drug Application submission processes. Regulatory compliance, site monitoring, and trial auditing.

**Unit-IV: Trial Design and Essential Documents**  
(12 hours)

Epidemiological and clinical study designs: Observational vs. Interventional studies. Randomized Controlled Trials, double-blind, placebo-controlled, crossover, and adaptive trial designs. Preparation of Essential Documents: Clinical Trial Protocol, Investigator's Brochure, and Case Report Forms. Randomization techniques and blinding/masking procedures to eliminate bias.

**Unit-V: Clinical Data Management and Pharmacovigilance**  
(12 hours)

Basics of Clinical Data Management: data entry, data validation, discrepancy management, and database lock. Introduction to Biostatistics in clinical trials. Introduction to Pharmacovigilance: detecting, assessing, and preventing adverse effects. Defining Adverse Events and Serious Adverse Events. Causality assessment and expedited safety reporting timelines to regulatory bodies.

**Unit-VI: Current Contours (For Continuous Internal Assessment only):**

Daily news and case studies on ongoing clinical trials. Public awareness of patient rights and the societal impact of clinical trial participation. Exploring the ClinicalTrials.gov and CTRI databases to extract and analyze study design metadata. Drafting a mock Informed Consent Form for a hypothetical new antibiotic.

**Mapping with Specific Programme Outcomes**

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>CO1</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>CO2</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>CO3</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>CO4</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>CO5</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>CO6</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |

**Recommended References:**

1. Gupta, S. K. (2014). *Basic Principles of Clinical Research and Methodology*. Jaypee Brothers Medical Publishers. India.
2. Friedman, L. M., Furberg, C. D., DeMets, D. L., Reboussin, D. M., & Granger, C. B. (2015). *Fundamentals of Clinical Trials*, 5th Edition. Springer. USA.
3. Chow, S. C., & Liu, J. P. (2013). *Design and Analysis of Clinical Trials: Concepts and Methodologies*, 3rd Edition. Wiley. USA.
4. Hackshaw, A. (2009). *A Concise Guide to Clinical Trials*. Wiley-Blackwell. USA.

**Related Online Contents:**

1. <https://clinicaltrials.gov/>
2. <https://ctri.nic.in/>
3. <https://cdsco.gov.in/>

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**SEMESTER – IV****ENTREPRENEURSHIP IN MICROBIOLOGY**

| Course Code   | EIBC-1                                                                                                     | Course Type | Core | L | T | P | C | Syllabus version | 2026-2027 |
|---------------|------------------------------------------------------------------------------------------------------------|-------------|------|---|---|---|---|------------------|-----------|
| Pre-requisite | Knowledge of entrepreneurial start up programme, cost-benefit analysis and marketing of microbial products |             |      |   |   |   |   |                  |           |

**Course Objectives:**

- ✓ Describe the concepts of entrepreneurship and identify the various schemes of entrepreneurial start up programme.
- ✓ Develop the skills in various aspects to promote the success entrepreneur and interpret with business development, market need, goal setting as well as financial opportunities.
- ✓ Analyse the mass production, cost-benefit analysis and marketing of mushroom and SCP.
- ✓ Understand the quality control, good manufacturing practices, ISO standards.
- ✓ Develop a large-scale unit for the production of various biofertilizers and biopesticides and evaluate the marketing strategies and cost-benefit analysis.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                                                                                           | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Describe the concepts of entrepreneurship and identify the various schemes of entrepreneurial start up programme.                                                                         | K1, K2          |
| CO2                                                                                                                    | Develop the skills in various aspects to promote the success entrepreneur and interpret with business development, market need, goal setting as well as financial opportunities.          | K6              |
| CO3                                                                                                                    | Analyse the mass production, cost-benefit analysis and marketing of mushroom and SCP.                                                                                                     | K4              |
| CO4                                                                                                                    | Develop a large-scale unit for the production of various bacterial and fungal based biofertilizers and evaluate the marketing strategies and cost-benefit analysis of the biofertilizers. | K4 - K6         |
| CO5                                                                                                                    | Manage the large-scale production, cost-benefit analysis, marketing of agar, dairy products and vermicomposting.                                                                          | K6              |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                                                                                           |                 |

|                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-I:<br><b>Concept of Entrepreneur and Entrepreneurship</b><br>(9 hours)            | Definitions-concept of Entrepreneurship, development. Government and non-Govt. schemes for Entrepreneurship programmes. Structure of a biobased technology, start-up of biobased technology company and biobased business development. Global Perspectives: Trends in biobased technologies worldwide.                                                                                                                                    |
| Unit-II: <b>Skills for Entrepreneurs</b><br>(9 hours)                                  | Communication skills, problem solving skills; Business plan development; Networking and Collaboration: Building partnerships. Market need - distribution, price, promotion and market goal setting. Financial plan - Financial support for business, business insurance. Pitching and Presentation Skills - Legal and Ethical Considerations: Bioethics, sustainability.                                                                  |
| Unit-III:<br><b>Bio-industrial Projects</b> (9 hours)                                  | Identification, classification, formulation, appraisal. Small, large-scale production and cost benefit analysis and marketing of edible and medicinal mushroom cultivation-button, Oyster, <i>Ganoderma</i> . Single cell protein - Production of Yeast and <i>Spirulina</i> . Life cycle Assessment: Environmental impacts. Quality Control, Good Manufacturing Practices, ISO standards. Market Research: Consumer preferences, trends. |
| Unit-IV:<br><b>Commercial Production of Biofertilizers and Biopesticides</b> (9 hours) | Mass multiplication, production cost analysis, Biofertilizer Formulations and marketing of Cyanobacterial biofertilizer, Bacterial Biofertilizer- <i>Rhizobium</i> , <i>Azospirillum</i> , Fungal Biofertilizers- VAM, Actinobacterial Biofertilizer - <i>Frankia</i> sp. Seaweed liquid biofertilizer, Biopesticides and Integrated Pest Management- <i>Bacillus thuringiensis</i> , <i>Metarhizium anisoplaea</i> , NPV etc.            |
| Unit-V:<br><b>Commercial Production of Agar, and Food</b><br>(9 hours)                 | Small, large-scale production and cost benefit analysis and marketing of agar - <i>Gelidium</i> and fermented foods - cheese, pickles and other probiotic food. Biological food colorants production. Compost Production - Mass production and marketing of compost - Vermicomposting and microbial compost - types of compost pits - Laboratory and field application; cost-benefit analysis.                                            |
| Unit-VI: <b>Current Contours</b> (For Continuous Internal Assessment only):            | Entrepreneurship options in Biopharma – Drugs, vaccines, diagnostics; Bioindustries – Biofuels, nutraceuticals, enzymes; Bioagri – Hybrid crops; Bioservices – custom synthesis and manufacturing and contract research; Bioinformatics – data analytics and software and database services. Bioentrepreneurs                                                                                                                             |

**Mapping with Specific Programme Outcomes**

|            | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| <b>C01</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>C02</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>C03</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>C04</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>C05</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |
| <b>C06</b> | S    | S    | S    | S    | S    | S    | S    | S    | S    | S     | L     | S     |

**Recommended References:**

1. Nagendra S. (2008). Entrepreneurship and management Sanguine technical publishers. India.
2. Bhatia, B.S. and G.S Batra. (2003). Entrepreneurship and small business management. Deep and deep publications. India.
3. Naidu, N.V.R. (2008). Management and Entrepreneurship. I.K. International Pvt. Ltd. India.
4. Greene. (2000). Entrepreneurship ideas in action. Thomson learning. UK.
5. Tilak, K.V.B.R. (1990). Bacterial Biofertilizers. IARI Publications, New Delhi.
6. Sandera, F.E., B. Mosse and P.B. Tinke. (1975). Endomycorrhizae, Academic Press, London.
7. Rao, N.S. (1980). Biofertilizers in Agriculture. Oxford and IBH Publishing Co. Pvt. Ltd., Bombay.
8. Bunn, G.P. 2019. Good manufacturing practices for pharmaceuticals. CRC Press. USA.

**Related Online Contents:**

1. [https://study.com/microbiology\\_courses.html](https://study.com/microbiology_courses.html)
2. [https://study.com/academy/lesson/what-is-an-entrepreneur-definitioncharacteristics\\_examples.html](https://study.com/academy/lesson/what-is-an-entrepreneur-definitioncharacteristics_examples.html)
3. <https://study.com/academy/lesson/institutional-entrepreneurship-theoryexamples.html>
4. [https://study.com/articles/Fermentation\\_Microbiologist\\_Job\\_Description\\_Salary\\_and\\_Career\\_outlook.html](https://study.com/articles/Fermentation_Microbiologist_Job_Description_Salary_and_Career_outlook.html)

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**SEMESTER – IV****QUALITY ASSURANCE IN FOOD AND PHARMACEUTICAL INDUSTRIES**

| Course Code          | VAC-2                                                                                                                               | Course Type | Core | L | T | P | C | Syllabus version | 2026-2027 |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------|-------------|------|---|---|---|---|------------------|-----------|
|                      |                                                                                                                                     |             |      | - | - | - | 2 |                  |           |
| <b>Pre-requisite</b> | Basic understanding of general sciences and a strong interest in industrial manufacturing, quality control, and regulatory affairs. |             |      |   |   |   |   |                  |           |

**Course Objectives:**

- ✓ Bridge the gap between academic knowledge and industry-required quality assurance skills to enhance employability.
- ✓ Address challenges in drafting, implementing, and maintaining critical industry documentation like SOPs and BMRs.
- ✓ Become a creative problem solver by learning Root Cause Analysis (RCA) and implementing Corrective and Preventive Actions.
- ✓ Understand the practical preparation required to face and clear national and international regulatory audits.

**Expected Course Outcomes:**

**On the completion of the course the student will be able to**

| COs                                                                                                                    | COURSE OUTCOMES                                                                                                | KNOWLEDGE LEVEL |
|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|-----------------|
| CO1                                                                                                                    | Understand the fundamental terminology, scope, and differences between QA, QC, and TQM in industrial settings. | K1, K2          |
| CO2                                                                                                                    | Apply Good Manufacturing Practices and Good Laboratory Practices to routine industrial operations.             | K1, K2          |
| CO3                                                                                                                    | Analyze process hazards to develop and evaluate functional HACCP plans for food safety.                        | K4, K5          |
| CO4                                                                                                                    | Evaluate Out of Specification results and conduct Root Cause Analysis.                                         | K4, K5          |
| CO5                                                                                                                    | Design and draft industry-standard documentation, including Standard Operating Procedures and checklists.      | K5, K6          |
| <b>K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 - Analysis; K5 - Synthesis; K6 - Creation; K7- Evaluation</b> |                                                                                                                |                 |

Unit-I:  
**Quality Frameworks & Industry Standards**

Introduction to the industrial quality ecosystem. Differences between Quality Assurance and Quality Control. Total Quality Management and Six Sigma basics. Overview of major regulatory bodies and their mandates: FSSAI, US-FDA, WHO, EMA, and ISO. The concept of Quality by Design in modern manufacturing.

|                                                                                |                                                                                                                                                                                                                                                                                                                                                   |
|--------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit-II:<br><b>Good Practices and Documentation</b>                            | Core principles of Good Manufacturing Practices and Good Laboratory Practices. Personnel hygiene, cleanroom behaviour, and gowning qualifications. The bedrock of QA: Data Integrity and ALCOA+ principles. Hands-on approach to documentation: How to write and review Standard Operating Procedures, Batch Manufacturing Records, and Logbooks. |
| Unit-III:<br><b>Food Safety and Risk Management</b>                            | Categorization of food hazards. Pre-requisite programs and Sanitation Standard Operating Procedures. Step-by-step development of a Hazard Analysis and Critical Control Points plan. Determining Critical Limits and monitoring procedures. Food recall procedures and supply chain traceability.                                                 |
| Unit-IV:<br><b>Pharma QA and Deviation Management</b>                          | Life cycle of a pharmaceutical product. Raw material sampling, in-process quality control, and finished product release. Handling deviations and non-conformances in the manufacturing line. Out of Specification and Out of Trend investigations. Implementing Corrective and Preventive Actions.                                                |
| Unit-V:<br><b>Audits, Inspections, and Validations</b>                         | Understanding the audit lifecycle: preparation, execution, and closure. Types of audits: First-party, Second-party, and Third-party. Designing an internal audit checklist. Fundamentals of equipment calibration and validation. Environmental monitoring in sterile areas and basics of stability testing for expiry dating.                    |
| Unit-VI:<br><b>Current Contours</b> (For Continuous Internal Assessment only): | Industry guest lectures on navigating FDA warning letters and FSSAI penalties. Public awareness of product recalls. Practical assignments: Students will draft a real-world SOP for a piece of laboratory equipment or conduct a mock internal audit of their college laboratory to identify GMP/GLP gaps.                                        |

#### Mapping with Specific Programme Outcomes

|     | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 | PSO8 | PSO9 | PSO10 | PSO11 | PSO12 |
|-----|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| C01 | S    | S    | S    | S    | M    | M    | S    | S    | S    | S     | L     | S     |
| C02 | S    | S    | S    | S    | M    | M    | S    | S    | S    | S     | L     | S     |
| C03 | S    | S    | S    | S    | M    | M    | S    | S    | S    | S     | L     | S     |
| C04 | S    | S    | S    | S    | M    | M    | S    | S    | S    | S     | L     | S     |
| C05 | S    | S    | S    | S    | M    | M    | S    | S    | S    | S     | L     | S     |
| C06 | S    | S    | S    | S    | M    | M    | S    | S    | S    | S     | L     | S     |

#### Recommended References:

1. Potdar, M. A. (2006). *Pharmaceutical Quality Assurance*. Nirali Prakashan. India.
2. Surak, J. G., & Lorca, T. A. (2014). *Food Safety Management Programs: Applications, Best Practices, and Compliance*. CRC Press. USA.
3. Weinberg, S. (2003). *Good Laboratory Practice Regulations*, 3rd Edition. Marcel Dekker. USA.

4. Alli, I. (2003). *Food Quality Assurance: Principles and Practices*. CRC Press. USA.

**Related Online Contents:**

1. <https://www.iso.org/iso-22000-food-safety-management.html>
2. <https://www.fda.gov/drugs/guidance-compliance-regulatory-information>
3. <https://www.ifsqn.com/>

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