
**THIRUVALLUVAR UNIVERSITY**

**SERKKADU, VELLORE–632115**

# M.SC. MICROBIOLOGY

**SYLLABUS**

**(University Department)**

**FROM THE ACADEMIC YEAR**

**2024 – 2025**

**Preamble**

Post graduate Microbiology is a course focus on microbiology and its applications with different disciplines. Curriculum includes General Microbiology, Immunology, Immunomics and Microbial Genetics, Medical Bacteriology and Parasitology, Medical Mycology, Soil and Environmental Microbiology, Recombinant DNA Technology and Biotechnology, Fermentation Technology and Pharmaceutical Microbiology, Food & Dairy Microbiology, Research Methodology & Biostatistics, Commercial microbial technology, Microbiome and Omics Science.

M.Sc., Microbiology program designed by integrating the knowledge of cutting-edge technologies like omics technologies and recombinant technologies for the heterologous expression allowing the generation of new and improved products and services in microbiology. It is envisaged to produce competitive graduates with a great spectrum of proficiency, interdisciplinary focus at par with international qualification. The detailed syllabus for each paper is constructed to inculcate the graduate with outcome-based education pattern which provide space for Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation (K1 –K6).

**1. General Graduate Attributes**

- **Communication skills**

  The students gain the ability to accurately and effectively communicate information on microbiology using written, visual and oral reporting formats.

- **Research related skills**

  The students thinking ability increases with the ability to apply the principles of scientific experimental design and methods to investigate microbiologically relevant problems. They may gain the ability to analyze critique scientific papers in microbiologically relevant research areas.

- **Team work**

  The postgraduates acquires the ability to work effectively as a member and leader within a team. They are capable to employ the scientific method effectively as part of a collaborative team. And understands the role of network building in career development and has the ability to interact effectively with people from a wide range of backgrounds.

- **Knowledge**

  The students will gains integrated knowledge on various scientific disciplines such as, Microbiology, Immunology & Vaccinology, Pharmaceutical Chemistry, Medical Bacteriology and Parasitology, Medical Mycology and Virology, Molecular Biology and Applied Biotechnology, Bio Nano-technology and Infectomics, Food, Soil and Environmental Microbiology, Research Methodology and Computational biology.

- **Global Perspective**

  The graduates may acquire the current and emerging worldwide microbiological technologies, issues, and perspectives during their course period.

- **Critical thinking**

  The graduates sustains the skill to apply the scientific process, including ability to acquire, assimilate, synthesize, analyze and critique microbiological information.

- **Problem solving**

  The postgraduate students will have the attitude to evaluate and solve the problems with scientific evidences.

- **Analytical reasoning**

  The students were enhanced in logical reasoning, critical data evaluation and formation of evidence-based opinions.

- **Scientific reasoning**

  The students gain demonstrative understanding and evaluation of knowledge as the key to knowledge creation. An intellectual integrity, rigour, reasoning, analysis and interpretation of scientific and technical data.

- **Reflective thinking**

  The student potential in self-discipline, planning, organizational and time management skills and the ability to work independently will be enhanced.

- **Digital literacy**

  The data analysis ability to apply specific skills in acquiring, organizing, analyzing, evaluating and presenting microbiological information, in particular incorporating the increasing importance of digital-based activity.

- **Multicultural competence**

The students acquire an awareness of and appreciation for, the social and cultural context of the implications of microbiology and microbiological knowledge and investigation.

**2. Programme Specific Qualification Attributes**

Programme specific qualification attributes achieved through courses in the programme in terms of

- Knowledge and understanding level (K1 and K2)
- Application level (K3)
- Analytical level (K4)
- Evaluation capability level (K5)
- Scientific or synthesis level (K6)

1. **Vision**

Aspires to be a reference center for microbiology, committed to an academic excellence and to attain the national and international recognition for the quality of its education, research, and service activities in agriculture, medical and public health

2. **Programme Outcomes (Pos)**

**PO1: Problem Solving Skill**

Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context.

**PO2: Decision Making Skill**

Foster analytical and critical thinking abilities for data-based decision-making.

**PO3: Ethical Value**

Ability to incorporate quality, ethical and legal value-based perspectives to all Organizational activities.

**PO4: Communication Skill**

Ability to develop communication, managerial and interpersonal skills.

**PO5: Individual and Team Leadership Skill**

Capability to lead themselves and the team to achieve organizational goals.

**PO6: Employability Skill**

Inculcate contemporary business practices to enhanceemployability skills in the competitive environment.

**PO7: Entrepreneurial Skill**

Equip with skills and competencies to become an entrepreneur.

**PO8: Contribution to Society**

Succeed in career endeavors and contribute significantly to society.

**PO 9 Multicultural competence**

Possess knowledge of the values and beliefs of multiple cultures and a global perspective.

**PO 10: Moral and ethical awareness/reasoning**

Ability to embrace moral/ethical values in conducting one's life.

**Programme Specific Outcomes(PSOs):**

**PSO1 – Placement**

To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.

**PSO 2 - Entrepreneur**

To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.

**PSO3 – Research and Development**

Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development.

**PSO4 – Contribution to Business World**

To produce employable, ethical and innovative professionals to sustain in the dynamic business world.

**PSO 5 – Contribution to the Society**

To contribute to the development of the society by collaborating with stakeholders for mutual benefit.

## Template for P.G., Programmes

| Semester I | Credit | Hours | Semester II | Credit | Hours | Semester III | Credit | Hours | Semester IV | Credit | Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core I | 5 | 7 | Core IV | 5 | 6 | Core VII | 5 | 6 | Core XI | 5 | 6 |
| Core II | 5 | 7 | Core V | 5 | 6 | Core VIII | 5 | 6 | Core XII | 5 | 6 |
| Core III | 4 | 6 | Core VI | 4 | 6 | Core IX | 4 | 6 | Project with viva voce | **7** | 10 |
| Elective I | 3 | 5 | Elective III | 3 | 4 | Core X | 5 | 6 | Elective VI | 3 | 4 |
| Elective II | 3 | 5 | Elective IV | 3 | 4 | Elective V | 3 | 3 | Skill Enhancement course / Professional Competency Skill | 2 | 4 |
| | | | Skill Enhancement | 2 | 4 | Skill Enhancement | 2 | 3 | Extension Activity | 1 | |
| | | | Swayam/ MooC | 2 | | Internship/ Industrial Activity | 2 | - | | | |
| | | | Human Rights | 2 | 2 | | | | | | |
| | **20** | **30** | | **26** | **30** | | **26** | **30** | | **23** | **30** |
| **Total Credit Points -95** | | | | | | | | | | | |

## Credit Distribution for M.Sc., Microbiology

### Semester-I

| Part | Course | Course Title | Credit | Hours |
|---|---|---|---|---|
| | Core I | General Microbiology and Microbial Diversity | 5 | 7 |
| | Core II | Immunology, Immunomics and Microbial Genetics | 5 | 7 |
| | Core III | Practical-I | 4 | 6 |
| | Elective I | Forensic Science/ Health Hygiene/ Biological Techniques (Among the three choices anyone can be chosen by the student) | 3 | 5 |
| | Elective II | Bioinstrumentation / Herbal Technology and Cosmetic Microbiology / Essentials of Laboratory Management and Biosafety (Among the three choices anyone can be chosen by the student) | 3 | 5 |
| | | Total | **20** | **30** |

**Semester-II**

| Part | Course | Course Title | Credit | Hours |
|---|---|---|---|---|
| | Core IV | Medical Bacteriology and Mycology | 5 | 6 |
| | Core V | Medical Virology and Parasitology | 5 | 6 |
| | Core VI | Practical-II | 4 | 6 |
| | Elective III | Epidemiology/ Clinical Diagnostic Microbiology/ Mushroom Technology (Among the three choices anyone can be chosen by the student) | 3 | 4 |
| | Elective IV | Bioinformatics/ Nano biotechnology/ Clinical Research and Clinical Trials (Among the three choices anyone can be chosenby the student) | 3 | 4 |
| | SEC-1 | Commercial microbial technology | 2 | 4 |
| | | Swayam/Mooc | 2 | |
| | | Human Rights | 1 | |
| | | Total | **25** | **30** |

**Second Year**

**Semester-III**

| Part | Course | Course Title | Credit | Hours |
|---|---|---|---|---|
| | Core VII | Soil and Environmental Microbiology | 5 | 6 |
| | Core VIII | Recombinant DNA Technology and Biotechnology | 5 | 6 |
| | Core IX | Practical's III | 4 | 6 |
| | Core X (Industry Module) | Fermentation Technology and Pharmaceutical Microbiology | 5 | 6 |
| | Elective V | Biosafety, Bioethics and IPR/ Toxicology/ Recent Applications of Biosensors (Among the three choices anyone can be chosen by the student) | 3 | 3 |
| | SEC2 | Organic Farming and Bio fertiliser Technology | 2 | 3 |
| | | Internship / Industrial Activity | 2 | - |
| | | | **26** | **30** |

**Semester-IV**

| Part | Course | Course Title | Credit | Hours |
|---|---|---|---|---|
| | Core XI | Food & Dairy Microbiology | 5 | 6 |
| | Core XII | Research Methodology & Biostatistics | 5 | 6 |
| | Project | Project with Viva Voce | 7 | 10 |

| | | | | |
|---|---|---|---|---|
| | Elective VI | Microbiome and Omics Science / Marine Microbiology/ Life Science for Competitive Examinations (Among the three choices anyone can be chosen by the student) | 3 | 4 |
| Skill Enhancement Course | | Microbial Quality Control and Testing | 2 | 4 |
| | | Extension Activity | 1 | - |
| | | | **23** | **30** |

## Curriculum Structure

| Sem | Paper Code | Title of the Paper | Hrs/ Week | Credit | Marks | | |
|---|---|---|---|---|---|---|---|
| | | | | | CIA | EA | Total |
| I | 24TVMBC1C01 | Core- I- General Microbiology and Microbial Diversity | 7 | 5 | 25 | 75 | 100 |
| | 24TVMBC1C02 | Core II- Immunology, Immunomics and Microbial Genetics | 7 | 5 | 25 | 75 | 100 |
| | 24TVMBC1L01 | Core Course III-Practical I | 6 | 4 | 60 | 40 | 100 |
| | 24TVMBC1E01 | Elective Course I- Forensic Science | 5 | 3 | 25 | 75 | 100 |
| | 24TVMBC1E02 | Health Hygiene | | | | | |
| | 24TVMBC1E03 | Biological Techniques | | | | | |
| | 24TVMBC1E04 | Elective Course II- Bioinstrumentation | 5 | 3 | 25 | 75 | 100 |
| | 24TVMBC1E05 | Herbal Technology and Cosmetic Microbiology | | | | | |
| | 24TVMBC1E06 | Essentials of Laboratory Management and Biosafety | | | | | |
| II | 24TVMBC1C03 | Core Course IV- Medical Bacteriology and Mycology | 6 | 5 | 25 | 75 | 100 |
| | 24TVMBC1C04 | Core Course V Medical Virology and Parasitology | 6 | 5 | 25 | 75 | 100 |
| | 24TVMBC1L02 | Core Course VI- Practical II | 6 | 4 | 60 | 40 | 100 |
| | 24TVMBC1E07 | Elective Course III Epidemiology | 4 | 3 | 25 | 75 | 100 |
| | 24TVMBC1E08 | Clinical Diagnostic Microbiology | | | | | |
| | 24TVMBC1E09 | Mushroom Technology | | | | | |
| | 24TVMBC1E10 | Elective Course IV- Bioinformatics | 4 | 3 | 25 | 75 | 100 |
| | 24TVMBC1E11 | Nano biotechnology | | | | | |
| | 24TVMBC1E12 | Clinical Research and Clinical Trials | | | | | |
| | 24TVMBC1N01 | SEC Commercial microbial technology | 4 | 2 | 25 | 75 | 100 |
| | | Swayam/ Mooc | - | 2 | - | - | - |
| | 24TVPGC1C1H01 | Human Rights | - | 1 | 25 | 75 | 100 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| III | 24TVMBC1C05 | Core Course VII- Soil and Environmental Microbiology | 6 | 5 | 25 | 75 | 100 |
| | 24TVMBC1C06 | Core Course VIII- Molecular Biology and Recombinant DNA Technology | 6 | 5 | 25 | 75 | 100 |
| | 24TVMBC1L03 | Core Course IX- Practical's | 6 | 4 | 60 | 40 | 100 |
| | 24TVMBC1C07 | Core Course X- Fermentation technology and Pharmaceutical Microbiology (Industry Module). | 6 | 5 | 25 | 75 | 100 |
| | 24TVMBC1E13 | Elective Course V Biosafety, Bioethics and IPR | 3 | 3 | 25 | 75 | 100 |
| | 24TVMBC1E14 | Toxicology | | | | | |
| | 24TVMBC1E15 | Recent Applications of Biosensors | | | | | |
| | 24TVMBC1N02 | SEC- Organic Farming and Bio fertilizer Technology | 3 | 2 | 25 | 75 | 100 |
| | 24TVMBC1I01 | Internship / Industrial Activity | - | 2 | 40 | 60 | 100 |
| IV | 24TVMBC1C08 | Core Course XI- Food and Dairy Microbiology | 6 | 5 | 25 | 75 | 100 |
| | 24TVMBC1C09 | Core Course XII- Research Methodology and Biostatistics | 6 | 5 | 25 | 75 | 100 |
| | 24TVMBC1P01 | Project with Viva voce | 10 | 7 | 40 | 60 | 100 |
| | 24TVMBC1E16 | Elective Course VI- Microbiome and Omics Science | 4 | 3 | 25 | 75 | 100 |
| | 24TVMBC1E17 | Marine Microbiology | | | | | |
| | 24TVMBC1E18 | Life Science for Competitive Examinations | | | | | |
| | 24TV | Skill Enhancement Course III- Microbial Quality Control and Testing | 4 | 2 | 25 | 75 | 100 |
| | | Extension Activity | 1 | 2 | 25 | 75 | 100 |
| | | Total | | **95** | **775** | **1725** | **2500** |

## SEMESTER-I

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | (I A | External | Total |
| 24UPMBC1C01 | General Microbiology and Microbial Diversity | Core Course I | Y | Y | - | - | 5 | 7 | 25 | 75 | 100 |

| Course Objectives | |
|---|---|
| CO1 | Acquire knowledge on the principles of different types of microscopes and their applications. |
| CO2 | Compare and contrast the structure of bacteria and fungi. Illustrate nutritional requirements and growth in bacteria. |
| CO3 | Exemplify, isolate and cultivate microalgae from diverse environmental sources. |
| CO4 | Explain various pure culture techniques and discuss sterilization methods. |
| CO5 | Discuss the importance and conservation of microbial diversity. |

| UNIT | Details | Hours | Course Objectives |
|---|---|---|---|
| I | History and Scope of Microbiology. Microscopy – Principles and applications. Types of Microscopes - Bright field, Dark-field, Phase-contrast, Fluorescence microscope, Transmission electron microscope (TEM), and Scanning electron microscope (SEM). Sample preparation for SEM & TEM. Atomic force, Confocal microscope. Micrometry – Stage, Ocular and its applications. | 20 | CO1 |
| II | Bacterial Structure, properties and biosynthesis of cellular components – Cell wall. Actinomycetes and Fungi - Distribution, morphology, classification, reproduction and economic importance. Sporulation. Growth and nutrition - Nutritional requirements, Growth curve, Kinetics of growth, Batch culture, Synchronous growth, Measurement of growth and factors affecting growth. | 20 | CO2 |
| III | Algae - Distribution, morphology, classification, reproduction and economic importance. Isolation of algae from soil and water. Media and methods used for culturing algae, Strain selection and large-scale cultivation. Life cycle - *Chlamydomonas*, *Volvox Spirogyra* (Green algae), *Nostoc* (Cyanobacteria)*Ectocarpus, Sargassum* (Brown algae), *Polysiphonia*, *Batrachospermum* (Red algae). | 15 | CO3 |
| IV | Microbial techniques - Safety guidelines in Microbiology Laboratories. Sterilization, Disinfection and its validation. Staining methods – Simple, Differential and Special staining. Automated Microbial identification systems - Pure cultures techniques – Cultivation of Anaerobic organisms. Maintenance and preservation of pure cultures. Culture collection centres - National and International. | 15 | CO4 |

| | | | |
|---|---|---|---|
| V | Biodiversity - Introduction to microbial biodiversity – Thermophiles - Classification, Thermophilic Archaebacteria and its applications. Methanogens - Classification, Habitats, applications. Alkaliphiles and Acidophiles - Classification, discovery basin, its cell wall and membrane. Barophiles - Classification and its applications. Halophiles - Classification, discovery basin, cell walls and membranes – purple membrane, compatible solutes, Osmoadaptation / halotolerance - Applications of halophiles. Conservation of Biodiversity. | 20 | CO5 |
| | Total | 90 | |

**Course Outcomes**

| **Course Outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Examine various microbes employing the microscopic techniques learnt. Measure and compare the size of microbes. | PO1, PO4, PO11 |
| CO2 | Differentiate and appreciate the anatomy of various microbes. Plan the growth of microbes for different environmental conditions. | PO1, PO4 |
| CO3 | Identify and cultivate the algae understanding their habitat. Analyze the morphology, classify and propagate depending on its economic importance. | PO7, PO8, PO9 |
| CO4 | Create aseptic conditions by following good laboratory practices. | PO3, PO4,PO7 |
| CO5 | Categorize and cultivate a variety of extremophiles following standard protocols for industrial applications. | PO5, PO7, PO8, PO9 |

**Text Books**


| | |
|---|---|
| 1. | Kanunga R. (2017). Ananthanarayanan and Panicker's Text book of Microbiology. (10th Edition). Universities Press (India ) Pvt. Ltd. |
| 2. | Chan E.C.S., Pelczar M. J. Jr. and Krieg N. R. (2010). Microbiology. (5th Edition). Mc.Graw Hill. Inc, New York. |
| 3. | Prescott L. M., Harley J. P. and Klein D. A. (2004). Microbiology. (6th Edition). McGraw - Hill company, New York. |
| 4. | White D. Drummond J. and Fuqua C. (2011). The Physiology and Biochemistry of Prokaryotes, Oxford University Press, Oxford, New York. |
| 5. | Dubey R.C. and Maheshwari D. K. (2009). Textbook of Microbiology. S. Chand, Limited. |


**REFERENCES BOOKS**


| | |
|---|---|
| 1. | Tortora G. J., Funke B. R. and Case C. L. (2015). Microbiology: An Introduction (12th Edition).Pearson, London, United Kingdom |
| 2. | Webster J. and Weber R.W.S. (2007). Introduction to Fungi. (3rd Edition). Cambridge University Press, Cambridge. |
| 3. | Schaechter M. and Leaderberg J. (2004). The Desk encyclopedia of Microbiology. Elseiver Academic Press, California. |
| 4. | Ingraham, J.L. and Ingraham, C.A. (2000) Introduction to Microbiology. (2nd Edition). Books / Cole Thomson Learning, UK. |
| 5. | Madigan M. T., Bender K.S., Buckley D. H. Sattley W. M. and Stahl (2018) Brock Biology of Microorganisms. (15th Edition). Pearson. |

| Web Resources | |
|---|---|
| 1. | http://sciencenetlinks.com/tools/microbeworld |
| 2. | https://www.microbes.info/ |
| 3. | https://www.asmscience.org/VisualLibrary |
| 4. | https://open.umn.edu/opentextbooks/BookDetail.aspx?bookId=404 |
| 5. | https://www.grsmu.by/files/file/university/cafedry//files/essential_microbiology.pdf |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (K1) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyze (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| EvaluateK5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | | | M | | | | | | | S | | | |
| CO2 | L | | | S | | | | | | | | | | |
| CO3 | | | | | | | S | S | M | | | | | |
| CO4 | | | S | S | | | S | | | | | | | |
| CO5 | | | | | S | | S | S | S | | | | | |

| **Subject Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **S** | **Credits** | **Inst. Hours** | **Marks** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **CIA** | **External** | **Total** |
| **23UPMBC1C02** | **Immunology, Immunomics and Microbial Genetics** | **Core Course II** | **Y** | **Y** | **-** | **-** | **5** | **7** | **25** | **75** | **100** |

| **Course Objectives** | |
|---|---|
| CO1 | Discuss immunity, organs and cells involved in immunity. Compare the types of antigens and their properties. |
| CO2 | Describe immunoglobulin and its types. Categorize MHC and understand its significance. |
| CO3 | Elucidate the mechanisms of different hypersensitivity reactions. List out the Vaccines and discuss their development. |
| CO4 | Acquire knowledge the structure DNA in prokaryotes and eukaryotes |
| CO5 | Explain out gene transfer studies in microbes. |

| **UNIT** | **Details** | **No. of Hours** | **Course Objectives** |
|---|---|---|---|
| I | Introduction to biology of the immune system – Cells and organs of Immune System. T and B lymphocytes – Origin, development, differentiation, lymphocyte subpopulation in humans. Innate immunity- Complement, Toll-like receptors and other components. Acquired immunity – Active and Passive immunity. Antigens - features associated with antigenicity and immunogenicity. Basis of antigen specificity. MHC genes and products, Structure of MHC molecules, Genetics of HLA Systems – Antigens and HLA typing. Antigen processing and presentation to T- lymphocytes. | 20 | CO1 |
| II | Immunoglobulins. Theories of antibody production. Class switching and generation of antibody diversity. Monoclonal and polyclonal antibodies. Complement system – mode of activation- Classical, Alternate and Lectin pathways, biological functions. Antigen recognition – TCR, Diversity of TCR, T cell surface alloantigens, lymphocyte activation, clonal proliferation and differentiation. Physiology of acquired immune response – various phases of HI, CMI – Cell mediated cytotoxicity, DTH response. | 20 | CO2 |

| | | | |
|---|---|---|---|
| III | Hypersensitivity – Types and mechanisms, Autoimmunity, Tumor Immunity and Transplantation immunology. Immunodeficiency- Primary immunodeficiency and Secondary immunodeficiencies. Genetics of Immunohematology – Genetic basis and significance of ABO and other minor blood groups in humans, Bombay blood group, Secretors and Non-secretors, Rh System and genetic basis of D- antigens.<br>Diagnostic Immunology - Precipitation reaction, Immunodiffusion methods - SRID, ODD. Immunoelectrophoresis - Rocket and Counter current electrophoresis. Agglutination - Hemagglutination - Hemagglutination inhibition. Labeled Assay- Immunofluorescence assay, Radio immunoassay, FISH, ELISA. Flow cytometry. Immune regulation mechanisms – immuno-induction, immuno- suppression, immuno-tolerance, immuno-potentiation, Immunomodulation. Role of cytokines, lymphokines and chemokines. Introduction to Vaccines and Adjuvants - Types of vaccines. Development of vaccines and antibodies in plants.<br>Immunomics - Introduction and Applications. Antigen engineering for better immunogenicity and use for vaccine development- multiepitope vaccines. Reverse vaccinology. | 25 | CO3 |
| IV | Structural of prokaryotic and eukaryotic genome. Introduction to prokaryotic genomic structure, Eukaryotic Genome - Structure of chromatin, chromosome, centromere, telomere, nucleosome. Modifications- methylation, acetylation, phosphorylation and its effect on structure and function of chromatin, DNA methylation and gene imprinting, organelle genome. | 13 | CO4 |
| V | Gene Transfer Mechanisms- Conjugation and its uses. Transduction, Generalized and Specialized, Transformation– Natural Competence and Transformation. Transposition and Types of Transposition reactions. Insertion sequences, complex and compound transposons – T10, T5, and Retroposon. Mechanism – Transposons of *E. coli*, Bacteriophage and Yeast. Importance of transposable elements in horizontal transfer of genes and evolution. | 12 | CO5 |
| | Total | 60 | |

**Course Outcomes**

| **Course Outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Categorize the immune response to a variety of antigens. Identify different immune cells involved in immunity. | PO1, PO4, PO6, PO7, PO9 |
| CO2 | Justify the significance of MHC molecules in immune response and antibody production. | PO1, PO4, PO5,PO6, PO9 |
| CO3 | Design antibodies and evaluate immunological assays in | PO4, PO6, PO7, |

| | | |
|---|---|---|
| | patient samples. | PO8, PO9, PO10 |
| CO4 | Analyze genomic DNA of prokaryotes and eukaryotes. | PO4,PO5, PO6, PO7, PO9, PO10 |
| CO5 | Summarize gene transfer mechanisms for experimental study. | PO4,PO5, PO6, PO7, PO9, PO10 |

| **Text Books** | |
|---|---|
| 1. | Coico R., Sunshine G. and Benjamini E. (2003). Immunology – A Short Course. (5th Edition). Wiley-Blackwell, New York. |
| 2. | Owen J. A., Punt J., Stranford S. A. and Kuby J. (2013). Immunology, (7th Edition). W. H. Freeman and Company, New York. |
| 3. | Abbas A. K., Lichtman A. H. and Pillai S. (2021). Cellular and Molecular Immunology. (10thEdition).Elsevier. |
| 4. | Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi. |
| 5. | Gardner E. J. Simmons M. J. and Snusted D.P. (2006). Principles of Genetics. (8th Edition). Wiley India Pvt. Ltd. |
| **References Books** | |
| 1. | Travers J. (1997). Immunobiology - The Immune System in Health and Disease. (3rd Edition). Current Biology Ltd. New York. |
| 2. | Delves P.J., Martin S., Burton D. R. and Roitt I. M. (2006). Roitt's Essential Immunology. (11th Edition). Wiley-Blackwell. |
| 3. | Hay F. C. and Westwood O. M. R. ( 2002). Practical Immunology (4thEdition). Wiley-Blackwell. |
| 4. | Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press. |
| 5. | Russell P.J. (2010). Genetics - A Molecular Approach. (3rd Edition). Pearson New International Edition. |
| **Web Resources** | |
| 1. | https://www.ncbi.nlm.nih.gov/books/NBK279395/ |
| 2. | https://med.stanford.edu/immunol/phd-program/ebook.html |
| 3. | https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/ |
| 4. | [PDF] Lehninger Principles of Biochemistry (8th Edition) By David L. Nelson and Michael M. Cox Book Free Download - StudyMaterialz.in |

| **Methods of Evaluation** | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |
| **Methods of Assessment** | | |
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions | |

| | |
|---|---|
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyze (K4) | Problem-solving questions, finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | | | M | | M | S | | S | | | | | |
| CO2 | S | | | S | M | S | | | S | | | | | |
| CO3 | | | | S | | S | S | S | S | M | | | | |
| CO4 | | | | S | M | S | M | | S | M | | | | |
| CO5 | | | | S | M | S | M | | S | S | | | | |

| **Subject Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **S** | **Credits** | **Inst. Hours** | **Marks** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **CIA** | **External** | **Total** |
| **23UPMBC1L01** | **Practical I** | **Core Course III-Practical I** | **-** | **-** | **Y** | **-** | **4** | **6** | **60** | **40** | **100** |

**Course Objectives**

| | |
|---|---|
| CO1 | Gain knowledge on the fundamentals, handling and applications of microscopy, sterilization methods. Identify microbesby different staining methods. |
| CO2 | Prepare media for bacterial growth. Discuss plating and growth measurement techniques. |
| CO3 | Acquire adequate skills to perform blood grouping and serological reactions. |
| CO4 | Provide fundamental skills in preparation, separation and purification of immunoglobulin. |
| CO5 | Apply the knowledge of molecular biology skills in clinical diagnosis. |

| **UNIT** | **Details** | **No.of Hours** | **Course Objectives** |
|---|---|---|---|
| I | Microscopic Techniques: Light microscopy: Hay infusion broth. Wet mount to show different types of microbes, hanging drop.<br>Dark field microscopy – Motility of Spirochetes.<br>Washing and cleaning of glass wares: Sterilization methods: moist heat, dry heat, and filtration. | 20 | CO1 |

| | | | |
|---|---|---|---|
| | Quality control check for each method.<br>Staining techniques - Simple staining, Gram's staining, Acid fast staining, Meta chromatic granule staining, Spore, Capsule, Flagella. | | |
| II | Media Preparation: Preparation of liquid, solid and semisolid media. Agar deeps, slants, plates. Preparation of basal, enriched, selective and enrichment media.<br>Preparation of Biochemical test media, media to demonstrate enzymatic activities.<br>Microbial Physiology: Purification and maintenance of microbes. Streak plate, pour plate, and slide culture technique. Aseptic transfer.<br>Direct counts – Total cell count, Turbidometry. Viable count - pour plate, spread plate. Bacterial growth curve. Effect of physical and chemical factors on growth.<br>Anaerobic culture methods. | 20 | CO2 |
| III | Hematological reactions - Blood Grouping – forward and reverse, Rh Typing<br>Identification of various immune cells by morphology – Leishman staining, Giemsa staining.<br>Agglutination Reactions- Latex Agglutination reactions- RF, ASO, CRP.<br>Detection of HBs Ag by ELISA.<br>Precipitation reactions in gels– Ouchterlony double immunodiffusion (ODD) and Mancini's single radial immunodiffusion (SRID)<br>Immuno-electrophoresis and staining of precipitin lines- Rocket immune-electrophoresis and counter current immuno electrophoresis. | 20 | CO3 |
| IV | Preparation of lymphocytes from peripheral blood by density gradient centrifugation.<br>Purification of immunoglobulin– Ammonium Sulphate Precipitation.<br>Separation of IgG by chromatography using DEAE cellulose or Sephadex. | 10 | CO4 |
| V | Western Blotting – Demonstration.<br>Isolation of genomic DNA from *E. coli* and analysis by agarose gel electrophoresis<br>Estimation of DNA using colorimeter (Diphenylamine reagent)<br>Separation of proteins by polyacrylamide gel electrophoresis (SDS-PAGE)<br>UV induced mutation and isolation of mutants by replica plating technique.<br>Plasmid DNA isolation from *E.coli*. | 20 | CO5 |

| | | | |
|---|---|---|---|
| | RNA isolation from yeast.<br>RNA estimation by Orcinol method. | | |
| | Total | 60 | |

**Course Outcomes**

| Course Outcomes | On completion of this course, students will; | |
|---|---|---|
| CO1 | Apply microscopic techniques and staining methods in the identification and differentiation of microbes. | PO1, PO6, PO7, PO8, PO9, PO11 |
| CO2 | Apply the knowledge on the sterilization of glass wares and media by different methods and measurement of cell growth. | PO1, PO6, PO7, PO8, PO9, PO11 |
| CO3 | Perform and evaluate immunological reactions to aid diagnosis. | PO5, PO7, PO8, PO9, PO11 |
| CO4 | Assess the level of lymphocytes in a blood sample and purify immunoglobulin employing appropriate techniques. | PO6, PO7, PO8, PO9, PO11 |
| CO5 | Perform DNA extraction and gene transfer mechanisms, analyze and identify by gel electrophoresis | PO6, PO7, PO8, PO9, PO11 |

**Text Books**


| | |
|---|---|
| 1. | Dubey R.C. and Maheshwari D. K. (2010).Practical Microbiology. S. Chand. |
| 2. | Cappuccimo, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6th Edition). Pearson Education, Publication, New Delhi. |
| 3. | Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2nd Edition). - Taylor &Francis. |
| 4. | Rich R. R., Fleisher T. A., Shearer W. T., Schroeder H, Frew A. J. and Weyand C. M. (2018). Clinical Immunology: Principles and Practice. (5th Edition). Elsevier. |
| 5. | Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press. |


**References Books**


| | |
|---|---|
| 1. | Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie& McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi. |
| 2. | Gupta P. S. (2003). Clinical Immunology. Oxford University Press. |
| 3. | Brown T.A. (2016). Gene Cloning and DNA Analysis. (7th Edition). John Wiley and Jones, Ltd. |
| 4. | Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rdEdition). John Wileys and Sons Ltd. 2012. |
| 5. | Maloy S. R., Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2nd Edition). Narosa Publishing Home Pvt Ltd. |


**Web Resources**

| | |
|---|---|
| 1. | http://textbookofbacteriology.net/ |

| | |
|---|---|
| 2. | https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/ |
| 3. | https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/ |
| 4. | [PDF] Lehninger Principles of Biochemistry (8th Edition) By David L. Nelson and Michael M. Cox Book Free Download - StudyMaterialz.in |
| 5. | https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/ |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | |
| | Attendance and Class Participation | 40 Marks |
| External Evaluation | End Semester Examination | 60 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples,Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | | | | | S | M | M | S | | M | | | |
| CO2 | M | | | | | S | M | M | S | | M | | | |
| CO3 | | | | | S | | S | M | S | | M | | | |
| CO4 | | | | | | S | S | M | S | | S | | | |
| CO5 | | | | | | S | S | M | S | | S | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1E01** | **Forensic Science** | **Elective CourseI (Choice -1)** | **3** | **1** | **-** | **-** | **3** | **5** | **25** | **75** | **100** |

**Course Objectives**

| | |
|---|---|
| CO1 | Understand the Scope, need and learn the tools and techniques inforensic science. |
| CO2 | Comprehend organizational setup of a forensic science laboratory. |
| CO3 | Identify and Examine body fluids for identification. |

| | | | |
|---|---|---|---|
| CO4 | Extract DNA from blood samples for investigation. | | |
| CO5 | Recognizemedico legal post mortem procedures and their importance. | | |
| **UNIT** | **Details** | **No.of Hours** | **Course Objectives** |
| I | Forensic Science - Definition, history and development of forensic science. Scope and need of forensic science in present scenario. Branches of forensic science. Tools and techniques of forensic science. Duties of a forensic scientist. | 12 | CO1 |
| II | Forensic science laboratories - Organizational setup of a forensic science laboratory. Central and State level laboratories in India. Mobile forensic science laboratory and its functions. Forensic microbiology - Types and identification of microbial organisms of forensic significance. | 12 | CO2 |
| III | Forensic serology - Definition, identification and examination of body fluids - Blood, semen, saliva, sweat and urine. Forensic examination and identification of hair and fibre. | 12 | CO3 |
| IV | DNA profiling - Introduction, history of DNA typing. Extraction of DNA from blood samples -Organic and Inorganic extraction methods. DNA fingerprinting - RFLP, PCR, STR. DNA testing in disputed paternity. | 12 | CO4 |
| V | Forensic toxicology - Introduction and concept of forensic toxicology. Medico legal post mortem and their examination. Poisons - Types of poisons and their mode of action. | 12 | CO5 |
| | Total | 60 | |

| **Course Outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Identify the scope and need of forensic science in the present scenario. | PO1, PO6, PO7, PO8, PO9 |
| CO2 | Plan for the organizational setup and functioning of forensic science laboratories. | PO1, PO6, PO7, PO8, PO9 |
| CO3 | Analyze the biological samples found at the crime scene. | PO1, PO5, PO7, PO8, PO9 |
| CO4 | Perform extraction and identification of DNA obtained from body fluids. | PO1, PO6, PO7, PO8, PO9 |
| CO5 | Discuss the concept of forensic toxicology. | PO1, PO6, PO7, PO8, PO9 |

**Text Books**


| | |
|---|---|
| 1. | Nanda B.B. and Tewari R.K. (2001) Forensic Science in India: A Vision for the Twenty First Century. Select Publishers, New Delhi. ISBN- 10:8190113526 / ISBN-13:9788190113526. |
| 2. | James S.H. and Nordby,J.J. (2015) Forensic Science: An Introduction to Scientific and Investigative Techniques. (5$^{th}$Edition). CRC Press. ISBN-10:9781439853832 / ISBN-13:978-1439853832. |

| | |
|---|---|
| 3. | Li R. (2015) Forensic Biology. (2nd Edition). CRC Press, New York. ISBN-13:978-1-4398-8972-5. |
| 4. | Sharma B.R (2020) Forensic science in criminal investigation and trials. (6thEdition)Universal Press. |
| 5. | Richard Saferstein (2017). Criminalistics- An introduction to Forensic Science. (12th Edition).Pearson Press. |
| **Reference books** | |
| 1. | Nordby J. J. (2000). Dead Reckoning. The Art of Forensic Detection- CRC Press, New York. ISBN:0-8493-8122-3. |
| 2. | Saferstein R. and Hall A.B.(2020). Forensic Science Hand book, Vol.I, (3rd Edition). CRC Press, New York. ISBN-10:1498720196. |
| 3. | Lincoln, P.J. and Thomson, J. (1998). (2ndEdition). Forensic DNA Profiling Protocols. Vol. 98. Humana Press. ISBN:978-0-89603-443-3. |
| 4. | Val McDermid (2014). Forensics. (2nd Edition). ISBN 9780802125156. |
| 5. | Vincent J. DiMaio., Dominick DiMaio. (2001). Forensic Pathology (2nd Edition). CRC Press. |
| **Web resources** | |
| 1. | http://clsjournal.ascls.org/content/25/2/114 |
| 2. | https://www.ncbi.nlm.nih.gov/books/NBK234877/ |
| 3. | https://www.elsevier.com/books/microbial-forensics/budowle/978-0-12-382006-8 |
| 4. | https://www.researchgate.net/publication/289542469_Methods_in_microbial_forensics |
| 5. | https://cisac.fsi.stanford.edu/events/microbial forensics |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| **Methods of Assessment** | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |

| | |
|---|---|
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, short summary or overview |
| Application (K3) | Suggest idea/concept with examples, suggest formulae, solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | L | | | | | S | M | M | S | | | | | |
| CO2 | M | | | | | S | M | M | S | | | | | |
| CO3 | L | | | | S | | S | M | S | | | | | |
| CO4 | M | | | | | S | S | M | S | | | | | |
| CO5 | M | | | | | S | S | M | S | | | | | |

| **Subject Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **S** | **Credits** | **Inst. Hours** | **Marks** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **CIA** | **External** | **Total** |
| **23UPMBC1E02** | **Health and Hygiene** | **Elective CourseI (Choice- 2)** | **Y** | **Y** | **-** | **-** | **3** | **5** | **25** | **75** | **100** |

**Course Objectives**

| | |
|---|---|
| CO1 | Acquire knowledge on hygiene and live healthy. |
| CO2 | Provide insights on health laws for food safety and hygiene. |
| CO3 | Explainhealth, physical exercises and their importance. |
| CO4 | Illustrate mental hygiene and involved in mental hygiene. |
| CO5 | Describe the various health and health educationprogrammes by the government. |

| **UNIT** | **Details** | **No.of Hours** | **Course Objectives** |
|---|---|---|---|
| I | Introduction to hygiene and healthful live. Factors affecting health, health habits and practices. Recognizing positive & negative practices in the community. Scientific principles related to health. | 12 | CO1 |
| II | Nutrition and Health – Balanced diet, Food surveillance, food Fortification, adulteration and preventive measures. Health laws for food safety. Environmental and housing hygiene. Ventilation and lighting. | 12 | CO2 |

| | | | |
|---|---|---|---|
| III | Physical health, physical exercises and their importance – Walking, jogging, yoga and meditation, stress relief. International control of health, WHO. Personal hygiene, Sun bathing, Colon Hygiene. Health destroying habits and addictions - Pan, supari, ganja, drinking, smoking, tea and coffee. | 12 | CO3 |
| IV | Mental hygiene- factors responsible, developmental tasks, basic needs, emotional stability. Mental hygiene and health in infancy, early childhood, adolescence, adulthood and old age. Mental health occupational hazards. | 12 | CO4 |
| V | Health programme and health education – Malaria control, Tuberculosis control, AIDS control programmes and Immunization Programmes. Family planning, Reproductive and Child health programmes (RCH). | 12 | CO5 |
| | Total | 60 | |

**Course Outcomes**

| **Course Outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Identify factors affecting health and health habits. | PO1, PO5, PO10 |
| CO2 | Execute the knowledge of ventilation and lighting. Justify Health laws for food safety and hygiene. | PO5, PO10 |
| CO3 | Follow personal hygiene to avoid diseases and Prevent people from health-destroying habits and addictions. | PO5, PO10 |
| CO4 | Explore Mental hygiene and maintain emotional stability. | PO5, PO10 |
| CO5 | Participate in health education programmes | PO1, PO5, PO10 |

**Text Books**


1. Bamji M. S., Krishnaswamy K. and BrahmamG. N. V. (2019). Textbook of Human Nutrition. (4th Edition). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi
2. Swaminathan (1995)Food& Nutrition (Vol I) (2nd Edition). The Bangalore Printing &Publishing Co Ltd., Bangalore.
3. Paniker J. C. K. and Ananthanarayan R. (2017). Textbook of Microbiology. (10th Edition). Universities Press (India ) Pvt. Ltd
4. Lindsay Dingwall.(2010). **Personal Hygiene Care**
Print ISBN:9781405163071 |Online ISBN:9781444318708 |DOI:10.1002/9781444318708
5. Walter C. C. Pakes(1900). The Science of Hygiene: a Text-book of Laboratory Practice. (London: Methuen and Co.,).


**References Books**


1. Khader V. (2000) Food, Nutrition and Health, Kalyan Publishers, New Delhi.

| | |
|---|---|
| 2. | Srilakshmi, B. (2010)Food Science, (5th Edition) New Age International Ltd., New Delhi. |
| 3. | Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand. |
| 4. | Park K. 2007, Park's text book of Preventive and Social Medicine, Banarsidas Bhanot publishers, India. |
| 5. | Srilakshmi, 2002, Dietetics, New Age Publications, India |

**Web Resources**

| | |
|---|---|
| 1. | Health and Hygiene - Personal Hygiene, Community Hygiene and Diseases (vedantu.com) |
| 2. | Chapter-32.pdf (nios.ac.in) |
| 3. | Menstrual Health and Hygiene Guide \| Student Health and Counseling Services (ucdavis.edu) |
| 4. | https://nap.nationalacademies.org/read/11756/chapter/13 |
| 5. | http://ecoursesonline.iasri.res.in/mod/page/view.php?id=112325 |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | L | | | | S | | | | | M | | | | |
| CO2 | | | | | S | | | | | M | | | | |
| CO3 | | | | | S | | | | | L | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | | | | | S | | | | | M | | | | |
| CO5 | L | | | | S | | | | | M | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| 23UPMBC1E03 | Biological Techniques | Elective CourseI (Choice -3) | Y | Y | - | - | 3 | 5 | 25 | 75 | 100 |

**Course Objectives**

| | |
|---|---|
| CO1 | To learn about different types of Microscope |
| CO2 | To understand various methods of separation techniques available for biomolecule separation and their analysis |
| CO3 | To study about modified electrophoresis techniques |
| CO4 | To learn various methods of analytical methods |
| CO5 | To learn about different types of molecular methods using in the biology |

| UNIT | Details | No.of Hours | Course Objectives |
|---|---|---|---|
| I | Light Microscopy: Microscopic optics, components of microscopes. Basic principles and applications of Bright field, Dark field, Phase contrast, Fluorescence, Polarization, Atomic Force and Confocal microscopes. Electron Microscopy – Principle, Techniques and applications of Transmission Electron microscope (TEM) and Scanning Electron Microscope (SEM). Preparation of specimens for electron microscopy. Types and applications of Microtomes | 12 | CO1 |
| II | Chromatography Principles & Applications: General principles and definitions, Rf value. Methods based on polarity - Partition chromatography, adsorption chromatography, TLC, HPTLC, gas liquid chromatography, and reverse phase liquid chromatography. Methods based on partition - Gel filtration and Affinity chromatography. HPLC, Nano-LC, FPLC and Ion-exchange chromatography. | 12 | CO2 |
| III | Spectroscopic methods – UV-Visible, Atomic Absorption and Atomic Emission Spectroscopy. Centrifugation - Basic principles of sedimentation, types of centrifuges and rotors. Preparative ultracentrifugation - differential and density gradient. Electroanalytical methods – electrolytic – Potentiometric, conductimetric, coulometric & voltametric analysis. Biosensors. Radioactive analysis: Principles of radioactivity, GM counter & LS counter. Basic principles and methods used for structural elucidation: X-ray diffraction, fluorescence, ORD\CD, NMR, IR and MS. | 12 | CO3 |

| | | | |
|---|---|---|---|
| IV | Electrophoresis- Principle and application of Agarose gel electrophoresis, denaturing agarose gel electrophoresis, PFGE, Mobility shift analysis using AGE and Capillary electrophoresis.<br>Basic principles of PAGE - Native-PAGE, SDS-PAGE, Isoelectricfocussing and 2- Dimensional gels GE. | 12 | CO4 |
| V | Isolation of chromosomal and plasmid DNA. Polymerase chain reaction and its types – isolation of specific genes using PCR. Restriction digestion and Phosphatase treatment of cloning vectors. Cloning techniques – separation and quantification of DNA by spectrophotometric and electrophoretic techniques, gene transfer mechanisms – chemical and electroporation. Methods of detection of clones – Nucleic acid transfer by blotting, Hybridization -plaque, colony hybridization. Histochemical detection of β - galactosidase, antibody screening including colour development reaction. | 12 | CO5 |
| | Total | 60 | |

**Course Outcomes**

| **Course outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Learnt about functions of different microscope | PO1 |
| CO2 | Learnt about different separation techniques available for biomolecule separation and their analysis | PO1, PO6 |
| CO3 | Studied various electrophoresis techniques | PO7,PO8,PO9 |
| CO4 | Learnt about methods of analytical methods | PO7,PO9,PO11,PO14 |
| CO5 | Learnt about different types of molecular methods using in the biology | PO7,PO8,PO9 |

**Text Books**


| | |
|---|---|
| 1. | Spector DL& Goldman RD (2006) Basic methods in microscopy: Protocols and concepts from cells: A laboratory manual.1st edition, Cold Spring Harbor Laboratory Press, New York. |
| 2. | Bradbury S (1991) Basic measurement techniques for light microscopy, Oxford University Press, Royal Microscopical Society. |
| 3. | Webster JG (2007) Bioinstrumentation. University of Wisconsin, John Wiley & Sons, Inc. |
| 4. | Sambrook J and Russell DW (2012) Molecular Cloning – A Laboratory Manual (4th eidition, Vol. 1,2,3) Cold Spring Laboratory Press, New York. |
| 5. | Willard, Herrit, Dean and Settle (1988). Instrumental Methods of Analysis (7th edition), Wadsworth Publishing Company. |
| 6 | Glick BJ, Pasternak JJ and Patten CL (2010) Molecular Biotechnology: Principles and |

| | |
|---|---|
| | Applications of Recombinant DNA (4th edition) , ASM Press. |
| 7 | Surzeki, S. (2007) Basic Techniques in Molecular Biology, Springer. |
| 8 | Westermeier, R (2006) Electrophoresis in practice ($4^{th}$ Edition), Wiley |
| 9 | Willett, J.E. (1991) Gas Chromatography, John Wiley & Sons |
| 10 | Wilson K and Walker (2000) Principles and Techniques of Practical Biochemistry (5th edition), Cambridge University Press. |


| **Methods of Evaluation** | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| **Methods of Assessment** | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend(K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | | | | | | | | | | | | | |
| CO2 | S | | | | | M | | | | | | | | |
| CO3 | | | | | | | S | S | S | | | | | |
| CO4 | | | | | | | S | | S | | M | | | M |
| CO5 | | | | | | | M | S | S | | | | | |

| **Subject** | **Subject Name** | **Category** | **L** | **T** | **P** | **S** | **Credits** | **Inst.** | **Marks** |
|---|---|---|---|---|---|---|---|---|---|

| Code | | | | | | | | Hours | CIA | External | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 23UPMBC1E04 | Bioinstrumentation | Elective Course II(Choice -1) | Y | Y | - | - | 3 | 5 | 25 | 75 | 100 |

| Course Objectives | |
|---|---|
| CO1 | Explain the principles and working mechanisms of laboratory instruments. |
| CO2 | Discuss chromatography techniques and molecular biology techniques. |
| CO3 | Illustrate molecular techniques in biological applications. |
| CO4 | Acquire knowledge on spectroscopic techniques |
| CO5 | Demonstrate the use of radio isotopes in various techniques. |

| UNIT | Details | No.of Hours | Course Objectives |
|---|---|---|---|
| I | Basic laboratory Instruments. Aerobic and anaerobic incubator – Biosafety Cabinets - Fume Hood, pH meter, Lyophilizer, Flow cytometry. Centrifugation techniques: Basic principles of centrifugation - Standard sedimentation coefficient - measurement of sedimentation co-efficient; Principles, methodology, and applications of differential, rate zonal, and density gradient centrifugation - Applications in the determination of molecular weight. | 12 | CO1 |
| II | General principles of chromatography - Chromatographic Performance parameters; Types- Thin layer chromatography, Paper Chromatography, Liquid chromatography (LPLC &HPLC), Adsorption, ion exchange, Gel filtration, affinity, Gas-liquid (GLC). Flash Chromatography and Ultra Performance convergence chromatography. Two-dimensional chromatography. Stimulated moving bed chromatography (SEC). | 12 | CO2 |
| III | Electrophoresis: General principles - moving boundary electrophoresis - electrophoretic mobility – supportive materials – electro endosmosis – types (horizontal, vertical, and two-dimensional electrophoresis) - Principle and applications - paper electrophoresis, Serum electrophoresis, starch gel electrophoresis, Disc gel, Agarose gel, SDS – PAGE, Immunoelectrophoresis. Blotting techniques - Southern, northern and western blotting. | 12 | CO3 |
| IV | Spectroscopic techniques: Principle, simple theory of absorption of light by molecules, electromagnetic spectrum, instrumentation and application of UV- visible, Raman, FTIR spectrophotometer, spectrofluorimetry, Atomic Absorption Spectrophotometer, Flame spectrophotometer, NMR, ESR, Emission Flame Photometry and GC-MS. Detection of molecules in living cells - FISH and GISH. Biophysical methods: Analysis of biomolecules by | 12 | CO4 |

| | | | |
|---|---|---|---|
| | Spectroscopy UV/visible. | | |
| V | Radioisotopic techniques: Principle and applications of tracer techniques in biology. Radioactive isotopes - radioactive decay; Detection and measurement of radioactivity using ionization chamber, proportional chamber, Geiger- Muller and Scintillation counters, auto radiography and its applications. Commonly used isotopes in biology, labeling procedures and safety aspects. | 12 | CO5 |
| | Total | 60 | |

**Course Outcomes**

| Course Outcomes | On completion of this course, students will; | |
|---|---|---|
| CO1 | Make use of the laboratory instruments- laminar air flow, pH meter, centrifugation methods, biosafety cabinets following SOP. | PO4, PO6, PO7, PO8, P11 |
| CO2 | Apply chromatography techniques in the separation of biomolecules. | PO4, PO6, PO7, PO8, P11 |
| CO3 | Perform molecular techniques like mutagenesis and their detection. | PO4, PO6, PO7, PO8, P11 |
| CO4 | Estimate molecules in biological samples by adopting UV spectroscopic techniques. | PO4, PO6, PO7, PO8, P11 |
| CO5 | Cultivate organisms anaerobically. | PO4, PO6, PO7, PO8, P11 |

**Text Books**


| | |
|---|---|
| 1. | Sharma B. K. (2014). Instrumental Method of Chemical Analysis. Krishna Prakashan Media (P) Ltd. |
| 2. | Chatwal G. R and Anand S.K. (2014.) Instrumental Methods of Chemical Analysis. Himalaya Publishing House. |
| 3. | Mitchell G.H. (2017). Gel Electrophoresis: Types, Applications and Research. Nova Science Publishers Inc. |
| 4. | Holme D. Peck H. (1998). Analytical Biochemistry. (3rd Edition). Prentice Hall. |
| 5. | Jayaraman J. (2011). Laboratory Manual in Biochemistry. (2ndEdition). Wiley Eastrn Ltd., New Delhi. |


**References Books**


| | |
|---|---|
| 1. | Pavia D. L. (2012) Spectroscopy (4th Edition). Cengage. |
| 2. | Skoog A. and West M. (2014). Principles of Instrumental Analysis. (14th Edition). W.B.Saunders Co., Philadephia. |
| 3. | Miller J. M. (2007). Chromatography: Concepts and Contrasts (2nd Edition) Wiley-Blackwell. |
| 4. | Gurumani N. (2006). Research Methodology for Biological Sciences. (1st Edition) MJP Publishers. |
| 5. | Ponmurugan P. and Gangathara P. B. (2012). Biotechniques. (1st Edition). MJP |

| | |
|---|---|
| | Publishers. |
| **Web Resources** | |
| 1. | https://norcaloa.com/BMIA |
| 2. | http://www.biologydiscussion.com/biochemistry/centrifugation/centrifuge-introduction- types-uses-and-other-details-with-diagram/12489 |
| 3. | https://www.watelectrical.com/biosensors-types-its-working-and-applications. |
| 4. | http://www.wikiscales.com/articles/electronic-analytical-balance/ |
| 5. | https://study.com/academy/lesson/what-is-chromatography-definition-types-uses. |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend(K2 | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | S | | M | M | S | | | S | | | |
| CO2 | | | | S | | M | M | S | | | S | | | |
| CO3 | | | | S | | S | S | S | | | S | | | |
| CO4 | | | | S | | M | S | S | | | S | | | |
| CO5 | | | | S | | M | S | S | | | L | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPM BC1E05** | **Herbal Technology and Cosmetic Microbiology** | **Elective Course II (Choice 2)** | **Y** | **Y** | **-** | **-** | **3** | **5** | **25** | **75** | **100** |

| **Course Objectives** | |
|---|---|
| CO1 | Impart knowledge of Indian Medicinal Plants and their applications in microbiology. |
| CO2 | Promote the technical skills involved in preparation of different types of plant extracts. |
| CO3 | Explain methods to analyze the antimicrobial activity of medicinal plants. |
| CO4 | Acquire knowledge on cosmetic microbiology and role of microorganisms in cosmetics. |
| CO5 | Gain insight into pharmacopeial microbial assays and biosafety. |

| UNIT | Details | No.of Hours | Course Objectives |
|---|---|---|---|
| I | Herbs, Herbal medicine - Indian medicinal plants: Scope and Applications of Indian medicinal plants in treating bacterial, fungal and viral diseases. Basic principles involved in Ayurvedha, Sidha, Unani and Homeopathy. | 12 | CO1 |
| II | Collection and authentication of selected Indian medicinal plants: *Emblica officinalis, Withaniasomnifera, Phyllanthus amarus, Tinospora cordifolia, Andrographis paniculata, Piper longum, Ocimum sanctum, Azardirchata indica, Terminalia chebula, Allium sativum*. Preparation of extracts- Hot and cold methods. Preparation of stock solutions. | 12 | CO2 |
| 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 | CO3 |
| 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 | CO4 |

| | | | |
|---|---|---|---|
| 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 | CO5 |
| | Total | 60 | |

| **Course Outcomes** | | |
|---|---|---|
| **Course Outcomes** | On completion of this course, students will; | |
| CO1 | Identify the applications of Indian medicinal plants in treating diseases. | PO1, PO5 |
| CO2 | Identify and authenticate herbal plants. | PO6, PO7 |
| CO3 | Evaluate the antimicrobial activity of medicinal plants. | PO4, PO6, PO9 |
| CO4 | Describe the role of microorganisms and their metabolites in the preparation of cosmetics. | PO1, PO5, PO7 |
| CO5 | Validate procedures and biosafety measures in the mass production of cosmetics. | PO6, PO7 |

| **Text Books** | |
|---|---|
| 1. | Ayurvedic Formulary of India. (2011). Part 1, 2 & 3. Pharmacopoeia Commission for Indian Medicine and Homeopathy. ISBN-10:8190648977. |
| 2. | Panda H. (2004). Handbook on herbal medicines. Asia Pacific Business Press Inc. ISBN:8178330911. |
| 3. | Mehra P. S. (2019). A Textbook of Pharmaceutical Microbiology. Dreamtech Press. ISBN 13:9789389307344. |
| 4. | Geis P. A. (2020). Cosmetic microbiology: A Practical Approach. (3rd Edition). CRC Press.ISBN:9780429113697. |
| 5. | Brannan D. K. (1997). Cosmetic microbiology: A Practical Handbook. CRC Press.ISBN-10:0849337135. |

| **References Books** | |
|---|---|
| 1. | Indian Herbal Pharmacopoeia (2002). Vol. I &II Indian Drug Manufacturers Association, Mumbai. |
| 2. | British Herbal Pharmacopoeia.(1990).Vol.I.British Herbal Medicine Association's: 0903032090. |
| 3. | Verpoorte R. and Mukherjee, P. K. (2010). GMP for Botanicals: Regulatory and Quality issues on Phytomedicines. In GMP for botanicals: regulatory and quality issues on phytomedicines. (2nd edition). Saujanya Books, Delhi.ISBN-10:81-900788-5-2/8190078852. ISBN-13:978-81-900788-5-6/9788190078856. |
| 4. | Turner R. (2013). Screening methods in Pharmacology. Elsevier. ISBN:9781483264233. |
| 5. | Cupp M. J. (2010). Toxicology and Clinical Pharmacology of Herbal Products (pp. 85-93). M. J. Cupp. Humana Press.Totowa, NJ, USA. ISBN-10:1617371904. |

| Web Resources | |
|---|---|
| 1. | https://www.academia.edu/50236711/Modern_Extraction_Methods_for_Preparation_of_Bioactive_Plant_Extracts |
| 2. | https://www.nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl |
| 3. | https://pubmed.ncbi.nlm.nih.gov/17004305/ |
| 4. | https://www.fda.gov/cosmetics/potential-contaminants-cosmetics/microbiological-safety-and-cosmetics |
| 5. | https://pubmed.ncbi.nlm.nih.gov/15156038/ |

| Methods of Evaluation | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| Methods of Assessment | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

## Mapping with Programme Outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | | | | S | | | | | | | | | |
| CO2 | | | | | | S | M | | | | | | | |
| CO3 | | | | S | | S | | | M | | | | | |
| CO4 | M | | | | S | | S | | | | | | | |
| CO5 | | | | | | M | S | | | | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPM BC1E06** | **Essentials of Laboratory Management and Biosafety** | **Elective Course II (Choice 3)** | **Y** | **Y** | **-** | **-** | **3** | **5** | **25** | **75** | **100** |

| **Course Objectives** | |
|---|---|
| CO1 | To utilize containment principles to ensure biosafety. |
| CO2 | To enrich the student role and responsibilities of laboratory hazards and their control. |
| CO3 | To know the importance of first aid technique for various common lab accidents. |
| CO4 | To acquire knowledge of biosafety level, risk assessment and maintain proper hygiene in the laboratory. |
| CO5 | To discuss the biosafety regulations and guidelines and implementation of safety programs. |

| UNIT | Details | No.of Hours | Course Objectives |
|---|---|---|---|
| I | Introduction to the laboratory and laboratory hazards - General laboratory facilities – Occupational safety- Lab accidents - Fires, chemical burns, slips and falls, Animal bites. Cuts from broken glass. Toxic fume inhalation. General laboratory rules, Good laboratory practice (GLP). Laboratory plan. | 12 | CO1 |
| II | Common hazards in laboratory: Chemical hazards- Safe handling of chemicals and gases, hazard labels and symbols. Material safety datasheet (MSDS), Chemical handling-Fume hood, Storage of chemicals. Chemical Waste Disposal Guideline. Physical hazards - Physical agent data sheets (PADS), Electric hazards- Electrical shock, Electrical explosions, Electrical burns. Safe work practices. Potential ignition sources in the lab. Stages of Fire. Fire Extinguishers. Fire Response. | 12 | CO2 |
| III | Prevention and First aid for laboratory accidents. Personal protective equipment (PPE), Proper attire (Eye/Face Protection, laboratory coats, gloves, respirators. Disposal/Removal of PPE. Emergency equipment safety - Showers/ Eye Washes. Laboratory security and emergency response. First aid for- Injuries caused by broken glass, Acid/Alkali splashes on the skin, swallowing acid/alkali, burns caused by heat, electric shock. | 12 | CO3 |
| IV | Biosafety - Historical background. Blood borne pathogens | 12 | CO4 |

| | | | |
|---|---|---|---|
| | (BBP) and laboratory-acquired infections. Introduction to biological safety cabinets. Primary containment for biohazards. Biosafety levels of specific microorganisms. Recommended biosafety. Levels for infectious agents and infected animals. Risk groups with examples - Risk assessment. Safety levels. Case studies - Safe working, hand hygiene. Laboratory instruments, packing, sending, transport, import and export of biological agents. Hygiene, disinfection, decontamination, sterilization. | | |
| V | Biosafety regulations and guidelines. Centers for disease control and prevention and the National institutes of health. Occupational safety and health administration. Recombinant DNA advisory committee(RDAC), Institutional biosafety committee(IBSC), Review committee on genetic manipulation(RCGM), Genetic engineering approval committee (GEAC). Implementation of biosafety guidelines. | 12 | CO5 |
| | Total | 60 | |

| **Course Outcomes** | | |
|---|---|---|
| **Course Outcomes** | On completion of this course, students will; | |
| CO1 | Employ skills on laboratory safety and avoid laboratory accidents. | PO1, PO2, PO3, PO7, PO11 |
| CO2 | Prevent laboratory hazards by practicing safety strategies. | PO2, PO5, PO7, PO11 |
| CO3 | Practice various first aid procedures during common laboratory accidents. | PO1, PO2, PO3, PO5, PO10, PO11 |
| CO4 | Ensure biosafety strategies in the laboratory. | PO2, PO3, PO4, PO7, PO10, PO11 |
| CO5 | Recognize the importance of biosafety guidelines. | PO3, PO4, PO5, PO7, PO10, PO11 |

**Text Books**


1. Sateesh M. K. (2013).Bioethics and Biosafety, IK International Pvt Ltd.ISBN: 8190675702.
2. Muthuraj M. and Usharani B. (2019). Biosafety in Microbiological Laboratories. (1sr Edition).Notion Press. ISBN 10: 1645878856
3. Biosafety in Microbiological and Biomedical Laboratories- U.S. Health Department and Human Services. (2016). (5th Edition). Lulu.com.
4. Kanai. L. Mukherjee. (Medical Laboratory Technology(4th Edition). CBS Publishers.
5. Ramakrishnan (2012). Manual of Medical Laboratory Techniques. JP brothers.


**References Books**


1. World Health Organization, Biosafety program management. (2010). (4th Edition). WHO Publications.
2. Rashid N. (2013). Manual of Laboratory Safety (Chemical, Radioactive, and Biosafety with Biocides) (1st Edition).

| | |
|---|---|
| 3 | Dayuan X. (2015). Biosafety and Regulation for Genetically Modified Organisms, Alpha Science International Ltd, ISBN-10 :1842657917 |
| 4. | Ochei J. Kolhatkar(2000). A. (Medical Laboratory Science – Theory and Practice. ISBN; 13:978-0074632239. |
| 5. | Lynne S. Garcia. Clinical Laboratory Management (2nd Edition). ASM Press |
| **Web Resources** | |
| 1. | https://www.cdc.gov/labs/pdf/CDC-BiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf |
| 2. | https://ucanapplym.s3.ap-south-1.amazonaws.com/RGU/notifications/E_learning/0nline_study/PG-SEM-IV-Biosafety%20regulation.pdf |
| 3. | https://consteril.com/biosafety-levels-difference/ |
| 4. | https://www.cdc.gov/labs/pdf/CDC-BiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf |
| 5. | https://www.who.int/publications/i/item/9789240011311 |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | S | | | | S | | | | S | | | |
| CO2 | | S | | | S | | S | | | | S | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO3 | S | S | S | | S | | | | | S | S | | | |
| CO4 | | S | S | M | | | S | | | S | S | | | |
| CO5 | | | S | S | S | | S | | | S | S | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1C03** | **Medical Bacteriology and Mycology** | **Core CourseI V** | **Y** | **Y** | **-** | **-** | **5** | **6** | **25** | **75** | **100** |

| **Course Objectives** | |
|---|---|
| CO1 | Acquire Knowledge of the collection, transportation, and processing of various kinds of clinical specimens. |
| CO2 | Explain the morphology, characteristics, and pathogenesis of bacteria. |
| CO3 | Discuss various factors leading to the pathogenesis of bacteria. |
| CO4 | Acquire knowledge on antifungal agents and their importance. |
| CO5 | Describe various diagnostic methods available for fungal disease diagnosis. |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | Classification of medically important bacteria, Normal flora of the human body, Collection, transport, storage, and processing of clinical specimens, Microbiological examination of clinical specimens, and antimicrobial susceptibility testing. Handling and maintenance of laboratory animals – Rabbits, guinea pigs and mice. | 20 | CO1 |
| II | Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of *Staphylococci, Streptococci, Pneumococci, Neisseriae*., *Bacillus, Corynebacteria, Mycobacteria,* and *Clostridium.* | 20 | CO2 |
| III | Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by Enterobacteriaceae members, *Yersinia, Pseudomonas, Vibrio, Mycoplasma, Helicobacter, Rickettsiae, Chlamydiae, Bordetella, Francisella., Spirochaetes-Leptospira, Treponema* and *Borrelia*. Nosocomial, zoonotic and opportunistic infections -prevention and control. | 20 | CO3 |
| IV | Morphology, taxonomy and classification of fungi. Detection and recovery of fungi from clinical specimens. Dermatophytes and agents of superficial mycoses. *Trichophyton, Epidermophyton &Microsporum*. Yeasts of | 15 | CO4 |

| | | | |
|---|---|---|---|
| | medical importance – *Candida, Cryptococcus*. Mycotoxins. Antifungal agents, testing methods and quality control. | | |
| V | Dimorphic fungi causing Systemic mycoses, *Histoplasma, Coccidioides, Sporothrix, Blastomyces.* Fungi causing Eumycotic Mycetoma, Opportunistic fungi- Fungi causing secondary infections in immunocompromised patients. Immunodiagnostic methods in mycology- Recent advancements in diagnosis. Antifungal agents. | 15 | CO5 |
| | Total | 90 | |

| **Course Outcomes** | | |
|---|---|---|
| **Course Outcomes** | On completion of this course, students will; | |
| CO1 | Collect, transport and process of various kinds of clinical specimens. | PO1,PO5,PO9 |
| CO2 | Analyze various bacteria based on morphology and pathogenesis. | PO1,PO5,PO9 |
| CO3 | Discuss various treatment methods for bacterial disease. | PO1,PO5,PO9 |
| CO4 | Employ various methods detect fungi in clinical samples and apply knowledge on antifungal agents.. | PO5,PO9 |
| CO5 | Apply various immunodiagnostic method to detect fungal infections. | PO5,PO9 |

**Text Books**


| | |
|---|---|
| 1. | Kanunga R. (2017). Ananthanarayanan and Panicker'sText book of Microbiology. (2017).Orient Longman, Hyderabad. |
| 2. | Greenwood, D., Slack, R.B. and Peutherer, J.F. (2012) Medical Microbiology, (18th Edition). Churchill Livingstone, London. |
| 3. | Finegold, S.M. (2000) Diagnostic Microbiology, (10th Edition). C.V. Mosby Company, St. Louis. |
| 4. | Alexopoulos C. J., Mims C. W. and Blackwell M. (2007). Introductory Mycology, (4th Edition). Wiley Publishers. |
| 5. | Chander J. (2018). Textbook of Medical Mycology. (4th Edition). Jaypee brothers Medical Publishers. |


**References Books**


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|---|---|
| 1. | Salle A. J. (2007). Fundamental Principles of Bacteriology. (4th Edition). Tata McGraw-Hill Publications. |
| 2. | Collee J.C. Duguid J.P. Foraser, A.C, Marimon B.P, (1996). Mackie & McCartney Practical Medical Microbiology. 14thedn, Churchill Livingston. |
| 3. | Cheesbrough M. (2006). District Laboratory Practice in Tropical countries.- Part 22ndedn.Cambridge University Press. |
| 4. | Topley and Wilson's. (1998). Principles of Bacteriology.9thedn. Edward Arnold, London. |
| 5. | Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7thedn. Elsevier, Mosby Saunders. |

| Web Resources | |
|---|---|
| 1. | http://textbookofbacteriology.net/nd |
| 2. | https://microbiologysociety.org/members-outreach-resources/links.html |
| 3. | https://www.pathelective.com/micro-resources |
| 4. | http://mycology.cornell.edu/fteach.html |
| 5. | https://www.adelaide.edu.au/mycology/ |

| Methods of Evaluation | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| Methods of Assessment | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyze (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | | | | S | | | | M | | | | | |
| CO2 | M | | | | S | | | | M | | | | | |
| CO3 | M | | | | S | | | | M | | | | | |
| CO4 | | | | | S | | | | M | | | | | |
| CO5 | | | | | S | | | | M | | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1C04** | **Medical Virology and Parasitology** | **Core Course V Theory** | **Y** | **Y** | **-** | **-** | **5** | **6** | **25** | **75** | **100** |

| **Course Objectives** | |
|---|---|
| CO1 | Describe the replication strategy and cultivation methods of viruses. |
| CO2 | Acquire knowledge about oncogenic virus and human viral infections. |
| CO3 | Develop diagnostic skills, in the identification of virus infections. |
| CO4 | Impart knowledge about parasitic infections. |
| CO5 | Develop diagnostic skills, in the identification of parasitic infections. |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | General properties of viruses - Structure and Classification - viroids, prions, satellite RNAs and virusoids. Cultivation of viruses -embryonated eggs, experimental animals and cell cultures. Purification and Assay of viruses – Physical and Chemical methods (Electron Microscopy, Protein and Nucleic acids studies.) Infectivity Assays (Plaque and end-point). | 20 | CO1 |
| II | Virus Entry, Host Defenses Against Viral Infections, Epidemiology, pathogenic mechanisms, Pathogenesis, laboratory diagnosis, treatment for the following viruses: DNA Viruses- Pox,Herpes,Adeno ,Papova and Hepadna , RNA Viruses- Picorna, Orthomyxo, Paramyxo, Rhabdo, Rota, HIV and other Hepatitis viruses, Arbo – Dengue virus, Ebola virus, Emerging and reemerging viral infections | 20 | CO2 |
| III | Bacterial viruses - ΦX 174, M13, MU, T4, lambda, Pi; Structural organization, life cycle and phage production. Lysogenic cycle-typing and application in bacterial genetics. Diagnosis of viral infections –conventional serological and molecular methods. Antiviral agents and viral vaccines. | 15 | CO3 |
| IV | Introduction to Medical Parasitology – Classification, host-parasite relationships. Epidemiology, life cycle, pathogenic mechanisms, laboratory diagnosis, treatment for the following: Protozoa causing human infections – *Entamoeba,* Aerobic and Anaerobic amoebae, *Giardia, Trichomonas, Balantidium. Toxoplasma, Cryptosporidium, Leishmania,* and *Trypanasoma.* | 15 | CO4 |

| | | | |
|---|---|---|---|
| V | Classification, life cycle, pathogenicity, laboratory diagnosis and treatment for parasites – Helminthes - Cestodes –*Taenia Solium, T. Saginata, T. Echinococcus*. Trematodes –*Fasciola Hepatica, Fasciolopsis Buski, Paragonimus, Schistosomes*. Nematodes - *Ascaris, Ankylostoma, Trichuris, Trichinella, Enterobius, Strongyloides* and *Wuchereria*. Other parasites causing infections in immune-compromised hosts and AIDS. Cultivation of parasites. Diagnosis of parasitic infections – Serological and molecular diagnosis. Anti-protozoan drugs. | 20 | CO5 |
| | Total | 90 | |
| **Course Outcomes** | | | |
| **Course Outcomes** | On completion of this course, students will; | | |
| CO1 | Cultivate viruses by different methods and aid in diagnosis. Perform purification and viral assay. | PO5, PO7, PO8, PO10 | |
| CO2 | Investigate the symptoms of viral infections and presumptively identify the viral disease. | PO5, PO7, PO8, PO10 | |
| CO3 | Diagnose various viral diseases by different methods.(serological, conventional and molecular) | PO5, PO7, PO8, PO10 | |
| CO4 | Educate public about the spread, control and prevention of parasitic diseases. | PO5, PO7, PO8, PO10 | |
| CO5 | Identify the protozoans and helminthes present in stool and blood specimens. Perform serological and molecular diagnosis of parasitic infections. | PO5, PO7, PO8, PO10 | |
| **Text Books** | | | |
| 1. | Kanunga R. (2017). Ananthanarayanan and Panicker's Text book of Microbiology. (10th Edition). Universities Press (India ) Pvt. Ltd. | | |
| 2. | Dubey, R.C. and Maheshwari D.K. (2010). A Text Book of Microbiology. S. Chand & Co. | | |
| 3. | Rajan S. (2007). Medical Microbiology. MJP publisher. | | |
| 4. | Paniker J. (2006). Text Book of Parasitology. Jay Pee Brothers, NewDelhi. | | |
| 5. | Arora, D. R. and Arora B. B. (2020). Medical Parasitology. (5thEdition). CBS Publishers & Distributors Pvt. Ltd. New Delhi. | | |
| **Reference Books** | | | |
| 1. | Carter J. (2001). Virology: Principles and Applications (1st Edition). Wiley Publications. | | |
| 2.. | Willey J., Sandman K. and Wood D. Prescott's Microbiology. (11th Edition). McGraw Hill Book. | | |
| 3. | Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A. | | |
| 4. | Finegold S.M. (2000). Diagnostic Microbiology. (10th Edition). C.V. Mosby Company, St. Louis. | | |

| Web Resources | |
|---|---|
| 1. | https://en.wikipedia.org/wiki/Virology |
| 2. | https://academic.oup.com/femsre/article/30/3/321/546048 |
| 3. | https://www.sciencedirect.com/science/article/pii/S0042682215000859 |
| 4. | https://nptel.ac.in/courses/102/103/102103039/ |
| 5. | https://www.healthline.com/health/viral-diseases#contagiousness |

| Methods of Evaluation | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |


| | |
|---|---|
| 5. | Levanthal R. and Cheadle R. S. (2012). Medical Parasitology. (6th Edition). S.A. Davies Co. Philadelphia. |


| Methods of Assessment | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend(K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyses (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | M | | L | L | | M | | | | |
| CO2 | | | | | M | | L | L | | M | | | | |
| CO3 | | | | | M | | L | L | | M | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | | | | | M | | L | L | | M | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1L02** | **Practical II** | **Core Course VI-Practical II** | **-** | **-** | **Y** | **-** | **4** | **6** | **40** | **60** | **100** |

| **Course Objectives** | |
|---|---|
| CO1 | Develop skills in the diagnosis of bacterial infections and antimicrobial sensitivity. |
| CO2 | Impart knowledge on fungal infections and its diagnosis. |
| CO3 | Diagnose parasitic |
| CO4 | To gain knowledge about industrially important microbes. |
| CO5 | Screen and utilize microorganisms for effective industrial production of metabolites. |

| UNIT | Details | Hours | Course Objectives |
|---|---|---|---|
| I | Staining of clinical specimens - Wet mount, Differential and Special staining methods.<br>Isolation and identification of bacterial pathogens from clinical specimens - cultivation in basal, differential, enriched, selective and special media – Biochemical identification tests.<br>Enumeration of bacteria in urine to detect significant bacteriuria.<br>Antimicrobial sensitivity testing - Kirby Bauer method and Stokes method.<br>Minimum inhibitory concentration (MIC) test.<br>Minimum bactericidal concentration (MBC) test. | 20 | CO1 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO5 | | | | | M | | L | L | | M | | | | |

| | | | |
|---|---|---|---|
| II | Identification and Classification of common fungi.<br>Mounting and staining of VAM spores.<br>Examination of different fungi by Lactophenol cotton blue staining.<br>Examination of different fungi by KOH staining.<br>Cultivation of fungi and their identification - *Mucor, Rhizopus, Aspergillus, Penicillium.*<br>Microscopic observation of different asexual fungal spores.<br>Microscopic observation of fungal fruiting bodies.<br>Identification of Dermatophytes.<br>Isolation and characterization of bacteriophage from natural sources by phage titration.<br>Cultivation of viruses –Egg Inoculation methods.<br>Diagnosis of Viral Infections –ELISA –HIA.<br>Spotters of viral inclusions and CPE-stained smears. | 20 | CO2 |
| III | Examination of parasites in clinical specimens - Ova/cysts in faeces.<br>Concentration: methods – Floatation methods-simple Saturated salt solution method – Zinc sulphate methods - Sedimentation methods- Formal ether method.<br>Blood smear examination for malarial parasites. Thin smear by Leishman's stain – Thick smear by J.B. stain.<br>Identification of common arthropods of medical importance - spotters of *Anopheles, Glossina, Phlebotomus, Aedes,* Ticks and mites. | 20 | CO3 |
| IV | Good Laboratory Practices in Industrial Microbiology laboratory.<br>Study of Bioreactor and its essential parts.<br>Culturing and Characterization of microorganisms used in Dairy and Pharmaceutical industry.<br>Screening for Enzyme producers (amylase /protease).<br>Optimization of parameters for Amylase production.<br>Screening for Organic acid producers (acetic acid/lactic acid).<br>Screening for Antibiotic producers. | 15 | CO4 |
| V | Immobilization of microbial cells and enzyme and its assessment.<br>Microbiological assays of fermentation products – MIC-MBC.<br>Microbiological assay of antibiotics by cup plate method and other methods.<br>Sterility testing of pharmaceuticals. | 15 | CO5 |
| | Total | 90 | |
| **Course Outcomes** | | | |

| Course Outcomes | On completion of this course, students will; | |
|---|---|---|
| CO1 | Collection of different clinical samples, transport, culture and examination. | PO7, PO8, PO9 |
| CO2 | Identify medically important bacteria, fungus and parasites from the clinical samples by staining and biochemical tests. | PO7, PO8, PO9 |
| CO3 | Promote diagnostic skills; interpret laboratory tests in the diagnosis of infectious diseases. | PO7, PO8, PO9, PO10 |
| CO4 | Perform antibiotic sensitivity tests and compare with the standard tests. | PO7, PO8, PO9, PO10 |
| CO5 | Screening of industrially important microbes for metabolite production. | PO7, PO8, PO9 |

| | **Text Books** |
|---|---|
| 1. | Cullimore D. R. (2010). Practical Atlas for Bacterial Identification, 2nd Edition. Publisher-Taylor and Francis. |
| 2. | Abbott A.C. (2010). The Principles of Bacteriology. Nabu Press. |
| 3. | Parija S. C. (2012). Textbook of Practical Microbiology. Ahuja Publishing House. |
| 4. | Cappuccimo, J. and Sherman, N. (2002) Microbiology: A Laboratory Manual, (6thEdition). Pearson Education, Publication, New Delhi. |
| 5. | Morag C. and Timbury M.C. (1994).Medical Virology. 4th edn. Blackwell Scientific Publishers. |
| | **References Books** |
| 1. | Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi. |
| 2. | Chart H. (2018). Practical Laboratory Bacteriology. CRC Press. |
| 3. | Moore V. A. (2017). Laboratory Directions for Beginners in Bacteriology. Triste Publishing Ltd. |
| 4. | Cheesbrough M. (2006). District Laboratory Practice in Tropical countries.- Part 22ndEdition.Cambridge University Press. |
| 5. | Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7th Edition. Elsevier, Mosby Saunders |
| | **Web Resources** |
| 1. | http://textbookofbacteriology.net/ |
| 2. | https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7173454/ |
| 3. | https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3768729/ |

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|---|---|
| 4. | https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/ |
| 5. | https://www.intechopen.com/books/current-issues-in-molecular-virology-viral-genetics-and-biotechnological-applications/vaccines-and-antiviral-agents |

| **Methods of Evaluation** | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| **Methods of Assessment** | |
|---|---|
| Recall (K1) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | M | M | M | | | | | |
| CO2 | | | | | | | M | M | M | | | | | |
| CO3 | | | | | | | M | M | L | L | | | | |
| CO4 | | | | | | | M | M | M | L | | | | |
| CO5 | | | | | | | M | M | M | | | | | |

| **Subject Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **S** | **Credits** | **Inst. Hours** | **Marks** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **CIA** | **External** | **Total** |
| **23UPMBC1E07** | **Epidemi** | **Elective Course III** | **Y** | **Y** | **-** | **-** | **3** | **4** | **25** | **75** | **100** |

| | ology | (Choice 1) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|

| Course Objectives | | | |
|---|---|---|---|
| CO1 | Describe the role of epidemiology in public health. | | |
| CO2 | Explain epidemiology tools and disease surveillance methods. | | |
| CO3 | Analyze various communicable and non-communicable diseases in India. | | |
| CO4 | Discuss on mechanism of antimicrobial resistance. | | |
| CO5 | Outline National health programs that have been designed to address the issues. | | |
| **UNIT** | **Details** | **No. of Hours** | **Course Objectives** |
| I | Fundamentals of epidemiology - Definitions of epidemiology – Epidemiology of infectious diseases in Public Health. Natural history of disease -Historical aspects of epidemiology. Common risk factors- Epidemiologic Triad-Agent factors, host factors, and environmental factors. Transmission basics- Chain of infection, portal of entry. Modes of transmission-Direct and indirect. Stages of infectious diseases. Agents and vectors of communicable diseases of public health importance and dynamics of disease transmission. Epidemiology of Zoonosis-Factors, routes of transmission of bacterial, viral, parasitic, and fungal zoonotic agents. Control of zoonosis. | 12 | CO1 |
| II | Tools of Epidemiology - Measures of Disease -Prevalence, incidence. Index case. Risk rates. Descriptive Epidemiology - Cohort studies, measuring infectivity, survey methodology including census procedures. Surveillance strategies - Disease surveillance, geographical indication system, outbreak investigation in public health andcontact investigation. | 12 | CO2 |
| III | Epidemiological aspects of diseases of national importance-Background to communicable and non-communicable diseases. Vector borne diseases in India. Diarrhoeal diseases. Zoonoses. Viral haemorrhagic fevers. Mycobacterial infections. Sexually transmitted diseases. Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS). Emerging disease threats- Severe Acute Respiratory Syndrome (SARS), Covid-19, Ebola, MDR-TB,Malaria, Mucor mycosis, Avian flu. Dengue, Swine Flu, Chikungunya. Epidemiology, prevention, and control of non-communicable diseases- Asthma, Coronary heart disease, Malignancy, diabetes mellitus, respiratory diseases, eye diseases, Dental disorders. Emerging and Re-emerging Diseases. | 12 | CO3 |
| IV | Mechanisms of Antimicrobial resistance - Multidrug Efflux pumps, Extended Spectrum β-lactamases (ESBL). Hospital acquired infections-Factors, infection sites, mechanisms, Role of Multidrug resistant pathogens. Role of *Pseudomonas, Acinetobacter, Clostridium difficile,*HBV, HCV, Rotavirus*, Cryptosporidium* and *Aspergillus* in Nosocomial infections. | 12 | CO4 |

| | | | |
|---|---|---|---|
| | Prevention and management of nosocomial infections. | | |
| V | National Programmes related to Communicable and Non-Communicable diseases - National Malaria Eradication Programme, Revised National Tuberculosis Control Programme, Vector Borne Disease Control Programme, National AIDS Control Programme, National Cancer Control Programme and National Diabetes Control Programme. Biochemical and immunological tools in epidemiology- Biotyping, Serotyping, Phage typing, FAME (Fatty acid methyl ester analysis), Curie Point PyMS (Pyrolysis Mass spectrometry), Protein profiling, Molecular typing methods. | 12 | CO5 |
| | Total | 60 | |

**Course Outcomes**

| **Course Outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Apply the knowledge acquired on concepts of epidemiology to clinical and public health environment. | PO1 |
| CO2 | Plan various strategies to trace the epidemiology. | PO4, PO5, PO6 |
| CO3 | Plan the control of communicable and non-communicable diseases. | PO1, PO5, |
| CO4 | Analyze the implications of drug resistance in the society and design the control of antimicrobial resistance and its management. | PO5, |
| CO5 | Employ National control programs related to Communicable and Non-Communicable diseases with the public. | PO4, PO5, |

**Text Books**


| | |
|---|---|
| 1. | Dicker R., Coronado F., Koo. D. and Parrish. R. G. (2012). Principles of Epidemiology in Public Health Practice., (3rd Edition). CDC. |
| 2. | Gerstman B. (2013). Epidemiology Kept Simple: An Introduction to Classic and Modern Epidemiology. (3rd Edition). Wiley Blackwell. |
| 3. | Greenwood, D., Slack, R. B. and Peutherer, J. F. (2012) Medical Microbiology, (18th Edition). Churchill Livingstone, London. |
| 4. | Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A. |
| 5. | Dimmok N. J. and Primrose S. B. (1994). Introduction to Modern Virology.5thedn. Blackwell Scientific Publishers. |


**References Books**


| | |
|---|---|
| 1. | Bhopal R. S. (2016).Concepts of Epidemiology - An Integrated Introduction to the Ideas, Theories, Principles and Methods of Epidemiology. (3rd Edition). Oxford University Press, New York. |
| 2. | Celentano D. D. and Szklo M. (2018). Gordis Epidemiology. (6th Edition). Elseiver,USA. |

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|---|---|
| 3. | Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries- Part 2, (2nd Edition). Cambridge University Press. |
| 4. | Ryan K. J. and Ray C. G. (2004). Sherris Medical Microbiology. (4th Edition), McGraw Hill, New York. |
| 5. | TopleyW.W. C.,Wilson, G.S., Parker M.T. and Collier L. H. (1998). Principles of Bacteriology. (9th Edition). Edward Arnold, London. |

**Web Resources**

| | |
|---|---|
| 1. | https://www.scielo.br/j/rbca/a/mjDFGTtfWtBm786ZmR9TG9d/?lang=en |
| 2. | https://hal.archives-ouvertes.fr/hal-00902711/document |
| 3. | https://www.who.int/csr/resources/publications/whocdscsreph200212.pdf |
| 4. | https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7187955/ |
| 5. | https://www.who.int/diseasecontrol_emergencies/publications/idhe_2009_london_outbreaks.pdf |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend(K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, suggest formulae, Solve problems, Observe, Explain |
| Analyze (K4) | Problem-solving questions, finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Program Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | | | | | | | | | | | | | |
| CO2 | | | | L | L | S | | | | | | | | |
| CO3 | M | | | | S | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | | | | | S | | | | | | | | | |
| CO5 | | | | S | S | | | | | | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1E08** | **Clinical and Diagnostic Microbiology** | **Elective Course III (Choice2)** | **Y** | **Y** | **-** | **-** | **3** | **4** | **25** | **75** | **100** |

| **Course Objectives** | |
|---|---|
| CO1 | Describe appropriate safety protocol and laboratory techniques for handling specimens and biomedical waste management. |
| CO2 | Develop working knowledge of techniques used to identify infectious agents in the clinical microbiology lab. |
| CO3 | Elucidate various diagnostic procedures in microbiology. |
| CO4 | Acquire knowledge on different methods employed to check antibiotic sensitivity. |
| CO5 | Gain knowledge on hospital acquired infections and their control measures. |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | Microbiology Laboratory Safety Practices -General Safety Guidelines, Handling of Biological Hazards, Infectious health care waste disposal - Biomedical waste management, Emerging and Re-emerging infections. | 12 | CO1 |
| II | Diagnostic procedures - General concept of Clinical specimen collection, transport, storage and general processing in Microbiology laboratory - Specimen acceptance and rejection criteria. | 12 | CO2 |
| III | Diagnosis of microbial diseases - Clinical, differential, Microbiological, immunological and molecular diagnosis of microbial diseases. Modern and novel microbial diagnostic methods. Automation in Microbial diagnosis. | 12 | CO3 |
| IV | Antibiotic sensitivity tests - Disc diffusion - Stokes and Kirby Bauer methods, E test - Dilution - Agar dilution & broth dilution - MBC/MIC - Quality control for antibiotics and standard strains. | 12 | CO4 |
| V | Nosocomial infections – common types, sources, reservoir and mode of transmission, pathogenesis and control measures. Hospital Infection Control Committee (HICC) – Functions. | 12 | CO5 |
| | Total | 60 | |

| Course Outcomes | | |
|---|---|---|
| **Course Outcomes** | On completion of this course, students will; | |
| CO1 | Apply Laboratory safety procedures and hospital waste disposal strategies. | PO5, PO6, PO7 |
| CO2 | Collect various clinical specimens, handle, preserve and process safely. | PO6, PO7 |
| CO3 | Identify the causative agents of diseases by conventional and molecular methods following standard protocols. | PO6, PO7, PO9, PO11 |
| CO4 | Assess the antimicrobial susceptibility pattern of pathogens. | PO7, PO9 |
| CO5 | Trace the sources of nosocomial infection and recommend control measures. | PO5, PO7 |

**TEXT BOOKS**


| | |
|---|---|
| 1. | Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi. ISBN-10:0443047219 / ISBN-13-978-0443047213. |
| 2. | Tille P. M. (2021). Bailey and Scott's Diagnostic Microbiology. (15thEdition). Elsevier. ISBN:9780323681056. |
| 3. | Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A. |
| 4. | Mukherjee K.L. (2000). Medical Laboratory Technology.Vol. 1-3. (2nd Edition). Tata McGraw-Hill Education. ISBN-10:0074632604. |
| 5. | Sood R. (2009). Medical Laboratory Technology – Methods and Interpretations. (6thEdition). Jaypee Brothers Medical Publishers (P) Ltd. New Delhi. ISBN:9788184484496. |


**References Books**


| | |
|---|---|
| 1. | Murray P. R., Baron E. J., Jorgenson J. H., Pfaller M. A. and Yolken R.H. (2003). Manual of Clinical Microbiology. (8th Edition). American Society for Microbiology, Washington, DC. ISBN:1-555810255-4. |
| 2. | BennettJ.E., Dolin R. and BlaserM.J. (2019). Principles and Practice of Infectious Diseases. (9thEdition). Elsevier. EBook ISBN:9780323550277. Hardcover ISBN:9780323482554. |
| 3. | Ridgway G.L., Stokes E.J. and Wren M.W.D. (1987). Clinical Microbiology 7th Edition. Hodder Arnold Publication. ISBN-10:0340554231 / ISBN-13:9780340554234. |
| 4. | Koneman E.W., Allen S.D., Schreckenberg P.C. and WinnW.C. (2020). Koneman's Color Atlas and Textbook of Diagnostic Microbiology. (7th Edition). Jones & Bartlett Learning. ISBN:1284322378 9781284322378. |

| | |
|---|---|
| 5. | Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2nd Edition). Cambridge University Press. ISBN-13:978-0-521-67631-1 / ISBN-10:0-521-67631-2. |

| **Web Resources** | |
|---|---|
| 1. | https://www.ncbi.nlm.nih.gov/books/NBK20370/ |
| 2. | https://www.msdmanuals.com/en-in/home/infections/diagnosis-of-infectious3disease/diagnosis-of-infectious-disease |
| 3. | https://journals.asm.org/doi/10.1128/JCM.02592-20 |
| 4. | https://www.sciencedirect.com/science/article/pii/S2221169116309509 |
| 5. | http://www.textbookofbacteriology.net/normalflora_3.html |

| **Methods of Evaluation** | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| **Methods of Assessment** | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest ideas/concepts with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyze (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussions, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | S | M | M | | | | | | | |
| CO2 | | | | | | M | S | | | | | | | |
| CO3 | | | | | | M | S | | M | | S | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | | | | | | | S | | M | | | | | |
| CO5 | | | | | S | | M | | | | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| 23UPMBC1E09 | Mushroom Technology | Elective Course III (Choice 3) | Y | Y | - | - | 3 | 4 | 25 | 75 | 100 |

| Course Objectives | |
|---|---|
| CO1 | To obtain a good knowledge about Mushroom cultivation. |
| CO2 | To differentiate edible and Poisonous Mushrooms and their effects. |
| CO3 | To list the importance of Mushroom. |
| CO4 | List out the Nutrient Profile of Mushroom. |
| CO5 | To obtain a good understanding of Mushroom cultivation and its disease control. |

| UNIT | Details | No.of Hours | Course Objectives |
|---|---|---|---|
| I | Mushroom– Historical development Origin, Characteristics, Importance, Morphology. Classification of Mushroom, Nutritional value off Mushroom; Medicinal value of Mushroom; Edible Mushroom and Poisonous Mushroom; Medicinal and Environmental uses of Mushrooms. | 12 | CO1 |
| II | Types of Mushroom; Cultivation of Button Mushroom (Agaricus bisporus), Oyster Mushroom(Pleurotus),Milky Mushroom (Calocybe indica),and Paddy straw Mushroom(Volvariella volvaceae); Management of waste generated during Mushroom Cultivation. | 12 | CO2 |
| III | Substrate used for Mushroom Cultivation; spawn production for mushroom cultivation-starter culture, sterilization process, preparation of media and slants, mother spawn ,preparation of final spawn, precaution and storage of spawn. | 12 | CO3 |
| IV | Diseases of Mushrooms-Bacterial disease (Bacterial blotch ,Mummy disease),Viral disease (Die back disease):Fungal diseases (Dry bubble disease, Wet bubble disease), Fungal competitors during Mushroom cultivation -Green Mould, Olive Green Mould, Yellow Mould, Lipstick Mould and Cinnamon Mould.Insects Management during Mushroom Cultivation. | 12 | CO4 |
| V | Harvest technology and impact of Mushroom cultivation:Harvesting , Grading,Packaging,Storage,Transportation, Preservation | 12 | CO5 |

| | | | |
|---|---|---|---|
| | and Marketing; Environmental impact of Mushroom Cultivation ; Mushroom food recipes; Economical value of Mushroom . Current research thoughts in Mushroom Technology. | | |
| | Total | 60 | |

**Course Outcomes**

| Course Outcomes | | |
|---|---|---|
| CO1 | Obtain the information about the cultivation and Disease control of Mushroom | PO1,PO2,PO4,PO5 |
| CO2 | Gain knowledge about the nutritional value and medicinal value of Mushrooms | PO1,PO4, PO5,PO11 |
| CO3 | Obtain knowledge about different types of Mushrooms. | PO5,PO7,PO8,PO11 |
| CO4 | Maintenance of pure culture and outline the post-harvest practices. | PO5,PO6,PO7,PO8, PO9 |
| CO5 | Assess the nutrient and medicinal value of edible Mushrooms and analyse the effects of Poisonous Mushroom | PO1,PO5,PO6,PO7, PO8 |

**Text Books**


| | |
|---|---|
| 1. | Alice,D., K.Muthusamy &M.Yesuraja.,(1999).Mushroom Culture, Agriculture College ,Research Institute publication, Madurai, Tamilnadu,India. |
| 2. | Tripathi,D.P.,(2005).Mushroom cultivation, Oxford and IBH publishing Co.Pvt.Ltd.,New Delhi, India. |
| 3. | Kannaiyan., (2001). Handbook of Edible Mushrooms ,TNAU Publication, Coimbatore, India. |
| 4. | Naidu,N.N.R.,(2008). Management and Entrepreneurship ,I.K.International Pvt.Ltd.,India. |
| 5. | Nita Bhal,(2000).Handbook of Mushrooms,(2nd ed).Volume I&II New Delhi, India. |


**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |

| | |
|---|---|
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | | M | S | | | | | | | | | |
| CO2 | S | | | M | S | | | | | | S | | | |
| CO3 | | | | | S | | S | S | | | S | | | |
| CO4 | | | | | S | S | S | S | S | | | | | |
| CO5 | M | | | | S | M | S | S | | | | | | |

| **Subject Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **S** | **Credits** | **Inst. Hours** | **Marks** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **CIA** | **External** | **Total** |
| **23UPMBC1E10** | **Bioinformatics** | **Elective Course IV Theory (Choice1)** | **Y** | **Y** | **-** | **-** | **3** | **4** | **25** | **75** | **100** |

**Course Objectives**

| | |
|---|---|
| CO1 | Discuss about various biological data mining concepts, tools. |
| CO2 | Elucidate the principles and applications of sequence alignment methods and tools. |
| CO3 | Demonstrate different phylogenetic tree construction methods and its uses in phylogenetic analysis. |
| CO4 | Acquaint with various approaches in predicting 3D and 2D structure of proteins. |
| CO5 | Describe various tools and techniques used in molecular docking, immunoinformatics and subtractive genomics. |

| **UNIT** | **Details** | **No.of Hours** | **Course Objectives** |
|---|---|---|---|

| | | | |
|---|---|---|---|
| I | Biological Data Mining –Exploration of Data Mining Tools. Cluster Analysis Methods. Data Visualization. Biological Data Management. Biological Algorithms – Biological Primary and Derived Databases. Concept of Alignment, Pairwise Sequence Alignment (PSA), Multiple Sequence Alignment (MSA), BLAST, CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM). | 12 | CO1 |
| II | Phylogenetic Tree Construction - Concept of Dendrograms. Evolutionary Trees - Distance Based Tree Reconstruction - Ultrametric trees and Ultrametric distances – Reconstructing Trees from Additive Matrices - Evolutionary Trees and Hierarchical Clustering - Character Based Tree Reconstruction - Maximum Parsimony Method, Maximum likelihood method - Reliability of Trees – Substitution matrices – Evolutionary models. | 12 | CO2 |
| III | Computational Protein Structure prediction – Secondary structure – Homology modelling- Fold recognition and ab initio 3D structure prediction – Structure comparison and alignment – Prediction of function from structure. Geometrical parameters – Potential energy surfaces – Hardware and Software requirements-Molecular graphics – Molecular file formats- Molecular visualization tools. | 12 | CO3 |
| IV | Prediction of Properties of Ligand Compounds – 3D Autocorrelation -3D Morse Code-Conformation Dependent and Independent Chirality Codes –Comparative Molecular Field Analysis – 4 D QSAR –HYBOT Descriptors – Structure Descriptors – Applications – Linear Free Energy Relationships – Quantity Structure - Property Relationships – Prediction of the Toxicity of Compounds | 12 | CO4 |
| V | Molecular Docking- Flexible - Rigid docking- Target-Ligand preparation- Solvent accessibility- Surface volume calculation, Active site prediction- Docking algorithms-Genetic, Lamarckian - Docking analyses- Molecular interactions, bonded and nonbonded - Molecular Docking Software and Working Methods. Genome to drug discovery – Subtractive Genomics – Principles of Immunoinformatics and Vaccine Development. | 12 | CO5 |
| | Total | 60 | |

| **Course Outcomes** | | |
|---|---|---|
| **Course Outcomes** | On completion of this course, students will; | |
| CO1 | Access to databases that provides information on nucleic acids and proteins. | PO1,PO4,PO6,PO7,PO9,PO10,PO13 |

| | | |
|---|---|---|
| CO2 | Invent algorithms for sequence alignment. | PO7,PO9,PO10,PO13 |
| CO3 | Construct phylogenetic tree. | PO6, PO9, PO10 |
| CO4 | Predict the structure of proteins. | PO6,PO7,PO9,PO13 |
| CO5 | Design drugs by predicting drug ligand interactions and molecular docking. | PO4,PO5,PO6,PO7,PO9,PO10,PO13 |

**Text Books**

| | |
|---|---|
| 1. | Lesk A. M. (2002). Introduction to Bioinformatics. (4th Edition). Oxford University Press. |
| 2. | Lengauer T. (2008). Bioinformatics- from Genomes to Therapies (Vol-1).Wiley- VCH. |
| 3. | Rastogi S. C., Mendiratta N. and Rastogi P. (2014). Bioinformatics - Methods and Applications (Genomics,Proteomics and Drug Discovery) (4th Edition).Prentice-Hall of India Pvt.Ltd. |
| 4. | Attwood, T.K. and Parry-Smith, D.J. (1999). Introduction to Bioinformatics. Addision Wesley Longman Limited, England. |
| 5. | Mount D.W., (2013).Bioinformatics sequence and genome analysis, 2nd edn.CBS Publishers, New Delhi. |

**References Books**

| | |
|---|---|
| 1. | BaxevanisA. D. andOuellette F. (2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. (2nd Edition). John Wiley and Sons. |
| 2. | Bosu O. and Kaur S. (2007). Bioinformatics - Database, Tools, and Algorithms. Oxford University Press. |
| 3. | David W. M. (2001). Bioinformatics Sequence and Genome Analysis (2nd Edition). CBS Publishers and Distributors(Pvt.)Ltd. |
| 4. | Xiong J, (2011). Essential bioinformatics, First south Indian Edition, Cambridge University Press. |
| 5. | HarshawardhanP.Bal, (2006). Bioinformatics Principles and Applications, Tata McGraw-Hill Publishing Company Limited. |

**Web Resources**

| | |
|---|---|
| 1. | https://www.hsls.pitt.edu/obrc/ |
| 2. | https://www.hsls.pitt.edu/obrc/index.php?page=dna |
| 3. | https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1669712/ |
| 4. | https://www.ebi.ac.uk/ |
| 5. | https://www.kegg.jp/kegg/kegg2.html |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |

| | |
|---|---|
| Understand / ComprehendK2 | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | | | M | | M | | | M | M | | | M | |
| CO2 | | | | | | | S | | S | S | | | S | |
| CO3 | | | | | | S | | | S | S | | | | |
| CO4 | | | | S | | S | S | | S | | | | S | |
| CO5 | | | | S | S | S | S | | S | S | | | S | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| 23UPMBC1E11 | Nanobiotechnology | Elective Course IV (Choice 2) | Y | Y | - | - | 3 | 4 | 25 | 75 | 100 |

| Course Objectives | |
|---|---|
| CO1 | Analyze nanomaterials based on the understanding of nanobiotechnology. |
| CO2 | Discuss the methods of fabrication of nanomaterials. |
| CO3 | Gain Knowledge on characterization of nanomaterials. |
| CO4 | Discover nanomaterials for targeted drug delivery. |
| CO5 | Explain nanomaterials in nanomedicine and environmental pollution. |

| UNIT | Details | No.of Hours | Course Objectives |
|---|---|---|---|
| I | Introduction to nanobiotechnology, Nano size-changing phenomena at nano scale, Classification of nanomaterials based on their dimensions (0D, 1D, 2D and 3D materials) and based on realization of their applications (The First, second, third and fourth generation materials),Class of nanomaterials and their applications. Need for nanomaterials and the risks associated with the materials. | 12 | CO1 |
| II | Fabrication of Nanomaterials-Top-down and Bottom-up approaches, Solid phase synthesis-milling, Liquid phase synthesis-Sol-gel synthesis, colloidal synthesis, micro emulsion method, hydrothermal synthesis and solvo thermal synthesis, Vapor/Gas phase synthesis-Inert gas condensation, flame pyrolysis, Laser ablation and plasma synthesis techniques. Microbial synthesis of nanoparticles. | 12 | CO2 |
| III | Characterization of nanoparticles – Based on particle size/morphology- Dynamic light scattering (DLS), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM), Based on surface charge-zeta potential, Based on structure –X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), Energy dispersive X-ray analysis (EDX),Based on optical properties- UV – Spectrophotometer, Based on magnetic properties-Vibrating sample magnetometer(VSM). | 12 | CO3 |
| IV | Nanomaterial based Drug delivery and therapeutics-surface modified nano particles, MEMS/NEMS based devices, peptide/DNA coupled nanoparticles, lipid and inorganic nano particles for drug delivery, Metal/metaloxide nano particles as antibacterial, antifungal and antiviral agents. Toxicity of nanoparticles and Toxicity Evaluation. | 12 | CO4 |

| | | | |
|---|---|---|---|
| V | Nanomaterials in diagnosis-Imaging, nanosensors in detection of pathogens. Treatment of surface water, ground water and waste water contaminated by toxic metal ions, organic and inorganic solutes and microorganisms. | 12 | CO5 |
| | Total | 60 | |

| **Course Outcomes** | | |
|---|---|---|
| **Course Outcomes** | On completion of this course, students will; | |
| CO1 | Employ knowledge in the field of nanobiotechnology for development. | PO1,PO9 |
| CO2 | Identify various applications of nanomaterials in the field of medicine and environment. | PO1,PO9 |
| CO3 | Examine the prospects and significance of nanobiotechnology. | PO1,PO6,PO11 |
| CO4 | Identify recent advances in this area and create a career or pursue research in the field. | PO1,PO5,PO7,PO9 |
| CO5 | Design non-toxic nanoparticles for targeted drug delivery. | PO1,PO5,PO7,PO9, PO11 |

**Text Books**


1. Brydson R. M., Hammond, C. (2005). Generic Methodologies for Nanotechnology: Characterization. In Nanoscale Science and Technology. John Wiley & Sons, Ltd.
2. Leggett G. J., Jones R. A. L. (2005). Bionanotechnology. In Nanoscale Science and Technology. John Wiley & Sons, Ltd.
3. Mohan Kumar G. (2016). Nanotechnology: Nanomaterials and nanodevices. Narosa Publishing House.
4. Goodsell D. S. (2004). Bionanotechnology. John Wiley & Sons, Inc.
5. Pradeep T. (2007). Nano: The Essentials-Understanding nanoscience and nanotechnology. Tata McGraw-Hill.


**References Books**


1. Nouailhat A. (2008). An Introduction to Nanoscience and Nanotechnology, Wiley.
2. Sharon M. and Maheshwar (2012). Bio-Nanotechnology: Concepts and Applications. New Delhi. Ane books Pvt Ltd.
3. Niemeyer C.M. and Mirkin C. A. (2005). Nanobiotechnology. Wiley Interscience.
4. Rehm, B. (2006). Microbial Bionanotechnology: Biological Self-Assembly Systems and Biopolymer-Based Nanostructures. Horizon Scientific Press.
5.. Reisner, D.E. (2009). Bionanotechnology: Global Prospects. CRC Press


**Web Resources**

1. https://www.gale.com/nanotechnology
2. https://www.understandingnano.com/resources.html

| | |
|---|---|
| 3. | http://dbtnanobiotech.com/index2.php |
| 4. | http://www.istl.org/11-winter/internet1.html |
| 5. | https://www.cdc.gov/niosh/topics/nanotech/default.html |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| Methods of Assessment | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand/ Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | | | M | | | | | M | | | | | |
| CO2 | S | | | | | | | | S | | | | | |
| CO3 | S | | | | | M | | | | | S | | | |
| CO4 | S | | | | S | | M | | S | | | | | |
| CO5 | S | | | | S | | M | | S | | S | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |

| 23UPMBC1E12 | Clinical Research and Clinical Trials | Elective CourseIV (Choice 3) | Y | Y | - | - | 3 | 4 | 25 | 75 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|

| Course Objectives | |
|---|---|
| CO1 | Provide an overview of history and methods involved in conducting clinical research. |
| CO2 | Design the principles involved in ethical, legal, and regulatory issues in clinical research on human subjects. |
| CO3 | Describe principles and issues involved in monitoring patient-oriented research. |
| CO4 | Formulate a well- defined quality assurance and quality control plans. |
| CO5 | Acquire business development skills in the area of clinical research. |

| UNIT | Details | No.of Hours | Course Objectives |
|---|---|---|---|
| I | Introduction to Clinical Research: Clinical Research: An Overview, Different types of Clinical Research. Clinical Pharmacology: Pharmacokinetics, Pharmacodynamics, Pharmacoepidemiology, Bioavailability, Bioequivalence, Terminologies and definition in Clinical Research. Drug Development Process: Drug Discovery Pipeline, Drug Discovery Process. Preclinical trail, Human Pharmacology (Phase-I), Therapeutic Exploratory trail (Phase-II), Therapeutic Confirmatory Trail (Phase-III) and Post marketing surveillance (Phase-IV). | 12 | CO1 |
| II | Ethical Considerations and Guideline in Clinical Research: Historical guidelines in Clinical Research-Nuremberg code, Declaration of Helsinki, Belmont report. International Conference on Harmonization (ICH)-Brief history of ICH, Structure of ICH & ICH Harmonization Process, Guidelines for Good Clinical Practice. Regulation in Clinical Research-Drug and cosmetic act, FDA, Schedule-Y- Ethics Committee and their responsibilities. Clinical Research Regulatory Submission & approval Process- IND, NDA and ANDA submission Procedure. DCGI submission procedure. Other Regulatory authorities- EMEA, MHRA, PhRMA. | 12 | CO2 |
| III | Clinical Trial Management: Key Stakeholders in Clinical Research, Ethics Committees and Institutional Review Board,Responsibilities of Sponsor. Responsibilities of Investigator, Protocol in Clinical Research Clinical Trial Design, Project Planning Project Managements - Informed Consent, Investigator's Brochure (IB), Selection of an Investigator and Site, Patient screening, Inclusion and exclusion criteria, Randomization, Blinding. Essential Documents in clinical research -IB, ICF, PIS, TMF, ISF, CDA & CTA. | 12 | CO3 |
| IV | Quality Assurance, Quality Control & Clinical Monitoring: | 12 | CO4 |

| | | | |
|---|---|---|---|
| | Defining the terminology-Quality, Quality system, Quality Assurance & Quality Control-QA audit plan.21 CRF Part 11,Site Auditing, Sponsor Compliance and Auditing, SOP For Clinical Research-CRF Review & Source Data Verification, Drug Safety Reporting Corrective and preventative action process. | | |
| V | Business Development in the Clinical Research Industry: Introduction & Stages of Business Development-Start-up Phase, Growth Phase, Maturity Phase, Decline Phase. Outsourcing in Clinical Research, Reasons for outsourcing to contract research organizations, The India Advantage, Scope and Future of CRO, List of Clinical Research Organizations in India, List of IT companies offering services in Clinical Research. Role of business development manager. | 12 | CO5 |
| | Total | 60 | |

| **Course Outcomes** | | |
|---|---|---|
| **Course Outcomes** | On completion of this course, students will; | |
| CO1 | Apprehend the Drug Development process and different phases of clinical trials. | PO1, PO2, PO3, PO5 |
| CO2 | Recognize the ethics and regulatory perspectives on clinical research trials activities. | PO3, PO5, PO6, PO9 |
| CO3 | Accentuate about clinical trials management concepts and documentation process. | PO2, PO4, PO6, PO9 |
| CO4 | Accomplish quality assurance and quality control to ensure the protection of human subjects and the reliability of clinical trial results. | PO2, PO4. PO6. PO7, PO9 |
| CO5 | To nurture skills recitation to commercial start up and industriousness. | PO4, PO8, PO9, PO11, PO13 |

| **Text Books** | |
|---|---|
| 1. | Gallin J. I., Ognibene F. P. and Johnson L. L. (2007). Principles and Practice of Clinical Research. (4th Edition). Elsevier, 2007.ISBN-10: 0128499052 |
| 2. | Friedman L. M., Furberg C. D. and Demets D. (1998). Fundamentals of Clinical Trials, Vol: XVIII. (3rd Edition). Springer Science & Business Media. |
| 3. | Hulley S. B., Cummings S. R.,Browner W. S., Grady D. G. and Newman T. B. (2013). Designing Clinical Research. (4th Edition). Jaypee Medical. ISBN-13: 978-1608318049. |
| 4. | Reed,G. (2004). Prescott and Dunn's Industrial Microbiology, 4thedn, CBS publication and distributors. |
| 5. | Himanshu B. Text book of Clinical Research, Pee Vee books. |
| **References Books** | |
| 1. | Friedman L.M., Fuberge C.D., DeMets D. and Reboussen, D.M. (2015). Fundamentals |

| | |
|---|---|
| | of Clinical Trials, Springer. |
| 2. | Browner W. S., (2012). Publishing and Presenting Clinical Research. (3rd Edition). Lippincott Williams and Wilkins. |
| 3. | Rondel R. K., Varley S. A. and Webb C. F. (2008). Clinical Data Management. (2nd Edition). Wiley. |
| 4. | Peppler, H.J. and Pearl Man, D. (1979). Fermentation Technology, Vol 1 & 2, 2nd Edition<br>Academic Press, London. |
| 5. | E1-Mansi, E.M.T., Bryce, C.F.A., Demain, A.L. and Allman,A.R. (2007). Fermentation Microbiology and Biotechnology. 2nd Edition, CRC press, Taylor and Francis Group. |
| **Web Resources** | |
| 1 | https://www.hzu.edu.in/uploads/2020/10/Textbook-of-Clinical-Trials-Wiley-(2004).pdf |
| 2 | https://www.routledge.com/A-Practical-Guide-to-Managing-Clinical-Trials/Pfeiffer-Wells/p/book/9780367497828 |
| 3 | https://www.auctoresonline.org/journals/clinical-research-and-clinical-trials |
| 4 | https://www.who.int/health-topics/clinical-trials#tab=tab_1 |
| 5 | https://www.cancerresearchuk.org/about-cancer/find-a-clinical-trial/what-clinical-trials-are/types-of-clinical-trials |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand/ Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain. |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons. |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations. |

**Mapping with Programme Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | S | | S | | | | | | | | | |
| CO2 | | | S | | S | S | | | S | | | | | |
| CO3 | | S | | S | | S | | | S | | | | | |
| CO4 | | S | | S | | S | S | | S | | | | | |
| CO5 | | | | S | | | | S | S | | S | | M | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1N01** | **Commercial Microbial Technology** | **NME- I** | **Y** | **-** | **-** | **-** | **2** | **4** | **25** | **75** | **100** |

**Course Objectives**

| | |
|---|---|
| CO1 | To study the scope of microbial products and their Therapeutics applications |
| CO2 | Learn about the industrially important microorganisms |
| CO3 | To learn the production and application of industrially important products |
| CO4 | To learn the primary and secondary microbial metabolites |
| CO5 | To under stand the production and entrepreneurial activities of microbial products |

| UNIT | Details | No.of Hours | Course Objectives |
|---|---|---|---|
| I | Introduction of microbial technology: definition, industrially important microbes, Fermentation- general concepts, Applications of fermentation; Scope and application of microbial technology: scope of microbial technology applications of microbial technology in Human Therapeutics, Agriculture, Food Technology SCP, Environment, Bioremediation, Biomining, Waste Water Treatment and Biosensors. | 6 | CO1 |
| II | Biology of industrially important microorganisms- *Streptomyces*, yeasts, *Spirulina* and *Penicillium*. Strategies of Strain improvement (mutation, rDNA, protoplast, metabolic regulation) Culture preservation-Stock culture collection centers–Criteria used for the selection of microorganisms for fermentation | 6 | CO2 |
| III | Alcohol production – beer and wine; Organic acids - Vinegar and lactic acid. Production of antibiotics – Penicillin and Streptomycin; Production of amino acids (Tryptophan), Enzymes (Amylase), Vitamins | 6 | CO3 |

| | | | |
|---|---|---|---|
| | (VitaminB12), Biotransformation (Steroid), Vaccines– (BCG,Polio) and Insulin | | |
| IV | Production of primary and secondary metabolites, Microorganisms in bioremediation, Microbial sensors, Techniques of whole cell immobilization. Advantages and Disadvantages of Immobilized enzymes over native enzymes; Various Immobilized products of commercial interest. Preservation and improvement of industrially important microorganisms: Preservation of microorganisms with advantages and disadvantages – long term and short-term preservation techniques. | 6 | CO4 |
| V | Microbial pesticide, microbial insecticide, microbial polysaccharides and polyesters, biocompost, biogas, microbial fuels. Genetically modified microorganisms. Applications of GMM- derived products. | 6 | CO5 |
| | Total | 30 | |

| **Course Outcomes** | | |
|---|---|---|
| **Course Outcomes** | On completion of this course, students will; | |
| CO1 | Learn the scope of microbial products and their Therapeutics applications | PO1, PO4, PO5, PO9, |
| CO2 | Understand the industrially important microorganisms | PO1, PO4, PO6, |
| CO3 | Learn about production and application of industrially important products | PO1, PO4, PO6, PO7, PO8 |
| CO4 | Learn the primary and secondary microbial metabolites | PO6,PO7, PO8,PO9, |
| CO5 | Understand the production and entrepreneurial activities of microbial products | PO1, PO4, PO5,PO6, PO7 |

| **Text Books** | |
|---|---|
| 1 | Stanbury, P. F., Whitaker and Hall, A. S. J. (). Principles of Fermentation Technology. Butterworth-Heinemann |
| 2 | Nicholl D. S. T. (2008). An Introduction to Genetic Engineering, Cambridge University Press. 2. Glick BR, Pasternak JJ. (2003). Molecular Biotechnology. ASM Press Washington D.C |
| 3 | Behrens D, Kraemer P. (1990). Bioprocess engineering: Down Stream processing & recovery of bioproducts, safety in biotechnology and regulations. Lectures. Germany. |
| 4 | Crueger W, Crueger A. (2000). A Text of Industrial Microbiology. 2nd Edition, Panima Publishing Corp. |
| 5 | Glaser AN, Nilaido H. (1995). Microbial Biotechnology: Fundamentals of Applied Microbiology. W.H Freeman & Co. |

| | |
|---|---|
| 6 | Prescott SC, Dunn CG. (2009). Industrial Microbiology. Agrobios (India) Publishers. |
| 7 | Raledge C, Kristiansen B. (2001). Basic Biotechnology. 2nd Edition, Cambridge University Press |

| **Methods of Evaluation** | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| **Methods of Assessment** | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, summary or overview |
| Application (K3) | Suggest ideas/concepts with examples, suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussions, Debating, or Presentations |

**Mapping with Programme Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | | | M | S | | | | S | | | | | |
| CO2 | S | | | M | | S | | | S | | | | | |
| CO3 | S | | | S | | S | S | S | | | | | | |
| CO4 | | | | | | S | S | S | S | | | | | |
| CO5 | S | | | M | S | M | S | | | | | | | |

**Second Year**

**Semester- III**

| Subject | Subject | Catego | L | T | P | S | Credits | Inst. | Marks |
|---|---|---|---|---|---|---|---|---|---|

| Code | Name | ry | | | | | | Hours | CIA | External | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **23UPMBC1C05** | **Soil and Environmental Microbiology** | **Core Course VII** | **Y** | **Y** | **-** | **-** | **5** | **6** | **25** | **75** | **100** |

| **Course Objectives** | |
|---|---|
| CO1 | Explain the role of microorganisms in soil fertility. |
| CO2 | Discuss the benefits of interactions among soil microbes and acquire awareness about microbes as biofertilizers and biocontrol agents. |
| CO3 | Create awareness. about components of environment, environmental pollution, and detection methods. |
| CO4 | Acquire in depth knowledge about solid and liquid waste treatments. |
| CO5 | Develop knowledge about organic matter degradation, bioremediation, and the environment risk assessment. |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | Soil Microbiology– Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity, and distribution of major group of microorganisms in soil. Quantification of soil microflora, role of microorganism in soil fertility. Mineralization of Organic & Inorganic Matter in Soil. Biological Nitrogen fixation- Chemistry and Genetics of BNF. Phytopathology and Disease cycle of Plant pathogens - Tikka and Citrus canker, Types of disease symptoms, Structural and Inducible biochemical defenses - Systemic Acquired Resistance (SAR), pathogenesis-related (PR) proteins, Plantibodies, Phenolics, Phytoalexins | 20 | CO1 |
| II | Microbial Interactions - Mutualism, Commensalism, Amensalism, Synergism, Competition, Rhizosphere-Rhizosphere effect, Mycorrhizae – Types, Endophytes, PGPR- Plant growth-promoting bacteria– symbiotic (*Bradyrhizobium, Rhizobium, Frankia*), Non-Symbiotic (*Azospirillum, Azotobacter*, Mycorrhizae, MHBs, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs. Biofertilizers and Biocontrol agents – Types, benefits, and application. Advantages, social and environmental aspects - Bt crops, golden rice. | 20 | CO2 |
| III | Components of Environment: Hydrosphere, lithosphere, atmosphere, and biosphere – definitions with examples; Energy flow in the ecosystem- Carbon, Nitrogen, Sulfur, and Phosphorous cycles. Physical factors affecting the distribution of microorganisms in various environments. Predisposing factors for Environmental diseases – infectious (water and airborne) and pollution-related, spread and control of these | 15 | CO3 |

| | | | |
|---|---|---|---|
| | diseases. Treatment and safety of drinking (potable) water, methods to detect potability of water samples. Space microbiology - Microbiological research in space environment. | | |
| IV | Waste management – Solid waste - Types - management - Factors affecting solid waste generation rates. Industrial effluent treatment, primary, secondary, tertiary, and advanced treatment process. Quality assessment of decontaminated matters and other biological effluents. Biological reference standards. Utilization of Solid Waste as Food, Feed and Fuel-Composting, Vermicomposting, Bio manure and Biogas production. E waste management. | 15 | CO4 |
| V | Degradation of organic matter - lignin, cellulose, hemicellulose, pectin, common pesticides- herbicides (2,4-D) and pesticides (DDT), heavy metals. Biodegradation of Xenobiotics - Recalcitrant Halocarbons, Recalcitrant TNTs, PCBs and Synthetic polymers. Biodegradation of Hydrocarbons. Biodeterioration of Textiles and Leather. Pollution Control Bodies and Environmental laws in India. Environmental impact assessment, EIA guidelines, US Environment protection Agency norms. | 20 | CO5 |
| | Total | 90 | |

**Course Outcomes**

| **Course Outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Depict diversity and significance of soil microbes and predict the role of microbes in biological nitrogen fixation. | PO1 |
| CO2 | Utilize the knowledge of microbial interactions, with beneficial application of biofertilizers for sustainable agriculture and benefits of biopesticides. | PO1, PO7, PO8 |
| CO3 | Explain the different types of microorganisms in water. Identify the causes of water pollution and the methods for quality assessment of water and control of water borne diseases. | PO1, PO5, PO6, PO7, PO8 |
| CO4 | Apply knowledge about waste treatments and microbial decomposition and bio-remediation process in environmental cleanup. | PO1, PO5 |
| CO5 | Plan a clear approach on environmental issues. Control pollution and explain protection laws to public. | PO1, PO5 |

**Text Books**


| | |
|---|---|
| 1. | Subba Rao. N.S. (2017). Soil Microbiology. (5$^{th}$Edition). MedTech Publishers. |
| 2. | Daniel. C.J. (2006). Environmental Aspects of Microbiology. (2$^{nd}$ Edition). Bright Sun Publications. |

| | |
|---|---|
| .3. | Rangaswami. G. and Mahadevan. A. (2006). Diseases of Crop Plants in India. (4th Edition). Prentice–Hall of India Pvt. Ltd. |
| 4. | Sharma P.D. (2010). Microbiology and Plant Pathology. (2nd Edition). Rastogi Publications. |
| 5. | Subba Rao. N.S. (2005). Soil Microorganisms and Plant Growth. (4th Edition). Oxford and IBH Publishing Pvt. Ltd. |
| **References Books** | |
| 1. | Pepper I.L., Gerba C.P. and Gentry T.J. (2014). Environmental Microbiology (1st Edition). Academic Press, Elsevier. |
| 2. | Bitton, G. (2011). Wastewater Microbiology. (4th edition). Wiley-Blackwell. |
| 3. | Bridgewater L. (2012). Standard Methods for the Examination of Water and Wastewater. American Public Health Association. |
| 4. | Shrivastava A.K. (2003). Environment Auditing. A.P.H. Publishing Corporation. |
| 5. | Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan. |
| **Web Resources** | |
| 1. | https://academic.oup.com/femsec/article/93/5/fix044/3098413 |
| 2. | http://www.fao.org/3/t0551e/t0551e05.htm |
| 3. | www.environmentshumail.blogspot.in/ |
| 4. | https://www.frontiersin.org/articles/10.3389/fpls.2017.01617/full |
| 5. | https://serc.carleton.edu/microbelife/index.html |

| **Methods of Evaluation** | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| **Methods of Assessment** | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand/ Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest ideas/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |

| | |
|---|---|
| Create (K6) | Check knowledge in specific or offbeat situations, Discussions, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | | | | | | | | | | | | | |
| CO2 | M | | | | | | M | M | | | | | | |
| CO3 | M | | | | S | S | S | S | | | | | | |
| CO4 | M | | | | M | | | | | | | | | |
| CO5 | M | | | | M | | | | | | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1C06** | **Molecular Biology and Recombinant DNA Technology** | **Core Course VIII Theory** | **4** | **2** | **-** | **-** | **5** | **6** | **25** | **75** | **100** |

**Course Objectives**

| | |
|---|---|
| CO1 | Provide knowledge on the structure, replication and repair mechanisms of DNA. Illustrate the structure, functions and significance of RNA. |
| CO2 | Discuss the gene regulatory mechanisms in prokaryotes and eukaryotes and importance of mutations. |
| CO3 | Provide in depth knowledge about artificial gene transfer mechanisms and selection of Recombinants. |
| CO4 | Impart knowledge on various molecular techniques and their importance in biotechnology. |
| CO5 | Explain the applications of genetic engineering in various fields. |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | DNA replication – modes and enzymes involved. Detailed mechanism of semi-conservative replication. Prokaryotic and eukaryotic transcription. Structure and processing of m-RNA, r-RNA and t-RNA. Ribosomes. Genetic Code and Wobble hypothesis, Translation in prokaryotes and eukaryotes, post translational modifications. | 20 | CO1 |
| II | Gene regulation and expression – Lac operon, arabinose and | 20 | CO2 |

| | | | |
|---|---|---|---|
| | tryptophan operons. Gene regulation in eukaryotic systems-repetitive DNA, gene rearrangement, promoters, enhancer elements. Molecular basis of gene mutation - Types of mutations - base substitutions, frameshift, deletion insertion, duplication, inversion. Silent, conditional, and lethal mutation. Chemical mutagenesis. Repair of DNA damage. Photoreactivation. SOS repair mechanism. Base excision repair. Nucleotide excision repair. Detection and analysis of mutations (Replica plating, Antibiotic enrichment, Ames test). | | |
| III | Tools and methods in gene cloning. Restriction endonucleases – nomenclature, classification and characteristics - DNA methylases, DNA polymerases, Ligases. Adapters, linkers, and homopolymer tailing. Artificial gene transfer techniques - electroporation, microinjection, protoplast fusion, and microparticle bombardment. Screening for recombinants. Gene cloning vectors for prokaryotes and eukaryotes - cloning properties and types of plasmids vectors (pBR322 and derivatives, pUC vectors and pGEM3Z) - Phage Vectors(M13 and Lambda), cosmids, phasmids, phagemids and BACs - Eukaryotic vectors - Yeast vectors – Animal and plant vectors – expression vectors. Shuttle vectors - Expression of foreign genes in bacteria, animals, plants, algae, and fungi – merits and demerits. | 20 | CO3 |
| IV | Genomic DNA and cDNA library-Construction and Screening. Subtractive hybridization for tissue-specific DNA libraries. Techniques in genetic engineering Characterization of cloned DNA: Hybrid arrested translation (HAT) - Restriction mapping - restriction fragment length polymorphism (RFLP) - Polymerase chain reaction (PCR) – Principles, types, and their applications. DNA sequencing - Primer walking, Sanger's method, and automated sequencing methods. Pyrosequencing – DNA chips and microarray. Protein engineering and techniques Site-directed mutagenesis – methods - Design and construction of novel proteins and enzymes, Basic concepts in enzyme engineering, engineering for kinetic properties of enzymes. protein folding, protein sequencing, protein crystallization. Applications of protein engineering. | 15 | CO4 |

| | | | |
|---|---|---|---|
| V | Plant biotechnology - constituents and concepts of sterilization - preparation, isolation, and selection of explant. Suspension cell culture, callus culture, protoplast isolation, culture & fusion. Anther and pollen culture for production. Animal biotechnology – equipment and media used for animal cell culture technology. Primary and established cell line culture and culture media. Applications of animal cell cultures. Serum protein media viability and cytotoxicity. Applications of Genetic Engineering - transgenic animals, Recombinant Cytokines, and their use in the treatment of animal infections. Monoclonal Antibodies in Therapy- Vaccines and their Applications in Animal Infections - Human Gene Therapy-Germline and Somatic Cell Therapy-Ex-vivoGene Therapy. In-vivoGene Therapy. Vectors in Gene Therapy-Viral and Non-Viral Vectors. Transgenic Plants. | 15 | CO5 |
| | Total | 90 | |

**Course Outcomes**

| **Course Outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Analyze, demonstrate, and appreciate DNA replication and protein synthesis. | PO4, PO6, PO9 |
| CO2 | Investigate the types of mutation and its impact on microbes. Illustrate various strategies for gene cloning. | PO4, PO6, PO9 |
| CO3 | Analyze, modify, and characterize DNA modifying enzymes. | PO4, PO6, PO9 |
| CO4 | Illustratively assess the molecular techniques for DNA and protein analysis. | PO4, PO6, PO9 |
| CO5 | Adopt the applications of Genetic Engineering in the field of agriculture and medicine towards scientific research. | PO1, PO3, PO4, PO5, PO6, PO7, PO8, PO9 |

**Text Books**


| | |
|---|---|
| 1. | Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi. |
| 2. | Snusted D.P. and Simmons M. J. (2019). Principles of Genetics. (7th Edition). John Wiley and Soms, Inc. |
| 3. | Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd. |
| 4. | Primrose S.B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics. (7th Edition). Blackwell Publishing. |
| 5. | Maloy S. R. Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2nd Edition). Narosa Publishing House Pvt. Ltd. |

| | References Books |
|---|---|
| 1. | Brown T. A. (2016). Gene Cloning and DNA Analysis- An Introduction. (7th Edition). John Wiley and Sons, Ltd. |
| 2. | Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press. |
| 3. | Russell P.J. (2010). Genetics - A Molecular Approach. (3rd Edition). Pearson New International Edition. |
| 4. | Synder L., Peters J. E., Henkin T.M. and Champness W. (2013). Molecular Genetics of Bacteria. (4th Edition). ASM Press Washington-D.C. ASM Press. |
| 5. | Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd. |
| | **Web Resources** |
| 1. | https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/ |
| 2. | https://geneticeducation.co.in/what-is-transcriptomics |
| 3. | https://www.molbiotools.com/usefullinks.html |
| 4. | https://geneticeducation.co.in/what-is-transcriptomics |
| 5. | https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/ |

| **Methods of Evaluation** | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| **Methods of Assessment** | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / ComprehendK2 | MCQ, True/False, Short essays, Concept explanations, summary or overview |
| Application (K3) | Suggest ideas/concepts with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

## Mapping with Programme Outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | S | M | S | L | L | S | L | L | | | |
| CO2 | | | | S | M | S | L | L | S | L | M | | | |
| CO3 | | | | S | M | S | L | L | S | L | M | | | |
| CO4 | | | | S | M | S | L | L | S | L | L | | | |
| CO5 | S | | S | S | S | S | S | S | S | M | L | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1L03** | **Practical III** | **Core Course IX Practicals** | **-** | **-** | **6** | **-** | **4** | **6** | **40** | **60** | **100** |

| **Course Objectives** | |
|---|---|
| CO1 | Illustrate the significance of artificial transformation and mutations. |
| CO2 | Discuss blotting techniques and PCR. |
| CO3 | Analyze and estimate water quality and potability |
| CO4 | Prepare Biofertilizers, vermicompost and test their efficiency |
| CO5 | Familiarize with common plant infections |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | Artificial Transformation<br>Detection of Antibiotic resistant mutants<br>Identification of mutants by replica plating method | 20 | CO1 |
| II | Amplification of DNA by PCR<br>Western blotting - Demonstration<br>Southern blotting – Demonstration | 15 | CO2 |
| III | Detection of Water hardness<br>Microbiological analysis of water<br>Total Heterotrophic Count<br>B) Test for indicative organisms<br>1) MPN<br>2) Membrane Filtration<br>Physical, chemical, assessment of water<br>Physical - Color, pH,<br>Chemical - alkalinity, acidity, DO, BOD, COD | 15 | CO3 |

| | | | |
|---|---|---|---|
| | Enumeration of bacteria and fungi from air – Air sampler<br>Isolation of free-living nitrogen fixers from soil and *Rhizobium* from root nodules of leguminous plants.<br>Isolation and enumeration of phosphate-solubilizing bacteria from soil | | |
| IV | Preparation of Biofertilizers and testing the efficiency of prepared biofertilizers<br>R:S ratio of soil microbes<br>Estimation of soil enzymes- urease and phosphatase<br>Study of phylloplane microflora by leaf impression method<br>Isolation of cellulose degrading bacteria<br>Preparation of a vermicompost<br>Isolation of VAM fungi from soil<br>Isolation of plant pathogen - *Alternaria* &*Curvularia*spps.,<br>Cultivation of edible mushroom from solid waste<br>Cultivation of *Azolla* | 20 | CO4 |
| V | Visual examination, observation, and identification of some common plant infections.<br>To test Koch postulates using plant pathogens<br>Collection of 5 herbarium specimens of infected leaves. | 20 | CO5 |
| | Total | 90 | |

**Course Outcomes**

| Course Outcomes | On completion of this course, students will; | |
|---|---|---|
| **CO1** | Utilize various molecular techniques for gene manipulation and detection of mutants. | PO4, PO6, PO7, PO9, PO11 |
| **CO2** | Undertake novel research with techniques like PCR and blotting analysis. | PO4, PO6, PO7, PO10, PO11 |
| **CO3** | Assess the microbial quality of water and air and relate the results to standards. | PO1, PO4, PO5, PO7, PO8 |
| **CO4** | Synthesize biofertilizers and vermicompost. Cultivate mushrooms using solid waste. | PO1, PO4, PO5, PO7, PO8 |
| **CO5** | Identify various plant pathogens | PO5, PO10 |

**Text Books**


| | |
|---|---|
| 1. | Russell P. J. (2019). Genetics – A Molecular Approach (3rd Edition). Pearson Education, Inc. |
| 2. | Glick B. R. and Patten C. L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA (5th Edition). ASM Press. |
| 3. | Gunasekaran P. (2007). Laboratory Manual in Microbiology. New Age International. |
| 4. | James G Cappucino. and Natalie Sherman. (2016). Microbiology – A laboratory manual. (5th Edition). The Benjamin publishing company. New York. |

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|---|---|
| 5. | Hurst, C.J., Crawford R.L., Garland J.L., Lipson D.A., Mills A.L. and Stetzenbach L.D. (2007). Manual of Environmental Microbiology. (3rd Edition). American Society for Microbiology. |
| **References Books** | |
| 1. | Sambrook J. and Russell D.W. (2001). Molecular Cloning: A Laboratory Manual. (7th Edition). Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press. |
| 2. | Brown T.A. (2016). Gene Cloning and DNA Analysis. (7th Edition). John Wiley and Jones, Ltd. |
| 3. | Dale J. W., Schantz M. V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd. |
| 4. | Pepper I., Gerba C. and Brendecke J. (2004). Environmental Microbiology - A Laboratory Manual. (2nd Edition). Academic Press, Elsevier. |
| 5. | Yates M.V., Nakatsu C.H., Miller R.V. and Pillai, S.D. (2016). Manual of Environmental Microbiology. (4th Edition). Wiley. |
| **Web Resources** | |
| 1. | https://www.molbiotools.com/usefullinks.html |
| 2. | https://geneticgenie.org3. |
| 3. | https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5 |
| 4. | https://vlab.amrita.edu/index.php?sub=3&brch=272 |
| 5. | https://nptel.ac.in/courses/102105087 |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 40 Marks |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 60 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | S | M | S | S | M | S | M | S | | | |
| CO2 | | | | S | M | S | S | M | M | S | S | | | |
| CO3 | M | | | S | S | | S | M | | | | | | |
| CO4 | M | | | S | S | | S | S | | | | | | |
| CO5 | | | | | M | | | | | M | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1C07** | **Fermentation technology and Pharmaceutical Microbiology** | **Core Course X Industry Module** | **3** | **1** | **-** | **-** | **5** | **6** | **25** | **75** | **100** |

**Course Objectives**

| | |
|---|---|
| CO1 | Discuss about fermentation and its types, sensitize on methods of strain development for improved yield. |
| CO2 | Impart knowledge on the fermenter design and types. |
| CO3 | Acquire knowledge on the effective recovery and purification of the products. |
| CO4 | Explain the importance of pharmaceutical microbiology. |
| CO5 | Illustrate methods for production products using microorganisms and their quality control. |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | Bioprocesses - concepts and design. Industrially important microorganisms – Isolation, primary and secondary screening, preservation and improvement of industrially important strains. Upstream processing - Development of inoculums for fermentation process. Media for industrial fermentation - Formulation, optimization. Sterilization. Stages of upstream - Growth of inoculums, fermenter pre-culture and production fermentation. Types of fermentation - Batch, continuous, dual or multiple, surface, submerged, aerobic and anaerobic. | 12 | CO1 |
| II | Fermenter – Design, types and construction, Instrumentation and control. Productivity. Yield | 12 | CO2 |

| | | | |
|---|---|---|---|
| | coefficients. Heat production. Aeration and agitation. Gas exchange and mass transfer. Computer Applications in fermentation technology. Fermentation Economics. | | |
| III | Downstream Processing - Recovery and purification of intracellular and extracellular products. Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration - Physical, chemical and enzymatic methods. Extraction - Solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction. Purification by different methods. Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization. | 12 | CO3 |
| IV | Overview of pharmaceutical microbiology - Ecology of microorganisms - Atmosphere, water, skin, respiratory flora of workers, raw materials, packaging, building equipment and their control measures. Design and layout of sterile manufacturing unit. Contamination and Spoilage of Pharmaceutical products - sterile injectable and non-injectable, ophthalmologic preparation, implants. | 12 | CO4 |
| V | Production of pharmaceutical products and quality assurance – Vaccines, immunodiagnostics, immuno-sera, immunoglobulin. Antibiotics - Penicillin, Griseofulvin, Metronidazole. Enzymes - Streptokinase, Streptodornase. Quality assurance and quality management in pharmaceuticals – In-Process, Final-Product Control and sterility tests. Regulatory aspects - BIS (IS), ISI, ISO, WHO and US certification. | 12 | CO5 |
| | Total | 60 | |

**Course Outcomes**

| **Course Outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Develop microbial strains, carry out fermentation and recover the products of the process. | PO6, PO7, PO8, PO9 |
| CO2 | Design fermenters according to needs for various products. | PO6, PO7, PO8, PO9 |
| CO3 | Recover the end products of the fermentation process economically. | PO4, PO6, PO7, PO8, PO9 |
| CO4 | Utilize the knowledge on pharmaceutical microbiology for industrial production of products. | PO6, PO7, PO8 |
| CO5 | Produce therapeutic products from microbes employing technology and analyze the quality the products. | PO6, PO7, PO8 |

**Text Books**


| | |
|---|---|
| 1. | Patel A. H. (2016). Industrial Microbiology. (2nd Edition). Laxmi Publications, |

| | |
|---|---|
| | New Delhi. |
| 2. | Casida L. E. J. R. (2019). Industrial Microbiology. New Age International Publishers. |
| 3. | Sathyanarayana U. (2005). Biotechnology. (1st Edition). Books and Allied (P) Ltd. |
| 4. | Reed G. (2004). Prescott and Dunn's Industrial Microbiology. (4th Edition). CBS Publishers & Distributors. |
| 5. | Waites M. J., Morgan N. L., Rockey J. S. and Higton G. (2013). Industrial Microbiology: An Introduction. Wiley Blackwell Publishers. |
| **References Books** | |
| 1. | Stanbury P. T. and Whitaker. (2016). Principles of Fermentation Technology. (3rd Edition). Pergamon Press. NY. |
| 2. | Handa S. S. and Kapoor V. K. (2022). Pharamcognosy, (4th Edition). Vallabh Prakashan Publishers, New Delhi. |
| 3. | Kokate C. K., Durohit A. P. and Gokhale S. R. Pharmacognosy. (2002). (12th Edition). Nirali Prakasham Publishers, Pune. |
| 4. | Hugo W. B. and Russell A. D. (2004). Pharmaceutical Microbiology. (7th Edition). Blackwell Scientific Publication, Oxford. |
| 5. | Wallis, T.E. (2005). Text book of Pharmacognosy. (5th Edition). CBS publishers and distributors, New Delhi. |
| **Web Resources** | |
| 1. | https://ib.bioninja.com.au/options/untitled/b1-microbiology organisms/fermenters.html |
| 2. | https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/penicillin.html |
| 3. | https://www.sciencedirect.com/topics/biochemistry-genetics-andmolecular-biology/ethanol-fermentation |
| 4. | https://www.usp.org/sites/default/files/usp/document/harmonization/genmethod/q05b_pf_ira_34_6_2008.pdf |
| 5. | http://www.simbhq.org/ |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Test | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |

| | |
|---|---|
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | L | L | M | L | | | | | |
| CO2 | | | | | | L | M | L | S | | | | | |
| CO3 | | | | M | | L | M | M | L | | | | | |
| CO4 | | | | | | L | L | M | | | | | | |
| CO5 | | | | | | L | M | L | | | | | | |

| **Subject Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **S** | **Credits** | **Inst. Hours** | **Marks** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **CIA** | **External** | **Total** |
| **23UPMBC1E13** | **Biosafety, Bioethics and IPR** | **Elective Course V (Choice 1)** | **Y** | **Y** | **-** | **-** | **3** | **3** | **25** | **75** | **100** |

| **Course Objectives** | |
|---|---|
| CO1 | Create a research environment. Encourage investigation, analysis and study the bioethical principles, values, concepts, and social and juridical implications in the areas of science, biotechnology and medicine. |
| CO2 | Discuss about various aspects of biosafety regulations, IPR and bioethics concerns arising from the commercialization of biotechnological products. |
| CO3 | Familiarize fundamental aspects of Intellectual property Rights in the development and management of innovative projects in industries. |
| CO4 | Acquire knowledge about bioethics, biodiversity and Genetically modified foods and food crops |
| CO5 | Provide students with an understanding of bioethics in research associated with medicine |

| UNIT | Details | No.of Hours | Course Objectives |
|---|---|---|---|
| I | Intellectual Property Rights: Different forms of Intellectual Property Rights – their relevance, importance to industry, Academia. Role of IPR's in Biotechnology, Patent Terminology - Patents, trademarks, copyrights, industrial designs, geographical indications, trade secrets, non-disclosure agreements. Patent life and geographical boundaries. International organizations and IPR - Overview of WTO, TRIPS, WIPO, GATT, International conventions, Trade agreements, Implication of TRIPS for developing countries. | 12 | CO1 |
| II | Process involved in patenting. Patent Search - Procedural steps in patenting,process of filing, PCT application, pre-grant &post-grant opposition, PCT and patent harmonization including Sui-generis system, patent search methods, patent databases and libraries, online tools, Country-wise patent searches (USPTO, EPO, India etc.), patent mapping. | 12 | CO2 |
| III | Patentability of biotechnology inventions - Patentability of biotechnology inventions in India, statutory provisions regarding biotechnological inventions under the current Patent Act 1970 (as Amended 2005). Biotechnological inventions as patentable subject matter, territorial nature of patents - from territorial to global patent regime, interpreting trips in the light of biotechnology inventions, feasibility of a uniform global patent system, merits and demerits of uniform patent law, relevance of the existing international patent, tentative harmonisation efforts, implications of setting up a uniform world patent system. | 12 | CO3 |
| IV | Introduction to bioethics - need of bioethics, applications and issues related to bioethics, social and cultural issues. Bioethics and biodiversity - conserving natural biodiversity, convention on protecting biodiversity, protocols in exchanging biological material across borders. Bioethics & GMO's - issues and concerns pertaining to genetically modified foods and food crops, organisms and their possible health implications and mixing up with the gene-pool. | 12 | CO4 |
| V | Bioethics in medicine - Protocols of ethical concerns related to prenatal diagnosis, gene therapy, organ transplantation, xeno transplantation, ethics in patient care, informed consent. bioethics and cloning - permissions and | 12 | CO5 |

| | | | |
|---|---|---|---|
| | procedures in animal cloning, human cloning, risks and hopes. Bioethics in research: stem cell research, human genome project, use of animals in research, human volunteers for clinical research, studies on ethnic races. he Nuremberg code. | | |
| | Total | 60 | |

| **Course Outcomes** | | |
|---|---|---|
| **Course Outcomes** | On completion of this course, students will; | |
| CO1 | Execute the role of IPR, Patent, Trademarks and its importance. | PO1, PO2, PO3, PO5, PO6 |
| CO2 | Develop patent procedure, patent filling and its mapping. | PO3, PO4, PO13 |
| CO3 | Become Patent attorneys and Patent officers. | PO2, PO3, PO4, PO7, PO9 |
| CO4 | Applybioethics in GMO, food crops and its biodiversity. | PO2, PO3, PO5, PO9 |
| CO5 | Analyze the importance of bioethics in research associated with HGP, clinical research, stem cell therapy. | PO1, PO3, PO5, PO6, PO9, PO10 |

| **Text Books** | |
|---|---|
| 1. | Usharani B., Anbazhagi S. and Vidya C. K. (2019). Biosafety in Microbiological Laboratories. (1st Edition). Notion Press. ISBN-101645878856 |
| 2. | Satheesh M. K. (2009). Bioethics and Biosafety. (1st Edition). J. K International Publishing House Pvt. Ltd: Delhi. ISBN: 9788190675703 |
| 3. | Goel D. and Parashar S. (2013). IPR, Biosaftey and Bioethics. (1st Edition). Pearson education: Chennai. ISBN-13: 978-8131774700 |
| 4. | Raj Mohan joshi. Biosafety and Bioethics. Wiley Publications. |
| 5. | Sibi. G Intellectual, Property Rights, Bioethics, Biosafety and Entrepreneurship in biotechnology. (2021). Wiley Publications. |

| **References Books** | |
|---|---|
| 1. | Nithyananda K. V. (2019). Intellectual Property Rights: Protection and Management, India, IN: Cengage Learning India Private Limited. |
| 2. | Neeraj, P. and Khusdeep, D. (2014). Intellectual Property Rights, India, IN: PHI learning Private Limited, |
| 3. | Ahuja, V K. (2017). Law relating to Intellectual Property Rights, India, IN: Lexis Nexis. |

| | |
|---|---|
| 4. | Tony Hope (2004). Medical Ethics: A very Short introduction,. Oxford Publication. |
| 5. | Goel Parashar. IPR, Biosafety and Bioethics (2013). Pearson Publications. |

| **Web Resources** | |
|---|---|
| 1. | http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf. |
| 2. | https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub _489.pdf. |
| 3. | https://www.cdc.gov/training/quicklearns/biosafety/ |
| 4. | https://bioethics.msu.edu/what-is-bioethics |
| 5. | https://www.wto.org/english/tratop_e/trips_e/intel1_e.htm |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend(K2 | MCQ, True/False, Short essays, Concept explanations, Short summary or Overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | S | | S | S | | | | | | | | |
| CO2 | | | S | S | | | | | | | | | M | |
| CO3 | | S | S | S | | | S | | S | | | | | |
| CO4 | | S | S | | S | | | | S | | | | | |
| CO5 | S | | S | | S | S | | | S | M | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1E14** | **Toxicology** | **Elective Course V (Choice 2)** | **3** | **1** | **-** | **-** | **3** | **3** | **25** | **75** | **100** |

**Course Objectives**

| | |
|---|---|
| CO1 | Recognize the various categories of environmental toxins and their hazardous consequence |
| CO2 | Enhance the knowledge of the underlying etiology of diseases |
| CO3 | Strengthen the evidence for a causal link between exposure to hazardous agents and the development of diseases |
| CO4 | Illustrate various techniques to isolate and characterize the toxin |
| CO5 | Examine, interpret, and discuss the certainty of toxic substances, proposing a deep understanding of medicinal and industrial applications |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | General Introduction - Definition of toxins, different categories of toxins and venoms, recent trends in venom and toxin research. | 12 | CO1 |
| II | Bacterial toxins - Bacterial toxins Bacterial toxinogenesis, endotoxins, exotoxins, exotoxins, bacterial protein toxins with special reference to cholera, diphtheria, and tetanus toxins, molecular mechanism of action of endotoxins, exotoxins, enterotoxins, neurotoxins and mycotoxins. | 12 | CO2 |
| III | Plant toxins & Toxins from snake venom - Natural toxins in plants, Plant toxic proteins, impact of plant toxin on humans, natural toxins in food, plants, allelopathy. Toxins from snake venom Snakes and the Biological significance of their venoms, composition of snake venom, evolution of venom, 3D structure of some important venom constituents and their | 12 | CO3 |

| | | | |
|---|---|---|---|
| | mechanism of action (phospholipase A2, cardiotoxin, neurotoxin) three-finger toxins, anti-venom and medicinal plants in the treatment of snakebite patients. | | |
| IV | Tools for isolation and characterization of toxins - Multidimensional chromatographic techniques (gel-filtration, ion-exchange reverse-phase HPLC, SDS-PAGE, 2-dimensional gel electrophoresis), toxin mass fingerprinting, N-terminal peptide sequencing, analysis of protein data by using proteomics software. | 12 | CO4 |
| V | Medicinal and industrial applications of venoms and toxins. Use of toxins in neurobiology and muscular research, anticancer drugs, diagnosis of hemostatic disorders, antibacterial agents, bioinsecticides, and other industrial applications. | 12 | CO5 |
| | Total | 60 | |

**Course Outcomes**

| **Course Outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Perceive the adverse effects of toxin and its potential role in research. | PO1, PO2, PO9 |
| CO2 | Assess the toxicity, properties, and mode of action of microbial toxins. | PO2, PO4, PO6, PO10 |
| CO3 | Explicate the mode of actions and their biological significance. | PO1, PO2, PO4 |
| CO4 | Evaluate the toxicity level with the help of advanced techniques. | PO6, PO7. PO9.PO11 |
| CO5 | Elucidate the various natures of application of toxic substances. | PO4, PO5, PO6, PO8, PO9 |

**Text Books**


| | |
|---|---|
| 1. | Holst O. (2008). Bacterial Toxin –Methods & Protocols. Humana Press.ISBN 9781592590520. |
| 2. | Shier W. T. (1990). Handbook of Toxicology. CRC Press. ISBN 9780824783747. |
| 3. | Wilson K. and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. (7th edition). Cambridge University Press India Pvt. Ltd. ISBN 1-4051-3544-1. |
| 4. | Pholtan Rajeev S.R. (2021Pictorial handbookfortoxinology. Rudra Publications. |
| 5. | Cora Lancester. (2015). Molecular Toxinology Handbook. Callisto Reference |

| References Books | |
|---|---|
| 1. | Reilly M.J. (2018). Bioinstrumentation. CBS Publishers and Distributors Pvt Ltd. ISBN 13 978-8123928395. |
| 2. | Greenberg M., Hamilton R., Phillips S. and McCluskey G. J. (2003). Occupational, Industrial and Environmental Toxicology. St Louis: C.V. Mosby. |
| 3. | Wiley-Vch. (2005). Ullmann's Industrial Toxicology. New York: John Wiley & Sons. |
| 4. | Winder C. and Stacey N.H. and Boca Raton F. L.(2004). Occupational Toxicology. (2nd Edition). CRC Press. |
| 5. | Gopalakrishnakone(2015). Biological Toxins and Bioterrorism. Springer. |
| **Web Resources** | |
| 1. | https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5869414/ |
| 2. | https://www.reseachgate.net/publication/269037373_TOXIN_AS_A_MEDICINE |
| 3. | https://www.toxinology.org/ |
| 4. | https://www.mdpi.com/journal/toxins/special_issues/snakebite_clinical_toxinology |
| 5. | https://pubmed.ncbi.nlm.nih.gov/12807310 |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest ideas/concepts with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate K5 | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussions, Debating, or |

| | |
|---|---|
| | Presentations |

## Mapping with Programme Outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | | | | | | | S | | | | | |
| CO2 | | S | | S | | S | | | | S | | | | |
| CO3 | S | S | | S | | | | | | | | | | |
| CO4 | | | | | | S | S | | S | | S | | | |
| CO5 | | | | S | S | S | | S | S | | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1E15** | **Recent Applications of Biosensors** | **Elective Course V (Choice 3)** | **Y** | **Y** | **-** | **-** | **3** | **3** | **25** | **75** | **100** |

### Course Objectives

| | |
|---|---|
| CO1 | To gain knowledge on fundamentals of biosensor |
| CO2 | To familiarize the student with the design and construction of biosensors |
| CO3 | To expose the students to recent advances in the application of biosensors in health, environment, agriculture, and food industry |
| CO4 | To gain knowledge on the application of nanomaterials in biosensors |
| CO5 | |

| UNIT | Details | No.of Hours | Course Objectives |
|---|---|---|---|
| I | Definition and general components of biosensors, biomolecules in biosensors such as enzymes, DNA, antigen-antibody, protein, classification of biosensors based on principle: amperometric, potentiometric biosensors, optical, acoustic, piezoelectric, and calorimetric biosensors, scope of biosensors, and its limitations. | 12 | CO1 |
| II | Design Considerations: calibration, dynamic Range, signal to noise, sensitivity, selectivity, Interference recognition. Transduction membrane protein sensors: ion channels, Types of Transducers, Optical; Fiber Optic, ECL, Surface Plasmon Resonance, Electrochemical; FET, Impedance, Piezoelectric, and Cantileave. | 12 | CO2 |

| | | | |
|---|---|---|---|
| III | Biosensors and diabetes management, Microfabricated biosensors and point-of-care diagnostics systems, Noninvasive biosensors in clinical analysis; Surface plasmon resonance and evanescent wave biosensors, Biosensors in cancer and HIV early diagnosis. | 12 | CO3 |
| IV | Detection of product content, allergic components, pathogens, and pesticide residues. Monitoring of raw material conversions. Detection of crop diseases, pathogens in plants, Detection of soil nutrients, pesticides, and residual detection. | 12 | CO4 |
| V | Nano Materials in biosensors; Carbon-based Nano Material, Metal oxide and nanoparticle, Quantum dots, Role of nanomaterial in Signal Amplifications, Detection, and Transducer Fabrication | 12 | CO5 |
| | Total | 60 | |

**Course Outcomes**

| **Course Outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Able to classify types of biosensors based on principle | PO1, PO2, PO4, PO5, PO10 |
| CO2 | Able to differentiate different types of transducers based on their physicochemical characteristics | PO1, PO2, PO5, PO10, PO14 |
| CO3 | Apply biosensor technology in the health, environment, agriculture, and food industry | PO4, PO6, PO10 |
| CO4 | Use biomaterial and nanomaterials in biosensors for signal amplification, Detection, and Transducer Fabrication | PO4, PO5, PO6, PO9 |

**Text Books**


| | |
|---|---|
| 1. | Jeong-Yeol Yoon. (2016). Introduction to Biosensors, Springer-Verlag New York Ed. |
| 2. | Mohammed Zourob. (2010). Recognition Receptors in Biosens; Publisher: Springer-Verlag New York Ed. |
| 3. | Zvi Liron. (2001). Novel Approaches in Biosensors and Rapid Diagnostic Assays; Publisher: Springer US Ed. |
| 4. | Pierre R. C and Loïc J.B. (2019). Biosensor Principles and Applications, CRC Press. |


**Methods of Evaluation**

| | | |
|---|---|---|
| Internal | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |

| | | |
|---|---|---|
| Evaluation | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| **Methods of Assessment** | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | | S | S | | | | | S | | | | |
| CO2 | S | S | | | S | | | | | S | | | | S |
| CO3 | | | | S | | S | | | | S | | | | |
| CO4 | | | | S | S | S | | | S | | | | | |
| CO5 | | | | | S | | M | S | S | S | S | | | |

| **Subject Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **S** | **Credits** | **Inst. Hours** | **Marks** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **CIA** | **External** | **Total** |
| **23UPMBC1N02** | **Organic Farming and Bio fertilizer Technology** | **NME- II** | 2 | - | - | - | 2 | 3 | 25 | 75 | 100 |

| **Course Objectives** | |
|---|---|
| CO1 | Impart knowledge on the importance, types and advantages of organic farming thereby creating awareness on conserving environment and natural resources, |

| | |
|---|---|
| | encouraging sustainable agriculture. |
| CO2 | Familiarize with the basic concepts of farm development and relate the development of organic farming in their countries to meet global trends. |
| CO3 | Explain the various types of biofertilizer and the scope in its production. |
| CO4 | Discuss about biofertilizer production and its field application, promoting economy. |
| CO5 | Develop the skill to analyze the quality of packaging, storage, assess the shelf life and bio efficacy of biofertilizers |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | Organic farming – Definition, relevance. Biological nutrient management- Organic manures, vermicompost, green manure, organic residue, biofertilizer soil amendments. Integrated pest and weed management - Use of biocontrol agents, bio pesticides etc. Organic and Conventional farming. Organic and Chemical farming – Comparison. | 6 | CO1 |
| II | Certification and Schemes - Certification and Schemes. Organic certification in brief. Integrated farming system-definition, goal, components. Factors affecting ecological balance. Land degradation. Soil health management. Models of IFS for rainfed and irrigated conditions and different categories of farmers. Government schemes - NPOF, NPOF, NHM, HMNEH, NPMSH&F and RKVY. | 6 | CO2 |
| III | Biofertilizers - Introduction, types, advantages and future perspective. Introduction, status and scope. Structure and characteristic features of bacterial biofertilizers- *Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium* and *Frankia*. | 6 | CO3 |
| IV | Cyanobacterial biofertilizers- Anabaena, Nostoc, *Hapalosiphon*and fungal biofertilizers- AM mycorrhiza and ectomycorhiza. Nitrogen fixation -Free living and symbiotic nitrogen fixation. Mechanism of phosphate solubilization and phosphate mobilization, potassium solubilization. | 6 | CO4 |
| V | Production technology - Strain selection, sterilization, growth and fermentation, mass production of carrier based and liquid bio-fertilizers. FCO specifications and quality control of biofertilizers. Application technology for seeds, seedlings, tubers. Biofertilizers -Storage, shelf life, quality control and marketing. Factors influencing the efficacy of biofertilizers. | 6 | CO5 |
| | **Total** | **30** | |

**Course Outcomes**

| Course Outcomes | On completion of this course, students will; | |
|---|---|---|
| CO1 | Produce biofertilizers and distinguish between organic and conventional farming. | PO1, PO3, PO4, PO5, PO6, PO7, P08, PO9, PO10, PO11, PO12, PO14 |
| CO2 | Plan a Complete Farm Business including marketing, operation and financial outline. | PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8 |
| CO3 | Practice the application of microbial bio-fertilizers in large scales, thereby increasing soil fertility. | PO4, PO5, PO6 |
| CO4 | Develop integrated farming for sustainable agriculture. | PO6, PO9, PO10 |
| CO5 | Promote the quality of packaging, storage, increase shelf life, accelerate the bio efficacy of bio fertilizers as per BIS standards | PO5, PO7, PO8, PO11, PO13, PO14 |

| **Text Books** | |
|---|---|
| 1. | Sharma A. K. (2001). Hand book of Organic Farming.Agrobios. |
| 2. | Gaur A. C. (2006). Hand book of Organic Farming and Biofertilizers. Ambika Book Agency. |
| 3. | Subba Rao N.S. (2017). Bio-fertilizers in Agriculture and Forestry. (4th Edition). Med Tech publisher. |
| 4. | Subba Rao N. S. (2002). Soil Microbiology. Soil Microorganisms and Plant Growth. (4th Edition). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. |
| 5. | Sathe T.V. (2004). Vermiculture and Organic Farming. Daya Publishers. |
| **References Books** | |
| 1. | Rakshit A. and Singh H. B. (2015). ABC of Organic Farming. (1st Edition). Jain Brothers. |
| 2. | Dubey R. C. (2008). A Textbook of Biotechnology. S. Chand & Co., New Delhi. |
| 3. | Bansal M. (2019). Basics of Organic Farming. CBS Publisher. |
| 4. | Bhoopander G., Ram Prasad., (2019 ) Biofertilizer for sustainable agriculture and Environment, Springer |
| 5. | Niir Board., ( 2012) (1st Edition ) Biofertiliser and organic farming |
| **Web Resources** | |
| 1. | https://agritech.tnau.ac.in/org_farm/orgfarm_introduction.html |
| 2. | https://www.fao.org/organicag/oa-faq/oa-faq6/en/ |
| 3. | https://www.india.gov.in/topics/agriculture/organic-farming |
| 4. | https://agriculture.nagaland.gov.in/bio-fertilizer/ |

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|---|---|
| 5. | https://www.ccd.ngo/sustainable-agriculture.html?gclid=EAIaIQobChMI5a-KndCo-wIV2ZZLBR1ozQj9EAAYAiAAEgJW2_D_BwE |

| **Methods of Evaluation** | | |
|---|---|---|
| **Internal Evaluation** | Continuous Internal Assessment Test | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| **External Evaluation** | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| **Methods of Assessment** | |
|---|---|
| **Recall (K1)** | Simple definitions, MCQ, Recall steps, Concept definitions |
| **Understand/ Comprehend (K2)** | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| **Application (K3)** | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| **Analyze (K4)** | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| **Evaluate (K5)** | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| **Create (K6)** | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| CO /PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | | S | S | S | S | S | S | S | S | S | S | | S |
| CO2 | S | S | S | M | M | M | S | M | | | | | | |
| CO3 | | | | S | S | S | | | | | | | | |
| CO4 | | | | | | M | | | S | S | | | | |
| CO5 | | | | | M | | S | S | | | S | | M | S |

| **Subject Code** | **Subject Name** | **Category** | **L** | **T** | **P** | **S** | **Credits** | **Inst. Hours** | **Marks** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **CIA** | **External** | **Total** |
| **23UPMBC1C08** | **Food and Dairy** | **Core Course XI** | **Y** | **Y** | **-** | **-** | **5** | **6** | **25** | **75** | **100** |

| | Microbiology | Theory | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|

| Course Objectives | |
|---|---|
| CO1 | Discuss microorganisms involved in food spoilage. |
| CO2 | Illustrate bacterial and nonbacterial food borne infections important in public health. |
| CO3 | Familiarize various national and international aspects of food safety and quality assurance. |
| CO4 | Elaborate on microbiology of milk, preservation techniques and production of dairy products. |
| CO5 | Explain Dairy plant hygiene, quality control and waste disposal. |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | Microorganisms of food- Scope of food Microbiology. Contamination and spoilage of food –vegetables, fruits, poultry, fish, eggs, meat, meat products and canned foods. Food Preservation - Temperature (low and high), drying, radiation and chemicals. | 18 | CO1 |
| II | Food microbiology and public health. Food hazards. Food infections -*Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli, Salmonella, Shigella, Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*. Nonbacterial food borne illness - Helminthes, nematodes, protozoa, toxigenic fungi and food borne virus. | 18 | CO2 |
| III | Quality assurance of food - International aspects of Quality and safety assessment of foods. Microbiological quality standards for food. Government regulatory practices and policies - FDA, HACCP, BIS (IS), FSSAI-2014. Food adulteration and common food additives. | 18 | CO3 |
| IV | Introduction to Dairy microbiology – Milk production and hygiene. Microorganisms associated with milk. Microbial metabolites and their role in spoilages- souring, curdling, gassiness, ropiness, proteolysis, lipolysis, abnormal flavour and colour. Antimicrobial systems in raw milk. Microbiological grading of raw milk. Milk borne diseases and their control. Bacteriological aspects of milk processing – Thermization, pasteurization, boiling, sterilization, UHT, bactofugation, and membrane filtration. | 18 | CO4 |

| | | | |
|---|---|---|---|
| V | Composition and chemistry of cream, butter, ghee, ice-cream, cheese, kefir, koumiss, rennin, condensed and dried milks, infant food. Spoilage of ghee and use of antioxidants. Chemistry of milk fermentation. Chemistry of rennin coagulation of milk and changes occurring during ripening of cheese, physico-chemical changes in the manufacture and storage of milk powder, lactose, crystallization and its significance. Dairy plant hygiene and sanitation. Disposal of dairy waste. Microbiological standards for Milk and Milk products- PFA BIS, Codex/ ISO standards. | 18 | CO5 |
| | Total | 90 | |

**Course Outcomes**

| Course Outcomes | | |
|---|---|---|
| CO1 | Utilize the knowledge on process of food contamination and spoilage to preserve food. | PO7, PO8, PO9 |
| CO2 | Use the knowledge on food borne disease to protect public health. | PO5, PO7, PO8, PO9 |
| CO3 | Familiarize various national and international aspects of food safety and quality assurance. | PO4, PO7, PO8 |
| CO4 | Prepare dairy products and perform quality checks. | PO7, PO8 |
| CO5 | Apply microbiological standards to milk and milk products. | PO7, PO8 |

**Text Books**


1. Adams M. R. and Moss M. O. (1996). Food Microbiology, New Age International (P) Limited Publishers, New Delhi.
2. Frazier W.C., Westhoff. D. C. and Vanitha K.N. (2013). Food Microbiology. (6th Edition). McGraw Hill Education.
3. Jay J.M., Loessner M.J. and Golden D.A. (2006). Modern Food Microbiology. (7th Edition). Springer.
4. Doyle M. P., Buchanan R. L. (2012). Food Microbiology: Fundamentals and Frontiers. (4th Edition). American Society for Microbiology Press.
5. Ray B. and Bhunia A. (2013). Fundamentals of Food Microbiology. (5th Edition). CRC Press.


**References Books**


1. Robinson R. K. (2000). Dairy Microbiology3rdedn, Elsevier Applied Science, London.
2. Adams M.R, and Moss M.D, (2005). Food Microbiology 4thedn, New Age International Pvt. Ltd., Publishers. First edition.

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|---|---|
| 3. | Banwarst. G.J. (2003). Basic Food Microbiology 2nd edn, CBS Publishers and distributors. |
| 4. | Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7th edn. Edward Arnold: London. |
| 5. | Vijaya R K, (2004). Food Microbiology 1st edn. MJP Publishers, Chennai. |

**Web Resources**

| | |
|---|---|
| 1. | https://www.fssai.gov.in |
| 2. | https://www.who.int/news-room/fact-sheets/detail/food-safety |
| 3. | https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend(K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | S | M | M | | | | | |
| CO2 | | | | | S | | M | M | M | | | | | |
| CO3 | | | | S | | | M | M | | | | | | |
| CO4 | | | | | | | M | M | | | | | | |
| CO5 | | | | | | | M | M | | | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| 23UPMBC1C09 | Research Methodology and Biostatistics | Core Course XII Theory | Y | Y | - | - | 5 | 6 | 25 | 75 | 100 |

| Course Objectives | |
|---|---|
| CO1 | Discuss the methods and techniques of data collection. |
| CO2 | Explain sampling methods, and write research reports and articles. |
| CO3 | Discuss the basic concepts of Biostatistics. |
| CO4 | Describe statistical software for analysis. |
| CO5 | Explain the tests of significance. |

| UNIT | Details | No.of Hours | Course Objectives |
|---|---|---|---|
| I | Introduction to Research Methodology - Meaning and importance. Statement, Constraints. Review of literature - Review and synopsis presentation. Types of research, Research tools. Methods and techniques of data collection - types of data, methods of primary data collection (observation/ experimentation/ questionnaire/ interviewing/ case/pilot study, methods), methods of secondary data collection. | 20 | CO1 |
| II | Sampling and sampling distributions. Sampling frame, importance of probability sampling, sampling - simple random, systematic, stratified random, and cluster. Variables - nominal, ordinal, discontinuous, continuous, derived. Research process, designs, and Report writing - types of research reports, guidelines for writing an article and report, report format, appendices, Ethical issues related to publishing, Plagiarism, and Self-Plagiarism. | 20 | CO2 |
| III | Introduction to Biostatistics - Basic concepts, Measurement and measurement scales, Sampling and data collection, Data presentation. Measures of central tendency: Mean, Median, Mode. Measures of variability - Standard deviation, standard error, range, mean deviation and coefficient of variation. Frequency table of single discrete variable, bubble spot, computation of mean, variance and standard Deviations, t test, correlation coefficient. | 15 | CO3 |
| IV | Correlation and regression - Positive, negative, calculation of Karl-Pearsons co-efficient of correlation. Linear regression and multiple linear regression, ANOVA, one and two way classification. Calculation of an unknown variable using | 20 | CO4 |

| | | | |
|---|---|---|---|
| | regression equation. Tests of significance - Tests of significance: Small sample test (Chi-square t test, F test), large sample test (Z test) and standard error. | | |
| V | Probability and distributions - Introduction to probability theory and distributions, (concept without deviation) binomial, poison and normal (only definitions and problems) Computer oriented statistical techniques. RSM: methods for process optimization set up CCD, Box Behnken, optimal RSM design, regression models FDS curves, surface contours, multi linear constraints and categoric factors to optimal design. | 15 | CO5 |
| | Total | 90 | |

**Course Outcomes**

| **Course Outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Collect and present data suitable to the research design. | PO1, PO4, PO9, PO10 |
| CO2 | Write research manuscripts and articles for journals. | PO1, PO2, PO3, PO4, PO5, PO6, PO9, PO10, PO13 |
| CO3 | Recommend the utilization of biostatistics tools for analysis of biological data. | PO5, PO6, PO9, PO10, PO13 |
| CO4 | Prove and justify hypothesis for particular research. | PO3, PO4, PO9, PO10 |
| CO5 | Apply software tools for interpretation of biological data. | PO4, PO9, PO10, PO13 |

**Text Books**


| | |
|---|---|
| 1. | Sharma K.R. (2002) Research methodology. National Publishing House, New Delhi. |
| 2. | Daniel W.W. (2005). Biostatistics; A foundation for analysis in the health sciences. ($7^{th}$ Edition). Jhon Wiley & sons Inc, New York. |
| 3. | Rao P. S. S. and Richard J. (2006). Introductionto Biostatistics & Research methods. Prentice-Hall, New Delhi. |
| 4. | Veerakumari L. (2015) Bioinstrumentation $1^{st}$edn. MJP Publishers. |
| 5. | Ahuja V.K. (2017) Laws Relating to Intellectual Property Rights. Lexis Nexis. |


**References Books**


| | |
|---|---|
| 1. | Zar J. H. (2006). Biostatistical Analysis. ($4^{th}$ Edition). Pearson Education Inc. New Jersey. |
| 2. | Beins B. C. and McCarthy M.A. (2011). Research Methods and Statistics.Pearson Education Inc. New Jersey. |
| 3. | Adams K. A. and Lawrence E. M. K. (2014). Research Methods, Statistics, and Applications.SAGE Publications, Inc., New Delhi. |

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|---|---|
| 4. | Anderson J.B. and Poole M. (2011). Assignment and Thesis Writing. 4th edn. Wiley India Private Limited. |
| 5. | Kothari C.R. and Garg G (2004) Research Methodology: Methods and Techniques. 2nd Edition. New Age International Publishers |
| **Web Resources** | |
| 1. | https://www.studocu.com/en-ca/document/mount-royal-university/quantitative-research-methods-and-data-analysis/lecture-notes-all-lectures/344093 |
| 2. | https://www.khanacademy.org/math/statistics-probability/sampling-distributions-library |
| 3. | https://testbook.com/learn/maths-mean-median-mode/ |
| 4. | https://rcub.ac.in/econtent/ug/bcom/sem4/Business%20Statistics%20Unit%204%20Correlation%20and%20Regression.pdf |
| 5. | https://www.cse.iitk.ac.in/users/piyush/courses/pml_fall17/material/probabilty_tutorial.pdf |

| **Methods of Evaluation** | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| **Methods of Assessment** | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | L | | | L | | | | | L | L | | | | |
| CO2 | M | M | M | M | M | M | | | M | M | | | M | |
| CO3 | | | | | S | S | | | S | S | | | S | |
| CO4 | | | S | S | | | | | S | S | | | | |
| CO5 | | | | M | | | | | M | M | | | M | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1E16** | **Microbiome and Omics Science** | **Elective Course VI (Choice 1)** | **Y** | **Y** | **-** | **-** | **3** | **4** | **25** | **75** | **100** |

**Course Objectives**

| | |
|---|---|
| CO1 | To understand various types of microbiomes and microbiome engineering |
| CO2 | To familiarize the functional analysis of microbiome |
| CO3 | To familiarize the functional analysis of microbiome |
| CO4 | To expose the students to recent advances on omics studies |
| CO5 | To gain knowledge on genomics and proteomics |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | Definition and concepts. Types of Microbiomes-Human microbiome- Gut, Genital, skin, oral, Respiratory microbiomes, Animal, Plant microbiomes, Root, Environmental microbiomes, Bacteriabiome, Mycobiome, Phycobiome, Actinobiome, Virome, Phytobiome. Microbiome engineering- Natural and artificial microbiome Engineering- climatic conditions, diet and geography | 12 | CO1 |
| II | Pipeline, Mothurpipeline, metagenome SeqR package – Sequence data (fastq), Metadata about samples (mappingfile) Preprocessing: Operational Taxonomic Units (OTUs) Picking, Taxonomic Assignment, Phylogenetic Analysis, Downstream analysis and Visualization-knowledge discovery- Alpha, Beta-diversity. | 12 | CO2 |
| III | Functional analysis of the microbiome from DNA sequence functional analysis, metatranscriptome, metabolome, proteome, and glycome-Metatranscriptomic analysis-nano-LCMSMS, Proteome Discoverers of | 12 | CO3 |

| | | | |
|---|---|---|---|
| | twarev1.4, Functional mining of metagenomes, Plant growth-promoting genes in metagenome. | | |
| IV | Molecular mapping of the genome, Genetic and physical maps, physical mapping and map-based cloning, choice of mapping population, simple sequence repeat loci, southern and fluorescence in situ hybridization for genome analysis, micro cloning, molecular markers in genome analysis: RFLP, RAPD and AFLP analysis, molecular markers linked to disease resistance genes, Application of RFLP in forensic, disease prognosis, Next-generation Sequencing and Applications. Metagenomics and methods of metagenomics Evolution and structure of mitochondrial genomes, mtDNA and mitochondrial diseases, epigenomic markers of epigenomics, correlated diseases, and assessment of DNA modification | 12 | CO4 |
| V | Introduction to mass spectrometry; Strategies for protein identification; Protein sequencing; Phage Display; Applications of proteome analysis to drug; Protein-protein interaction (Two hybrid interaction screening). Protein engineering; Protein chips and functional proteomics; Clinical and biomedical application of proteomics; Proteome database; yeast one-hybrid assay, ChIP-chips. Yeast two hybrids system, SPR, Co-immuno-precipitations, GST- pull-downs and Far-Westerns, Metabolomics; Assessment of different metabolites and small molecules, integration of data across multiomics layer. | 12 | CO5 |
| | Total | 60 | |

**Course Outcomes**

| **Course Outcomes** | On completion of this course, students will | |
|---|---|---|
| CO1 | Able to know different types of microbiomes | PO1, PO5, PO6 |
| CO2 | Able to understand various pipelines and tools used to study microbiomes | PO5, PO7, PO8, PO11, |
| CO3 | Able to know various software used in microbiome analysis | PO1, PO4, PO5, PO7, |
| CO4 | Know the techniques used to analyses whole genome of the organism | PO5, PO7, PO8, PO11. |
| CO5 | Able to know clear idea about proteomics | PO4, PO5, PO7, PO8. |

**Text Books**

| | |
|---|---|
| 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. doi: 10.3389/fbioe.2020.00568 |
| 3. | Broberg et al. (2018). McDonald. Integrated multi-omic analysis of hostmicrobiota interactions in acute oak decline. Microbiome (2018) 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. | Saleem and Muhammad. (2015). Microbiome Community Ecology Fundamentals and Applications, Springer, New York, USA. |
| 6. | Tatusova T, DiCuccio M, Badretdin A, et al. (2013). Prokaryotic Genome Annotation Pipeline. In: The NCBI Handbook. 2ndedition. Bethesda (MD): National Center for Biotechnology Information (US). |
| **Web Resources** | |

| **Methods of Evaluation** | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

| **Methods of Assessment** | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest ideas/concepts with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussions, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | | | | S | S | | | | | | | | |
| CO2 | | | | | S | | S | S | | | S | | | |
| CO3 | M | | | S | S | | S | | | | | | | |
| CO4 | | | | | S | | S | S | | | S | | | |
| CO5 | | | | S | S | | S | S | | | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1E17** | **Marine Microbiology** | **Elective Course VI (Choice 2)** | **3** | **1** | **-** | **-** | **3** | **4** | **25** | **75** | **100** |

**Course Objectives**

| | |
|---|---|
| CO1 | Gain fundamental knowledge of marine environment and the microbial communities inhabiting the oceans. |
| CO2 | Discuss the metabolic diversity of marine microorganisms and their interrelationships. |
| CO3 | Explain the survival of microorganisms in extreme environments. |
| CO4 | Illustrate pathogens and contaminants in seafood. |
| CO5 | Describe the applications of marine biotechnological products and their future role in a rapidly changing planet. |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | Marine microbial environment - Benthic & littoral zone, salt pan, mangroves and estuarine microbes, microbial loop. Marine microbial communities – Bacteria, fungi, protozoa. Microbial interactions – Endosymbionts and Ectosymbionts. | 12 | CO1 |
| II | Dynamics of Marine Microbes - Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming – Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization – phosphorus cycle. Decomposition of organic matter. Bioleaching and biodeterioration of natural and synthetic materials. | 12 | CO2 |
| III | Marine extremophiles: Mechanism of survival at extreme environments – Adaptive mechanisms in thermophilic, alkalophilic, osmophilic, barophilic, psychrophilic hyperthermophilic and halophilic microorganisms – Importance in biotechnology. | 12 | CO3 |
| IV | Marine Microbial Diseases:Aqua culture pathogens & Water borne pathogens -*Aeromonas, Vibrio,Salmonella,* | 12 | CO4 |

| | | | |
|---|---|---|---|
| | *Pseudomonas, Leptospira, Corynebacteria* and viral diseases.Rapid diagnosis of contamination in sea foods and aquaculture products. | | |
| V | Applications of Marine Microbial Biotechnology: Production and applications of marine microbial products – Enzymes, Antibiotics, Organic acids, Toxins, Biosurfactants and Pigments. Sea food preservation methods. Probiotic bacteria and their importance in aquaculture. | 12 | CO5 |
| | Total | 60 | |

| **Course Outcomes** | | |
|---|---|---|
| **Course Outcomes** | On completion of this course, students will; | |
| CO1 | Apply the knowledge on marine microbial communities and their interactions. | PO1, PO9 |
| CO2 | Illustrate the role of marine microorganisms in biogeochemical cycles. | PO5, PO7 |
| CO3 | Categorize the extreme environments in the oceans and the survival mechanisms adapted by the microorganisms living in these environments. | PO7, PO9 |
| CO4 | Identify the diseases affecting marine organisms and its diagnosis. | PO5, PO7 |
| CO5 | Evaluate the marine microorganisms as a resource for novel microbial products. | PO7, PO8, PO9 |

**Text Books**


| | |
|---|---|
| 1. | Munn C. B. (2019). Marine Microbiology: Ecology and Applications. (3rd Edition). CRC Press. ISBN:9780367183561. |
| 2. | Bhakuni, D.S. and Rawat D.S. (2005). Bioactive Marine Natural Products. Anamaya Publishers, New Delhi. ISBN:1-4020-3472-5. |
| 3. | Brock T. D. (2011). Thermophilic Microorganisms and Life at High Temperatures. Springer. ISBN-13:978-1461262862 / ISBN-10:1461262860. |
| 4. | Nybakken, J.W. (2001). Marine Biology. (5th Edition). Benjamin Cummings. ISBN:0321030761 9780321030764. |
| 5. | Veena. (Understanding marine biology. Discovery Publishing. |


**References Books**


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|---|---|
| 1. | Maier R.M., Pepper I.L. and Gerba C.P. (2006). Environmental Microbiology. (2nd Edition). Academic Press. ISBN:978-0-12-370519-8. |
| 2. | Belkin S. and Colwell R.R. (2005). Oceans and Health: Pathogens in the Marine Environment. Springer. ISBN:978-0-387-23708-4. |
| 3. | Scheper T. (2009). Advances in Biochemical Engineering/Biotechnology-Marine Biotechnology. Springer. ISBN:978-3-540-69356-7. E-ISBN:978-3-540-69357-4. |
| 4. | Gasol J. M. and Kirchman D. L. (Eds.). (2018). Microbial Ecology of the |

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|---|---|
| | Oceans. (3rd Edition). Wiley-Blackwell. ISBN:978-1-119-10718-7. |
| 5. | Kim S. K. (2019). Essentials of Marine Biotechnology. Springer. |
| **Web Resources** | |
| 1. | https://link.springer.com/content/pdf/bfm%3A978-0-387-23709-1%2F1 |
| 2. | https://www.researchgate.net/publication/285931262_Bioactive_Marine_Natural_Products |
| 3. | http://link.springer.com/content/pdf/bfm%3A978-3-642-03470-1%2F1.pdf |
| 4. | https://link.springer.com/book/10.1007/b102184 |
| 5. | https://www.wiley.com/en-bs/Microbial+Ecology+of+the+Oceans%2C+3rd+Edition-p-9781119107187 |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain |
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | | | | | | | | M | | | | | |
| CO2 | | | | | M | | S | | | | | | | |
| CO3 | | | | | | | M | | S | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | | | | | M | | S | | | | | | | |
| CO5 | | | | | | | S | S | M | | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1E18** | **Life Sciences for Competitive Examinations** | **Elective Course VI (Choice 3)** | **3** | **1** | **-** | **-** | **3** | **4** | **25** | **75** | **100** |

**Course Objectives**

| | |
|---|---|
| CO1 | Impart knowledge of the structure, metabolism, and function of biomolecules. |
| CO2 | Understand the importance of inheritance biology. |
| CO3 | Discuss in-depth about the different types of ecosystems and their importance. |
| CO4 | Outline the major drivers in biodiversity and various conservation approaches. |
| CO5 | Introduce basic concepts of evolution and biological clock. |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | Composition, structure, and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Metabolism of carbohydrates, lipids, amino acids, nucleotides and vitamins. Structure of atoms, molecules and chemical bonds.Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.).Bioenergetics. | 12 | CO1 |
| II | Cellular Organisation,Cell division and cell cycle, Membrane structure and function, Organization of genes and chromosomes, Structural organization and function of intracellular organelles, DNA replication, repair and recombination, Protein synthesis and processing. | 12 | CO2 |
| III | Inheritance Biology, Mendelian principles- Dominance, segregation, independent assortment, Linkage and Gene mapping, Karyotyping, Extrachromosomal inheritance - Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. Human genetics-Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders. | 12 | CO3 |

| | | | |
|---|---|---|---|
| IV | Ecology-Habitat and Niche, biotic and abiotic interactions, Biome- biogeographical zones of India.Ecological Succession,Population Ecology- Characteristics of a population; population growth curves, Environmental pollution-global environmental change, Biodiversity: status, monitoring, and documentation; major drivers of biodiversity change; biodiversity management approaches. Biodiversity Management approaches. Indian case studies on Conservation/Management strategy (Project Tiger, Biosphere Reserves). | 12 | CO4 |
| V | Evolution and Behaviour- Evolution - Theories- Darwin's, Lamarck's, Oparin Haldane. Paleontological, Embryological and Molecular evidence. Hardy Weinberg's Law. Speciation; Allopatricity and Sympatricity. Adaptive radiation and Convergent evolution; Sexual selection; Co-evolution. Altruism, Biological clocks, Migration, and Parental care. Molecular Evolution- Concepts of neutral evolution, molecular divergence, and molecular clocks; Molecular tools in phylogeny. | 12 | CO5 |
| | Total | 60 | |

**Course Outcomes**

| **Course Outcomes** | On completion of this course, students will; | |
|---|---|---|
| CO1 | Define, classify and assess the structure, biological functions, and interactions of Biomolecules. | PO4, PO6, PO9 |
| CO2 | Validate the knowledge of collective and progressive notions of cellular organization. | PO4, PO6, PO9 |
| CO3 | Assess and describe the importance of inheritance biology. | PO4, PO6, PO9 |
| CO4 | Establish acquaintance and understanding of ecology & Biodiversity in a broader sense. | PO4, PO6, PO9 |
| CO5 | Understand the processes of evolution, related to natural selection, adaptation, and speciation. | PO4, PO6, PO9 |

**Text Books**


| | |
|---|---|
| 1. | Nelson D. L. and Cox M. M. (2008). Lehningers Principles of Biochemistry. (5th Edition). W.H. Freeman and Company. |
| 2. | Chapman J.L. (1998).Ecology: Principles and Applications. (2nd Edition). Cambridge University Press. |
| 3. | Krishnamurthy V.K. (2003). Textbook of Biodiversity. Science Publishers. |
| 4. | Rogers A.L. (2011). Evidence of Evolution. University of Chicago Press. Chicago. |
| 5. | Stites D.P.,AbbaI.Terr, Parslow T.G.(1997). Medical Immunology. 9thEdn, Prentice-Hall Inc. |

| | |
|---|---|
| | |
| **References Books** | |
| 1. | Pontarotti P. (2018). Origin and Evolution of Biodiversity. (1st Edition). Springer. |
| 2. | Verma P.S. and Agarwal V.K. (2004). Cell biology, Genetics, Molecular Biology, Evolution and Ecology. (2nd Edition). S Chand publication. |
| 3. | Lewin R. and Foley R. (2004). Principles of Human Evolution. (2nd Edition). Black Well Publishing Company. |
| 4. | Boyer R.F. (2002) Modern Experimental Biochemistry 3rd Edition. Pearson Education. |
| 5. | Wilson K., Walker J., Clokie S and Hofmann A. (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8th Edition Cambridge University Press. |
| | |
| **Web Resources** | |
| 1. | https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_ |
| 2. | https://www.livescience.com/474-controversy-evolution-works.html. |
| 3. | https://www.examrace.com/Study-Material/Life-Sciences/ |
| 4. | https://www.kopykitab.com/Methods-In-Biology-Life-Science-Study-Material-For-CSIR-NET-Exam-by-Panel-Of-Experts |
| 5 | https://www.erforum.net/2017/01/life-science-biology-handwritten-notes-for-competitive-exams.html |

**Methods of Evaluation**

| | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
| | Assignments | |
| | Seminars | |
| | Attendance and Class Participation | |
| External Evaluation | End Semester Examination | 75 Marks |
| | Total | 100 Marks |

**Methods of Assessment**

| | |
|---|---|
| Recall (KI) | Simple definitions, MCQ, Recall steps, Concept definitions |
| Understand / Comprehend (K2) | MCQ, True/False, Short essays, Concept explanations, Short summary or overview |
| Application (K3) | Suggest ideas/concepts with examples, Suggest formulae, Solve problems, Observe, Explain |

| | |
|---|---|
| Analyse (K4) | Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge |
| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
| Create (K6) | Check knowledge in specific or offbeat situations, Discussions, Debating, or Presentations |

**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | L | | | S | L | S | | | S | M | | | | |
| CO2 | L | | | S | L | S | | | S | M | | | | |
| CO3 | L | | | S | L | S | | | S | M | | | | |
| CO4 | L | | | S | L | S | | | S | M | | | | |
| CO5 | L | | | S | L | S | | | S | M | | | | |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23PGMBPRO** | **Project with Viva voce** | | **-** | **-** | **4** | **-** | **7** | **10** | **40** | **60** | **100** |

| Subject Code | Subject Name | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | CIA | External | Total |
| **23UPMBC1S01** | **Microbial Quality Control and Testing** | **Skill Enhancement Course III** | **Y** | **-** | **-** | **-** | **2** | **4** | **25** | **75** | **100** |

**Course Objectives**

| | |
|---|---|
| CO1 | Explain various microbiological quality standards for food, water and air regulatory practices and policies. |

| | |
|---|---|
| CO2 | Discuss collection, processing and preservation ofwater samples from industries in different areas. |
| CO3 | Enumeration and isolation of microorganism from the water samples. |
| CO4 | Enumeration and isolation of microorganism from the air samples. |
| CO5 | Gain knowledge on sterility testing of different components in industries and quality control techniques. |

| UNIT | Details | No. of Hours | Course Objectives |
|---|---|---|---|
| I | Concepts of quality control techniques - quality assurance, Total Quality Management (TQM) Continuous Quality Improvement (CQI) Quality Assurance (QA) pre analytical and post analytical techniques, ATCC, MTCC, microbial based assay. | 6 | CO1 |
| II | Waste water microbiology – types and sources of contamination, prevention of water borne diseases. Water management, water harvesting, water recycling. Characteristics of waste water from industries - Sugar factory, Pulp & Paper mill, Distillery, Textile, Engineering, Food Industry, Domestic waste. Waste water treatment plant types and quality control. Water pollution causes and remedies. | 6 | CO2 |
| III | Microflora of water. Microbiological analysis of water sample. Microbiological analysis of water sample collection, drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests Control of microbes in water: Water borne pathogens, water borne diseases. Control of water borne pathogens- Precipitation, chemical disinfection, filtration, high temperature, UV light. | 6 | CO3 |
| IV | Microflora of air - Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres. Collection of air samples and analysis. Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, isolation and Identification. Control Measures of Bioaerosols - UV light, HEPA filters, desiccation, Incineration. | 6 | CO4 |
| V | Quality control in food - Food X ray inspection, PPE Equipment, IoT sensors, preventive quality control and reality quality control. Quality control of pharma products. | 6 | CO5 |

| | | | |
|---|---|---|---|
| | Quality assurance framework, assessment of pharmaceutical quality, determinants of pharmaceutical quality, practical approaches to quality assurance. | | |
| | Total | 30 | |

| **Course Outcomes** | | |
|---|---|---|
| **Course Outcomes** | On completion of this course, students will; | |
| CO1 | Apply knowledge in quality analysis techniques suitable for industries. | PO4, PO5, PO7, PO8 |
| CO2 | Perform water managements, water harvestingand treat sewage, water pollutions and remedies. | PO4, PO5, PO7, PO8 |
| CO3 | Detect portability of water. Test water quality. | PO4, PO5, PO7, PO8 |
| CO4 | Impart knowledge on bioaerosols, impact and prevention | PO4, PO5, PO7, PO8 |
| CO5 | Apply quality control techniques for food and pharma products | PO4, PO5, PO7, PO8 |

**Text Books**


| | |
|---|---|
| 1. | Aneja R.P., Mathur B.N., Chandan R.C. and Banerjee, A.K. (2002). Experiments in Microbiology. |
| 2. | Adams M. R. and Moss M. O. (2006). Food Microbiology. (2nd Edition). Royal Society of Chemistry. |
| 3. | Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand. |
| 4. | Cappuccimo, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6th Edition). Pearson Education, Publication, New Delhi. |
| 5. | Rosamund M. Baird., Norman A. (2019). Handbook of Microbiological Quality Control in Pharmaceuticals and Medical Devices. CRC Press. |


**References Books**


| | |
|---|---|
| 1. | Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2nd Edition). - Taylor &Francis. |
| 2. | Sundararaj T. (2003). Microbiology Laboratory Manual. (2nd Edition). Published by A. Sundararaj |
| 3. | Hoges N. A., Denyer S P. and Baird R.M. (2003). Handbook of microbiological quality control. Microbial Quality Assurance in Pharmaceuticals, cosmetics & Toiletries. by Sally F. Bloomfield |
| 4. | Amitava Mitra. Fundamentals of Quality Control and Improvement. (3rd Edition). Wiley Publications |
| 5. | David Roesti, Marcel Goverde (2019). Pharmaceutical Microbiological Quality Assurance and Control: Practical guide for non-sterile Manufacturing. Wiley |

| | |
|---|---|
| | Publishers. |
| **Web Resources** | |
| 1. | https://www.researchgate.net › publication › 320730681 |
| 2. | https://www.fssai.gov.in |
| 3. | https://mofpi.nic.in/Schemes/implementation-haccp-iso-22000-iso-9000-ghp-gmp-etc |
| 4. | https://www.who.int/news-room/fact-sheets/detail/food-safety |
| 5. | https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines |

| **Methods of Evaluation** | | |
|---|---|---|
| Internal Evaluation | Continuous Internal Assessment Tests | 25 Marks |
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| Evaluate (K5) | Longer essay/ Evaluation essay, Critique or justify with pros and cons |
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**Mapping with Programme Outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | M | L | | S | S | | | | | | |
| CO2 | | | | M | L | | M | M | | | | | | |
| CO3 | | | | S | L | | S | S | | | | | | |
| CO4 | | | | S | L | | S | S | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO5 | | | | S | L | | M | M | | | | | | |

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