



**PONNAIYAH RAMAJAYAM INSTITUTE OF
SCIENCE & TECHNOLOGY (PRIST)**

Declared as DEEMED-TO-BE-UNIVERSITY
U/s 3 of UGC Act, 1956

SCHOOL OF ARTS AND SCIENCE

Department of Microbiology

M.SC., MICROBIOLOGY

SYLLABUS

**FROM THE ACADEMIC YEAR
2023-2024**



Master of Science in Microbiology

Our curriculum is intended to teach our majors in a diversity of significant microbiological disciplines, as well as to inspire, improve, technological skills and capabilities that take persistent value beyond the teaching space.

M. Sc., Graduate Attributes

- ❖ Capability and motivation for intellectual development.
- ❖ Research, inquiry and analytical thinking abilities.
- ❖ Communication in intra and inter disciplinary
- ❖ Ethical, social and professional understanding
- ❖ Information literacy in respective discipline
- ❖ Teamwork, collaborative and management skills in scientific research

❖ M. Sc Programme Educational Objectives-PEO

- ❖ **PEO1-** To provide detailed knowledge of Microbiology and their application fields. To understand the beneficial and harmful role of microorganisms in the environment and in the industries.
- ❖ **PEO2-** To understand the fundamentals of physiological reactions including metabolic pathways and biochemical reactions in microorganisms. To understand the fundamental concepts of immunology, biochemistry, biotechnology and genetics etc.
- ❖ **PEO3-** To develop human resource and entrepreneurs in microbiology with the ability to independently start their own ventures or small biotech units in the field of biotechnology.
- ❖ **PEO4-** Understand modern microbiology - practices and approaches with an emphasis in technology application in pharmaceutical, medical, industrial, environmental and agricultural areas.
- ❖ **PEO5-** Gain experience with standard molecular tools and approaches utilized: manipulate genes, gene products and organisms. Become familiar with handling of Laboratory animals for the research purpose. Interpret differences in data distributions via visual displays.

❖ M. Sc 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
- ❖ **M. Sc 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 enhance employability 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



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School of Arts and Science Department of Microbiology

M. Sc., Syllabus-Regulation 2023

COURSE STRUCTURE

| Course Code | Course Title | L | T | P | C |
|---------------------|---|-----------|----------|----------|-----------|
| SEMESTER I | | | | | |
| 23216AEC11 | General Microbiology and Microbial Diversity | 5 | 1 | 0 | 4 |
| 23216AEC12 | Immunology Immunomics and Microbial Genetics | 5 | 1 | 0 | 4 |
| 23216AEC13 | Forensic Science | 5 | 1 | 0 | 4 |
| 23216AEC14L | General Microbiology, Immunology and Genetics Lab | 0 | 0 | 4 | 4 |
| 23216DSC15_ | Discipline specific Elective Courses-I | 5 | 1 | 0 | 3 |
| 23216RMC16 | Research Methodology | 2 | - | - | 2 |
| | Total | 22 | 4 | 4 | 21 |
| SEMESTER II | | | | | |
| 23216AEC21 | Medical Bacteriology and Mycology | 4 | 1 | 0 | 4 |
| 23216AEC22 | Medical Virology and Parasitology | 4 | 1 | 0 | 4 |
| 23216AEC23 | Bioinformatics | 4 | 1 | 0 | 4 |
| 23216SEC24L | Medical Microbiology Lab | 0 | 0 | 4 | 4 |
| 23216DSC25_ | Discipline specific Elective Courses-II | 4 | 1 | 0 | 3 |
| 23216GEC26 | Vermitechnology | 4 | 0 | 0 | 3 |
| 23216BRC27 | Participation in Bounded research | 2 | - | - | 2 |
| 23216SEC28 | Internship | - | - | - | 2 |
| | Total | 22 | 3 | 4 | 26 |
| SEMESTER III | | | | | |
| 23216AEC31 | Soil and Environmental Microbiology | 5 | 1 | 0 | 4 |
| 23216AEC32 | Recombinant DNA Technology and Biotechnology | 4 | 1 | 0 | 4 |
| 23216AEC33 | Fermentation Technology and Pharmaceutical Microbiology | 4 | 1 | 0 | 4 |

| | | | | | |
|-------------|--|-----------|----------|-----------|-----------|
| 23216AEC34L | Environmental Microbiology & rDNA Technology Lab | 0 | 0 | 4 | 4 |
| 23216DSC35_ | Discipline specific Elective Courses-III | 4 | 1 | 0 | 3 |
| 23216GEC36 | Nanobiotechnology | 4 | 1 | 0 | 3 |
| 23216SEC37 | Industrial Visit | - | - | - | 2 |
| | Total | 21 | 5 | 4 | 24 |
| | SEMESTER IV | | | | |
| 23216AEC41 | Food & Dairy Microbiology | 4 | 1 | 0 | 4 |
| 23216AEC42 | Marine Microbiology | 4 | 1 | 0 | 4 |
| 23216PRW43 | Project with Viva Voce | 0 | 0 | 10 | 4 |
| 23216DSC44_ | Discipline specific Elective Courses-IV | 4 | 1 | 0 | 3 |
| 23216DSC45 | Microbial Quality Control and Testing | 4 | 1 | 0 | 3 |
| 23216SEC46 | Industrial Visit | - | - | - | 2 |
| | Total | 16 | 4 | 10 | 20 |
| | Total Credits for the Program | | | | 91 |

Discipline specific Electives

| Semester | Discipline specific Elective Courses-I |
|----------|--|
| I | a) 23216DSC15A- Bioinstrumentation b) 23216DSC15B - Health Hygiene c) 23216DSC15C - Microalgal Technology d) 23216DSC15D- Essentials of Laboratory Management and Biosafety |
| | Discipline specific Elective Courses-II |
| II | a) 23216DSC25A-Epidemiology b) 23216 DSC25B - Clinical Diagnostic Microbiology c) 23216 DSC25C - Bioremediation d) 23216 DSC25D - Clinical Research and Clinical Trials |
| | Discipline specific Elective Courses-III |
| III | a) 23216DSC35A- Biosafety, Bioethics and IPR b) 23216DSC35B-Toxinology c) 23216DSC35C-Water Conservation and Water Treatment |
| | Discipline specific Elective Courses-IV |
| IV | a) 23216DSC44A- Bioenergy b) 23216DSC44B-Herbal Technology and Cosmetic Microbiology c) 23216DSC44C - Life Science for Competitive Examinations |

Credit Distribution:

| Sem | SEC | DSC | GEC | RSB courses | Others | Total |
|--------------|------------|------------|------------|------------------------|---------------|--------------|
| I | 16 | 3 | - | 2 | - | 21 |
| II | 16 | 3 | 3 | 2 | 2 | 26 |
| III | 16 | 3 | 3 | 2 | - | 24 |
| IV | 12 | 3 | - | - | 2 | 20 |
| Total | 62 | 16 | 3 | 13 | 02 | 91 |

SEMESTER-I

| Course Code | Course Title | L | T | P | C |
|-------------|--|---|---|---|---|
| 23216AEC11 | General Microbiology and Microbial Diversity | 5 | 1 | 0 | 4 |

Course objective

| | |
|-----|---|
| 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. |

Course Detail:

UNIT 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.

UNIT 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.

UNIT 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*, *Volvox* (Green algae), *Nostoc* (Cyanobacteria) *Ectocarpus*, *Sargassum* (Brown algae), *Polysiphonia*, *Batrachospermum* (Red algae).

UNIT 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 centers - National and International.

UNIT V:

Biodiversity - Introduction to microbial biodiversity – Thermophiles - Classification, Thermophilic Archaeobacteria 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.

| 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. (10 th Edition). Universities Press (India) Pvt. Ltd. |
| 2. | Chan E.C.S., Pelczar M. J. Jr. and Krieg N. R. (2010). Microbiology. (5 th Edition). Mc.Graw Hill. Inc, New York. |
| 3. | Prescott L. M., Harley J. P. and Klein D. A. (2004). Microbiology. (6 th 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 (12 th Edition). Pearson, London, United Kingdom |
| 2. | Webster J. and Weber R.W.S. (2007). Introduction to Fungi. (3 rd Edition). Cambridge University Press, Cambridge. |
| 3. | Schaechter M. and Leaderberg J. (2004). The Desk encyclopedia of Microbiology. Elsevier Academic Press, California. |
| 4. | Ingraham, J.L. and Ingraham, C.A. (2000) Introduction to Microbiology. (2 nd 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. (15 th Edition). Pearson. |
| Web Resources | |
| 1. | http://sciencenetlinks.com/tools/microbeworWeb ResourcesId |
| 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 |

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 | | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|--------------|---|---|---|---|
|-------------|--------------|---|---|---|---|

| | | | | | |
|------------|--|---|---|---|---|
| 23216AEC12 | Immunology Immunomics and Microbial Genetics | 5 | 1 | 0 | 4 |
|------------|--|---|---|---|---|

COURSE OBJECTIVE

| | |
|-----|--|
| 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. |

Course Detail:

UNIT I :

Introduction to biology of the immune system – Cells and organs of the 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.

UNIT 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.

UNIT 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. 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, immune-tolerance, immuno-potential, Immunomodulation. Role of cytokines, lymphokines and chemokines. Introduction to Vaccines and Adjuvants - Types of vaccines. Development of vaccines and antibodies in plants. Immunomics - Introduction and Applications. Antigen engineering for better immunogenicity and use for vaccine development-multi epitope vaccines. Reverse vaccinology.

UNIT 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.

UNIT 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.

| 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 patient samples. | PO4, PO6, PO7, 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. (5 th Edition). Wiley-Blackwell, New York. |
| 2. | Owen J. A., Punt J., Stranford S. A. and Kuby J. (2013). Immunology, (7 th Edition). W. H. Freeman and Company, New York. |
| 3. | Abbas A. K., Lichtman A. H. and Pillai S. (2021). Cellular and Molecular Immunology. (10 th Edition). Elsevier. |
| 4. | Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4 th Edition). Narosa Publishing House, New Delhi. |
| 5. | Gardner E. J. Simmons M. J. and Snusted D.P. (2006). Principles of Genetics. (8 th Edition). Wiley India Pvt. Ltd. |

References Books

| | |
|----|---|
| 1. | Travers J. (1997). Immunobiology - The Immune System in Health and Disease. (3 rd Edition). Current Biology Ltd. New York. |
| 2. | Delves P.J., Martin S., Burton D. R. and Roitt I. M. (2006). Roitt's Essential Immunology. (11 th Edition). Wiley-Blackwell. |
| 3. | Hay F. C. and Westwood O. M. R. (2002). Practical Immunology (4 th Edition). Wiley-Blackwell. |
| 4. | Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5 th Edition). ASM Press. |
| 5. | Russell P.J. (2010). Genetics - A Molecular Approach. (3 rd 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 (8 th Edition) By David L. Nelson and Michael M. Cox Book Free Download - StudyMaterialz.in |
| 5. | https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/ |

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 | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|------------------|---|---|---|---|
| 23216AEC13 | Forensic Science | 5 | 1 | 0 | 4 |

| Course Objectives | |
|-------------------|--|
| CO1 | Understand the Scope, need and learn the tools and techniques in forensic 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 | Recognize medico legal post mortem procedures and their importance. |

Course Detail:

UNIT I:

Forensic Science - Definition, history and development of forensic science. Scope and need of forensic science in the present scenario. Branches of forensic science. Tools and techniques of forensic science. Duties of a forensic scientist.

UNIT 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.

UNIT III:

Forensic serology - Definition, identification and examination of body fluids - Blood, semen, saliva, sweat and urine. Forensic examination and identification of hair and fibre

UNIT 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.

UNIT 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.

| 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. (2 nd Edition). CRC Press, New York. ISBN-13:978-1-4398-8972-5. |
| 4. | Sharma B.R (2020) Forensic science in criminal investigation and trials. (6 th Edition)Universal Press. |
| 5. | Richard Saferstein (2017). Criminalistics- An introduction to Forensic Science. (12 th 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, (3 rd Edition). CRC Press, New York. ISBN-10:1498720196. |
| 3. | Lincoln, P.J. and Thomson, J. (1998). (2 nd Edition). Forensic DNA Profiling Protocols. Vol. 98. Humana Press. ISBN: 978-0-89603-443-3. |
| 4. | Val McDermid (2014). Forensics. (2 nd Edition). ISBN 9780802125156. |
| 5. | Vincent J. DiMaio., Dominick DiMaio. (2001). Forensic Pathology (2 nd 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 |

Mapping with Programme Outcomes

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|----------|----------|----------|----------|----------|
| CO 1 | L | | | | | S | M | M | S | | | | | |
| CO 2 | M | | | | | S | M | M | S | | | | | |
| CO 3 | L | | | | S | | S | M | S | | | | | |
| CO 4 | M | | | | | S | S | M | S | | | | | |
| CO 5 | M | | | | | S | S | M | S | | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|---|---|---|---|---|
| 23216AEC14L | General Microbiology, Immunology and Genetics Lab | 0 | 0 | 4 | 4 |

| Course Objectives | |
|-------------------|--|
| CO1 | Gain knowledge on the fundamentals, handling and applications of microscopy, sterilization methods. Identify microbes by 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. |

Course Detail:

UNIT I :

- ❖ Microscopic Techniques: Light microscopy: Hay infusion broth. Wet mount to show different types of microbes, hanging drop.
- ❖ Dark field microscopy – Motility of Spirochetes. Washing and cleaning of glass wares: Sterilization methods: moist heat, dry heat, and filtration.
- ❖ Quality control check for each method. Staining techniques - Simple staining, Gram's staining, Acid fast staining, Meta chromatic granule staining, Spore, Capsule, Flagella.

UNIT II

- ❖ Media Preparation: Preparation of liquid, solid and semisolid media. Agar deeps, slants, plates.
- ❖ Preparation of basal, enriched, selective and enrichment media. Preparation of Biochemical test media, media to demonstrate enzymatic activities
- ❖ Microbial Physiology: Purification and maintenance of microbes. Streak plate, pour plate, and slide culture technique.
- ❖ Aseptic transfer.
- ❖ Direct counts – Total cell count, Turbidometry. Viable count - pour plate, spread plate. Bacterial growth curve. Effect of physical and chemical factors on growth.
- ❖ Anaerobic culture methods.

UNIT III

- ❖ Hematological reactions - Blood Grouping – forward and reverse, Rh Typing
- ❖ Identification of various immune cells by morphology – Leishman staining, Giemsa staining.
- ❖ Agglutination Reactions- Latex Agglutination reactions- RF, ASO, CRP.
- ❖ Detection of HBs Ag by ELISA.
- ❖ Precipitation reactions in gels– Ouchterlony double immunodiffusion (ODD) and Mancini's single radial immunodiffusion (SRID)
- ❖ Immuno-electrophoresis and staining of precipitin lines- Rocket immuno electrophoresis and counter current immuno electrophoresis.

UNIT IV

- ❖ Preparation of lymphocytes from peripheral blood by density gradient centrifugation.
- ❖ Purification of immunoglobulin– Ammonium Sulphate Precipitation.
- ❖ Separation of IgG by chromatography using DEAE cellulose or Sephadex.

UNIT V

- ❖ Western Blotting – Demonstration.
- ❖ Isolation of genomic DNA from *E. coli* and analysis by agarose gel electrophoresis.
- ❖ Estimation of DNA using colorimeter (Diphenylamine reagent)
- ❖ Separation of proteins by polyacrylamide gel electrophoresis (SDS-PAGE)
- ❖ UV induced mutation and isolation of mutants by replica plating technique.
- ❖ Plasmid DNA isolation from *E.coli*. RNA isolation from yeast.

| 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. | Cappuccino, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6 th Edition). Pearson Education, Publication, New Delhi. |
| 3. | Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2 nd 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. (5 th Edition). Elsevier. |
| 5. | Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5 th Edition). ASM Press. |
| References Books | |
| 1. | Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14 th Edition). Elsevier, New Delhi. |

| | |
|----------------------|---|
| 2. | Gupta P. S. (2003). Clinical Immunology. Oxford University Press. |
| 3. | Brown T.A. (2016). Gene Cloning and DNA Analysis. (7 th 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. (3 rd Edition). John Wileys and Sons Ltd. 2012. |
| 5. | Maloy S. R., Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2 nd 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 (8 th Edition) By David L. Nelson and Michael M. Cox Book Free Download - StudyMaterialz.in |
| 5. | https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/ |

Mapping with Programme Outcomes

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|----------|----------|----------|----------|----------|
| CO 1 | M | | | | | S | M | M | S | | M | | | |
| CO 2 | M | | | | | S | M | M | S | | M | | | |
| CO 3 | | | | | S | | S | M | S | | M | | | |
| CO 4 | | | | | | S | S | M | S | | S | | | |
| CO 5 | | | | | | S | S | M | S | | S | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|--------------------|---|---|---|---|
| 23216DSC15A | Bioinstrumentation | 5 | 1 | 0 | 3 |

| 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 radioisotopes in various techniques. |

Course Detail:

UNIT 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 coefficient; Principles, methodology and applications of differential, rate zonal and density gradient centrifugation - Applications in determination of molecular weight.

UNIT 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. Simulated moving bed chromatography (SEC)

UNIT III:

Electrophoresis: General principles - moving boundary electrophoresis - electrophoretic mobility – supportive materials – electroendosmosis – 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.

UNIT 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 Spectroscopy UV/visible.

UNIT 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,

autoradiography and its applications. Commonly used isotopes in biology, labeling procedures and safety aspects.

| 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. (3 rd Edition). Prentice Hall. | |
| 5. | Jayaraman J. (2011). Laboratory Manual in Biochemistry. (2 nd Edition). Wiley Eastrn Ltd., New Delhi. | |
| References Books | | |
| 1. | Pavia D. L. (2012) Spectroscopy (4 th Edition). Cengage. | |
| 2. | Skoog A. and West M. (2014). Principles of Instrumental Analysis. (14 th Edition). W.B.Saunders Co., Philadephia. | |
| 3. | Miller J. M. (2007). Chromatography: Concepts and Contrasts (2 nd Edition) Wiley-Blackwell. | |
| 4. | Gurumani N. (2006). Research Methodology for Biological Sciences. (1 st Edition) MJP Publishers. | |
| 5. | Ponmurugan P. and Gangathara P. B. (2012). Biotechniques. (1 st 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 . | |

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 | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|----------------|---|---|---|---|
| 23216DSC15B | Health Hygiene | 5 | 1 | 0 | 3 |

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

Course Details:

UNIT I:

Introduction to hygiene and healthy life. Factors affecting health, health habits and practices. Recognizing positive & negative practices in the community. Scientific principles related to health

UNIT 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.

UNIT 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.

UNIT 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.

UNIT V:

Health programme and health education – Malaria control, Tuberculosis control, AIDS control programmes and Immunization Programmes. Family planning, Reproductive and Child health programmes (RCH).

| 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 Brahman G. N. V. (2019). Textbook of Human Nutrition. (4 th Edition). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi |
| 2. | Swaminathan (1995) Food & Nutrition (Vol I) (2 nd Edition). The Bangalore Printing & Publishing Co Ltd., Bangalore. |
| 3. | Paniker J. C. K. and Ananthanarayan R. (2017). Textbook of Microbiology. (10 th 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, (5 th 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 |

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 | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|-----------------------|---|---|---|---|
| 23216DSC15C | Microalgal Technology | 5 | 1 | 0 | 3 |

| Course Objectives | |
|-------------------|---|
| CO1 | Characterize the different groups of algae. |
| CO2 | Describe the cultivation and harvesting of algae. |
| CO3 | Identify the commercial applications of various algal products. |
| CO4 | Apply microalgae for environmental applications. |
| CO5 | Employ microalgae as alternate fuels. |

Course Details:

UNIT I:

Introduction to Algae - General characteristics. Classification of algae according to Fritsch. Salient features of different groups of algae. Distribution - Freshwater, brackish water and marine algae. Identification methods. An overview of applied Phycology. Economically important microalgae.

UNIT II:

Cultivation of freshwater and marine microalgae - Growth media. Isolation and enumeration of microalgae. Laboratory cultivation and maintenance. Outdoor cultivation - Photobioreactors - construction, types and operation; raceway ponds - Heterotrophic and mixotrophic cultivation - Harvesting of microalgae biomass.

UNIT III:

Microalgae in food and nutraceutical applications - Algal single cell proteins. Cultivation of *Spirulina* and *Dunaliella*. Microalgae as aquatic, poultry and cattle feed. Microalgal biofertilizers. Value-added products from microalgae. Pigments - Production of microalgal carotenoids and their uses. Phycobiliproteins - production and commercial applications. Polyunsaturated fatty acids as active nutraceuticals. Microalgal secondary metabolites - Pharmaceutical and cosmetic applications

UNIT IV:

Microalgae in environmental applications. Phycoremediation - Domestic and industrial waste water treatment. High-rate algal ponds and surface-immobilized systems - Treatment of gaseous wastes by microalgae. Sequestration of carbon dioxide. Scavenging of heavy metals by microalgae. Negative effects of algae. Algal blooms, algicides for algal control

UNIT V:

Microalgae as feed stock for production of biofuels - Carbon-neutral fuels. Lipid-rich algal strains - *Botryococcus braunii*. Drop-in fuels from algae - hydrocarbons and biodiesel, bioethanol, biomethane, biohydrogen and syngas from microalgae biomass. Biocrude synthesis from microalgae. Integrated biorefinery concept. Life cycle analysis of algae biofuels

| Course Outcomes | | |
|-----------------|---|----------------------|
| Course Outcomes | On completion of this course, students will; | |
| CO1 | Acquire knowledge in the field of microalgal technology and their characteristics. | PO1 |
| CO2 | Identify the methods of algal cultivation and harvesting. | PO1, PO6 |
| CO3 | Recognize and recommend the use of microalgae as food, feed and fodder. | PO7, PO8, PO9 |
| CO4 | Promote microalgae in phyco remediation. | PO7, PO9, PO11, PO14 |
| CO5 | Compare and critically evaluate recent applied research in these microalgal applications. | PO7, PO8, PO9 |

| Text Books | |
|------------|--|
| 1. | Lee R.E. (2008). Phycology. Cambridge University Press. |
| 2. | Sharma O.P. (2011). Algae. Tata McGraw-Hill Education. |
| 3. | Shekh A., Schenk P., Sarada R. (2021). Microalgal Biotechnology. Recent Advances, Market Potential and Sustainability. Royal Society of Chemistry. |
| 4. | Lele. S.S., Jyothi Kishen Kumar (2008). Algal bio process technology. New Age International P(Ltd) |
| 5. | Das., Mihirkumar. Algal Biotechnology. Daya Publishing House, New Delhi. |

| References Books | |
|------------------|--|
| 1 | Andersen R.A. (2005). Algal culturing techniques. Academic Press, Elsevier. |
| 2 | Bux F. (2013). Biotechnological Applications of Microalgae: Biodiesel and Value-added Products. CRC Press. |
| 3 | Singh B., Baudh K., Bux, F. (2015). Algae and Environmental Sustainability. Springer. |
| 4 | Das D. (2015). An algal biorefinery: An integrated approach. Springer. |
| 5 | Bux F. and Chisti Y. (2016). Algae Biotechnology: Products and Processes. Springer. |

| Web Resources | |
|---------------|---|
| 1 | https://www.classcentral.com/course/algae-10442 |
| 2 | https://onlinecourses.nptel.ac.in/noc19_bt16/preview |
| 3 | https://freevideolectures.com/course/4678/nptel-industrial-biotechnology/46 |
| 4 | https://nptel.ac.in/courses/103103207 |
| 5. | https://www.sciencedirect.com/topics/earth-and-planetary-sciences/microalgae |

Mapping with Programme Outcomes

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

| Course Code | Course Title | L | T | P | C |
|-------------|---|---|---|---|---|
| 23216DSC15D | Essentials of Laboratory Management and Biosafety | 5 | 1 | 0 | 3 |

| 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. |

Course Details :

UNIT 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.

UNIT 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.

UNIT 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

UNIT IV:

Biosafety - Historical background. Blood borne pathogens (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.

UNIT 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

| 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 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. (1st Edition). Notion Press. ISBN 10: 1645878856 | |
| 3. | Biosafety in Microbiological and Biomedical Laboratories - U.S. Health Department and Human Services. (2016). (5 th Edition). Lulu.com. | |
| 4. | Kanai. L. Mukherjee. (Medical Laboratory Technology(4 th Edition). CBS Publishers. | |
| 5. | Ramakrishnan (2012). Manual of Medical Laboratory Techniques. JP brothers. | |
| References Books | | |
| 1. | World Health Organization, Biosafety programme management. (2010). (4 th Edition). WHO Publications. | |
| 2. | Rashid N. (2013). Manual of Laboratory Safety (Chemical, Radioactive, and Biosafety with Biocides) (1 st 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 (2 nd 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/Online_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 | |

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 | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|----------------------|---|---|---|---|
| 23216SEC16 | Research Methonology | 2 | - | - | 2 |

| Course Objectives | |
|-------------------|---|
| CO1 | To get the employ skills on laboratory safety and avoid laboratory accidents. |
| CO2 | To know about the prevent laboratory hazards by practicing safety strategies. |
| CO3 | To practice various first aid procedures during common laboratory accidents. |
| CO4 | To know about ensure biosafety strategies in the laboratory. |
| CO5 | To get the knowledge of recognize the importance of biosafety guidelines. |

Course Details:

UNIT 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.

UNIT II:

Common hazards in laboratory: Chemical hazards- Safe handling of chemicals and gases, hazard labels and symbols. Material safety data sheet (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.

UNIT 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.

UNIT IV:

Biosafety - Historical background. Blood borne pathogens (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.

UNIT 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.

| 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. (1st Edition). Notion Press. ISBN 10: 1645878856 | |
| 3. | Biosafety in Microbiological and Biomedical Laboratories - U.S. Health Department and Human Services. (2016). (5 th Edition). Lulu.com. | |
| 4. | Kanai. L. Mukherjee. (Medical Laboratory Technology(4 th Edition). CBS Publishers. | |
| 5. | Ramakrishnan (2012). Manual of Medical Laboratory Techniques. JP brothers. | |
| References Books | | |
| 1. | World Health Organization, Biosafety programme management. (2010). (4 th Edition). WHO Publications. | |
| 2. | Rashid N. (2013). Manual of Laboratory Safety (Chemical, Radioactive, and Biosafety with Biocides) (1 st 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 (2 nd 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/Online_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 | |

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 | | | |

SEMESTER II

| Course Code | Course Title | L | T | P | C |
|-------------|-----------------------------------|---|---|---|---|
| 23216AEC21 | Medical Bacteriology and Mycology | 4 | 1 | 0 | 4 |

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

Course Details:

UNIT I :

Classification of medically important bacteria, Normal flora of human body, Collection, transport, storage and processing of clinical specimens, Microbiological examination of clinical specimens, antimicrobial susceptibility testing. Handling and maintenance of laboratory animals – Rabbits, guinea pigs and mice.

UNIT II :

Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of *Staphylococci*, *Streptococci*, *Pneumococci*, *Neisseriae.*, *Bacillus*, *Corynebacteria*, *Mycobacteria* and *Clostridium*.

UNIT 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.

UNIT 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 medical importance – *Candida*, *Cryptococcus*. Mycotoxins. Antifungal agents, testing methods and quality control.

UNIT 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.

| Course Outcomes | | |
|-----------------|---|-------------|
| Course Outcomes | On completion of this course, students will; | |
| CO1 | Collect, transport and process 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 to detect fungi in clinical samples and apply knowledge on antifungal agents.. | PO5,PO9 |
| CO5 | Apply various immunodiagnostic methods to detect fungal infections. | PO5,PO9 |

Text Books

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

Web Resources

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

Mapping with Programme Outcomes

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO1 0 | PO1 1 | PO1 2 | PO1 3 | PO1 4 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----------|----------|----------|----------|----------|
| CO1 | M | | | | S | | | | M | | | | | |
| CO2 | M | | | | S | | | | M | | | | | |
| CO3 | M | | | | S | | | | M | | | | | |
| CO4 | | | | | S | | | | M | | | | | |
| CO5 | | | | | S | | | | M | | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|-----------------------------------|---|---|---|---|
| 23216AEC22 | Medical Virology and Parasitology | 4 | 1 | 0 | 4 |

Course Objectives

CO1:Describe the replication strategy and cultivation methods of viruses.

CO2:Acquire knowledge about oncogenic viruses 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.

Course Details:

UNIT 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).

UNIT 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

UNIT III:

Bacterial viruses - Φ X 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.

UNIT 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*.

UNIT 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.

| 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 the public about the spread, control and prevention of parasitic diseases. | PO5, PO7, PO8, PO10 |
| CO5 | Identify the protozoans and helminths 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. (10 th 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, New Delhi. |
| 5. | Arora, D. R. and Arora B. B. (2020). Medical Parasitology. (5 th Edition). CBS Publishers & Distributors Pvt. Ltd. New Delhi. |

| Reference Books | |
|------------------------|--|
| 1. | Carter J. (2001). Virology: Principles and Applications (1 st Edition). Wiley Publications. |
| 2.. | Willey J., Sandman K. and Wood D. Prescott's Microbiology. (11 th Edition). McGraw Hill Book. |
| 3. | Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19 th Edition). Lange Medical Publications, U.S.A. |
| 4. | Finegold S.M. (2000). Diagnostic Microbiology. (10 th Edition). C.V. Mosby Company, St. Louis. |
| 5. | Levanthal R. and Cheadle R. S. (2012). Medical Parasitology. (6 th Edition). S.A. Davies Co. Philadelphia. |

| 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 |

Mapping with Programme Outcomes

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

| Course Code | Course Title | L | T | P | C |
|-------------|----------------|---|---|---|---|
| 23216AEC23 | Bioinformatics | 4 | 1 | 0 | 4 |

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: Acquainted 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.

Course Details:

UNIT 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).

UNIT 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.

UNIT 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.

UNIT 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

UNIT 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.

| 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. | PO4, 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. (4 th 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) (4 th Edition). Prentice-Hall of India Pvt.Ltd. |
| 4. | Attwood, T.K. and Parry-Smith, D.J. (1999). Introduction to Bioinformatics. Addison Wesley Longman Limited, England. |
| 5. | Mount D.W., (2013).Bioinformatics sequence and genome analysis, 2 nd edn.CBS Publishers, New Delhi. |

| References Books | |
|------------------|---|
| 1. | Baxevanis A. D. and Ouellette F. (2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. (2 nd 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 (2 nd Edition). CBS Publishers and Distributors(Pvt.)Ltd. |
| 4. | Xiong J, (2011). <u>Essential bioinformatics</u> , First south Indian Edition, Cambridge University Press. |
| 5. | Harshawardhan P.Bal, (2006). <u>Bioinformatics Principles and Applications</u> , 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 |

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 | |

| Course Code | Course Title | L | T | P | C |
|-------------|--------------------------|---|---|---|---|
| 23216SEC24L | Medical Microbiology Lab | 0 | 0 | 4 | 4 |

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.

Course Details:

UNIT I:

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

UNIT II:

- ❖ Identification and Classification of common fungi. Mounting and staining of VAM spores.
- ❖ Examination of different fungi by Lactophenol cotton blue staining.
- ❖ Examination of different fungi by KOH staining.
- ❖ Cultivation of fungi and their identification - *Mucor*, *Rhizopus*, *Aspergillus*, *Penicillium*.
- ❖ Microscopic observation of different asexual fungal spores.
- ❖ Microscopic observation of fungal fruiting bodies.
- ❖ Identification of Dermatophytes.
- ❖ Isolation and characterization of bacteriophage from natural sources by phage titration.
- ❖ Cultivation of viruses –Egg Inoculation methods.
- ❖ Diagnosis of Viral Infections –ELISA –HIA.
- ❖ Spotters of viral inclusions and CPE-stained smears.

UNIT III:

- ❖ Examination of parasites in clinical specimens - Ova/cysts in faeces.
- ❖ Concentration: methods – Flootation methods-simple Saturated salt solution method – Zinc sulphate methods - Sedimentation methods- Formal ether method.
- ❖ Blood smear examination for malarial parasites. Thin smear by Leishman's stain – Thick smear by J.B. stain.
- ❖ Identification of common arthropods of medical importance - spotters of *Anopheles*, *Glossina*, *Phlebotomus*, *Aedes*, Ticks and mites.

UNIT IV:

- ❖ Good Laboratory Practices in Industrial Microbiology laboratory.
- ❖ Study of Bioreactor and its essential parts.
- ❖ Culturing and Characterization of microorganisms used in Dairy and Pharmaceutical industry.

- ❖ Screening for Enzyme producers (amylase /protease).
- ❖ Optimization of parameters for Amylase production.
- ❖ Screening for Organic acid producers (acetic acid/lactic acid).
- ❖ Screening for Antibiotic producers.

UNIT V:

- ❖ Immobilization of microbial cells and enzyme and its assessment.
- ❖ Microbiological assays of fermentation products – MIC- MBC.
- ❖ Microbiological assay of antibiotics by cup plate method and other methods.
- ❖ Sterility testing of pharmaceuticals.

| 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, 2 nd 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. | Cappuccino, J. and Sherman, N. (2002) Microbiology: A Laboratory Manual, (6 th Edition). Pearson Education, Publication, New Delhi. |
| 5. | Morag C. and Timbury M.C. (1994). Medical Virology. 4 th 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. (14 th 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 22 nd Edition. Cambridge University Press. |

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|----|---|
| 5. | Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7 th Edition. Elsevier, Mosby Saunders |
|----|---|

Mapping with Programme Outcomes

| | PO 1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO1 0 | PO1 1 | PO1 2 | PO1 3 | PO1 4 |
|------------|------|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-------|-------|-------|
| CO1 | | | | | | | M | M | M | | | | | |
| CO2 | | | | | | | M | M | M | | | | | |
| CO3 | | | | | | | M | M | L | L | | | | |
| CO4 | | | | | | | M | M | M | L | | | | |
| CO5 | | | | | | | M | M | M | | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|--------------|---|---|---|---|
| 23216DSC25A | Epidemiology | 4 | 1 | 0 | 3 |

Course Objectives

CO1:Describe the role of epidemiology in public health.

CO2:Explain about 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 on National health programmes that have been designed to address the issues.

Course Details:

UNIT 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.

UNIT 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 and contact investigation

UNIT 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.

UNIT 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. Prevention and management of nosocomial infections.

UNIT 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.

| 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., (3 rd Edition). CDC. |
| 2. | Gerstman B. (2013). Epidemiology Kept Simple: An Introduction to Classic and Modern Epidemiology. (3 rd Edition). Wiley Blackwell. |
| 3. | Greenwood, D., Slack, R. B. and Peutherer, J. F. (2012) Medical Microbiology, (18 th Edition). Churchill Livingstone, London. |
| 4. | Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19 th Edition). Lange Medical Publications, U.S.A. |
| 5. | Dimmok N. J. and Primrose S. B. (1994). <u>Introduction to Modern Virology</u> .5 th edn. 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. (3 rd Edition). Oxford University Press, New York. |
| 2. | Celentano D. D. and Szklo M. (2018). Gordis Epidemiology. (6 th Edition). Elseiver, USA. |
| 3. | Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2 nd Edition). Cambridge University Press. |
| 4. | Ryan K. J. and Ray C. G. (2004). Sherris Medical Microbiology. (4 th Edition), McGraw Hill, New York. |
| 5. | Topley W.W. C., Wilson, G. S., Parker M. T. and Collier L. H. (1998). Principles of Bacteriology. (9 th 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/whodscsreph200212.pdf |
| 4. | https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7187955/ |
| 5. | https://www.who.int/diseasecontrol_emergencies/publications/idhe_2009_london_outbreaks.pdf |

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 | | | | | | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|----------------------------------|---|---|---|---|
| 23216DSC25B | Clinical Diagnostic Microbiology | 4 | 1 | 0 | 3 |

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.

Course Details:

UNIT 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.

UNIT II:

Diagnostic procedures - General concept of Clinical specimen collection, transport, storage and general processing in Microbiology laboratory - Specimen acceptance and rejection criteria.

UNIT 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.

UNIT 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.

UNIT V:

Nosocomial infections – common types, sources, reservoir and mode of transmission, pathogenesis and control measures. Hospital Infection Control Committee (HICC) – Functions.

| 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. (14 th Edition). Elsevier, New Delhi. ISBN-10:0443047219 / ISBN-13-978-0443047213. |
| 2. | Tille P. M. (2021). Bailey and Scott's Diagnostic Microbiology. (15 th Edition). Elsevier. ISBN:9780323681056. |
| 3. | Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19 th Edition). Lange Medical Publications, U.S.A. |
| 4. | Mukherjee K.L. (2000). Medical Laboratory Technology. Vol. 1-3. (2 nd Edition). Tata McGraw-Hill Education. ISBN-10:0074632604. |
| 5. | Sood R. (2009). Medical Laboratory Technology – Methods and Interpretations. (6 th Edition). 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 Tenover F.C. (2003). Manual of Clinical Microbiology. (8 th Edition). American Society for Microbiology, Washington, DC. ISBN:1-555810255-4. |
| 2. | Bennett J. E., Dolin R. and Blaser M. J. (2019). Principles and Practice of Infectious Diseases. (9 th Edition). Elsevier. EBook ISBN:9780323550277. Hardcover ISBN:9780323482554. |
| 3. | Ridgway G. L., Stokes E. J. and Wren M. W. D. (1987). Clinical Microbiology 7 th Edition. Hodder Arnold Publication. ISBN-10:0340554231 / ISBN-13:9780340554234. |
| 4. | Koneman E.W., Allen S. D., Schreckenber P. C. and Winn W. C. (2020). Koneman's Color Atlas and Textbook of Diagnostic Microbiology. (7 th Edition). Jones & Bartlett Learning. ISBN:1284322378 9781284322378. |
| 5. | Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2 nd 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 |

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 | | | | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|----------------|---|---|---|---|
| 23216DSC25C | Bioremediation | 4 | 1 | 0 | 3 |

Course Objectives

CO1:Describe the nature and importance of bioremediation and use in real world applications.

CO2:Describe the typical composition of wastewater and application of efficient technologies for water treatment.

CO3:Explain the fundamentals of treatment technologies and the considerations for its design and implementation in treatment plants.

CO4:Explain the potential of microbes in ore extraction and acquaint students with methods of reducing health risks caused by xenobiotics.

CO5:Familiarize the role of plants and their associated microbes in remediation and management of environmental pollution.

Course Details:

UNIT I:

Bioremediation - process and organisms involved. Bioaugmentation - Ex-situ and in-situ processes; Intrinsic and engineered bioremediation. Major pollutants and associated risks; organic pollutant degradation. Microbial aspects and metabolic aspects. Factors affecting the process. Recent developments and significance.

UNIT II:

Microbes involved in aerobic and anaerobic processes in nature. Water treatment - BOD, COD, dissolved gases, removal of heavy metals, total organic carbon removal. Secondary waste water treatments - use of membrane bioreactor. Aquaculture effluent treatment. Aerobic sludge and landfill leachate process. Aerobic digestion.

UNIT III:

Composting of solid wastes, anaerobic digestion - methane production and important factors involved, Pros and cons of anaerobic process, sulphur, iron and nitrate reduction, hydrocarbon degradation, degradation of nitroaromatic compounds. Bioremediation of dyes, bioremediation in paper and pulp industries. Aerobic and anaerobic digesters – design. Various types of digester for bioremediation of industrial effluents.

UNIT IV:

Microbial leaching of ores - process, microorganisms involved and metal recovery with special reference to copper and iron. Biotransformation of heavy metals and xenobiotics. Petroleum biodegradation - reductive and oxidative. Dechlorination. Biodegradable plastics and superbugs.

UNIT V:

Phytoremediation of heavy metals in soil - Basic principles of phytoremediation - Uptake and transport, Accumulation and sequestration. Phytoextraction. Phytodegradation. Phytovolatilization. Rhizodegradation. Phytostabilization – Organic and synthetic amendments in multi metal contaminated mine sites. Role of Arbuscular mycorrhizal fungi and plant growth promoting rhizobacteria in phytoremediation.

| Course Outcomes | | |
|-----------------|---|-------------------------|
| Course Outcomes | | |
| CO1 | Differentiate Ex-situ bioremediation and In-situ bioremediation. Assess the roles of organisms in bioremediation. | PO1, PO2, PO4, PO5 |
| CO2 | Distinguish microbial processes necessary for the design and optimization of biological processing unit operations. | PO1, PO4, PO5, PO11 |
| CO3 | Identify, formulate and design engineered solutions to environmental problems. | PO5, PO7, PO8, PO11 |
| CO4 | Explore microbes in degradation of toxic wastes and playing role on biological mechanisms. | PO5, PO6, PO7, PO8, PO9 |
| CO5 | Establish the mechanisms of Arbuscular mycorrhizal fungi and Plant growth promoting <i>Rhizobacteria</i> in phytoremediation. | PO1, PO5, PO6, PO7, PO8 |

| Text Books | |
|------------|---|
| 1. | Bhatia H.S. (2018). A Text book on Environmental Pollution and Control. (2 nd Edition). Galgotia Publications. |
| 2. | Chatterjee A. K. (2011). Introduction to Environmental Biotechnology. (3 rd Edition). Printice-Hall, India. |
| 3. | Pichtel, J. (2014). Waste Management Practices: Municipal, Hazardous, and Industrial, 2 nd edition, CRC Press. |
| 4. | Liu, D.H.F and Liptak, B.G (2005). Hazardous Wastes and Solid Wastes, Lewis Publishers.. |
| 5. | Rajendran, P. & Gunasekaran, P. (2006). Microbial Bioremediation. 1 st edition. MJP Publishers |

| References Books | |
|------------------|--|
| 1. | Sangeetha J., Thangadurai D., David M. and Abdullah M.A. (2016). Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development. (1 st Edition). Apple Academic Press. |
| 2. | Singh A. and Ward O. P. (2004). Biodegradation and Bioremediation. Soil Biology. Springer. |
| 3. | Singh A., Kuhad R. C., and Ward O. P. (2009). Advances in Applied Bioremediation (1 st Edition). Springer-Verlag Berlin Heidelberg, Germany. |
| 4. | Atlas, R.M & Bartha, R. (2000). Microbial Ecology. Addison Wesley Longman Inc. |
| 5. | Rathoure, A.K. (Ed.). (2017). Bioremediation: Current Research and Applications. 1 st edition. I.K. International Publishing House Pvt. Ltd. |

Web Resources

| | |
|----|---|
| 1. | Bioremediation- Objective, Principle, Categories, Types, Methods, Applications (microbenotes.com) |
| 2. | https://agris.fao.org › agris-search |
| 3. | https://www.sciencedirect.com/topics/earth-and-planetary-sciences/bioremediation |
| 4. | https://www.intechopen.com/chapters/70661 |
| 5. | https://microbiologysociety.org/blog/bioremediation-the-pollution-solution.html |

Mapping with Programme Outcomes

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO1 0 | PO1 1 | PO1 2 | PO1 3 | PO1 4 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----------|----------|----------|----------|----------|
| 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 | | | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|---------------------------------------|---|---|---|---|
| 23216AEC23 | Clinical Research and Clinical Trials | 4 | 1 | 0 | 4 |

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.

Course Details:

UNIT 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).

UNIT 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

UNIT 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.

UNIT IV:

Quality Assurance, Quality Control & Clinical Monitoring: Defining the terminology- Quality, Quality system, Quality Assurance & Quality Control-QA audit plan. 21 CFR 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.

UNIT 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.

| 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. (4 th Edition). Elsevier, 2007. ISBN-10: 0128499052 |
| 2. | Friedman L. M., Furberg C. D. and Demets D. (1998). Fundamentals of Clinical Trials, Vol: XVIII. (3 rd 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. (4 th Edition). Jaypee Medical. ISBN-13: 978-1608318049. |
| 4. | Reed, G. (2004). Prescott and Dunn's Industrial Microbiology, 4 th edn, 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. (3 rd Edition). Lippincott Williams and Wilkins. |
| 3. | Rondel R. K., Varley S. A. and Webb C. F. (2008). Clinical Data Management. (2 nd Edition). Wiley. |
| 4. | Peppler, H.J. and Pearl Man, D. (1979). Fermentation Technology, Vol 1 & 2, 2 nd Edition Academic Press, London. |
| 5. | El-Mansi, E.M.T., Bryce, C.F.A., Demain, A.L. and Allman, A.R. (2007). Fermentation Microbiology and Biotechnology. 2 nd 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 |

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 | 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 | |

| Course Code | Course Title | L | T | P | C |
|-------------|-----------------|---|---|---|---|
| 23216GEC26 | Vermitechnology | 4 | 0 | 0 | 3 |

Course Objectives

CO1:Introduce the concepts of vermicomposting.

CO2:Explain the physiology, anatomy and biology of earthworms.

CO3:Acquire the knowledge of the vermicomposting process.

CO4:Explain the trouble shooting, harvesting and packaging of vermin composts.

CO5:Gain knowledge on applications of vermin composts and their value added products.

Course Details:

UNIT I:

Introduction to Vermiculture - Definition, classification, history, economic importance- In sustainable agriculture, organic farming, earthworm activities, soil fertility & texture, soil aeration, water impercolation, decomposition & moisture, bait & food and their value in maintenance of soil structure. Its role in the bio transformation of the residues generated by human activity and production of organic fertilizers. Choosing the right worm. Useful species of earthworms. Local species of earthworms. Exotic species of earthworms. Factors affecting distribution of earthworms in soil.

UNIT II:

Earthworm Biology and Rearing - Key to identify the species of earthworms. Biology of *Eisenia fetida*. a) Taxonomy Anatomy, physiology and reproduction of Lumbricidae. b) Vital cycle of *Eisenia fetida*: alimentation, fecundity, annual reproducer potential and limiting factors (gases, diet, humidity, temperature, PH, light, and climatic factors). Biology of *Eudrilus eugeniae*. c) Taxonomy Anatomy, physiology and reproduction of Eudrilidae. d) Vital cycle of *Eudrilus eugeniae*: alimentation, fecundity, annual reproducer potential and limit factors (gases, diet, humidity, temperature, PH, light, and climatic factors)

UNIT III:

Vermicomposting Process - Feeds for Vermitech systems- Animal manures- Kitchen Waste and Urban waste- Paper pulp and card board solids- Compost and waste products- Industrial Wastes. Vermicomposting Basic process- Initial pre-composting phase- Mesophilic phase- Maturing and stabilization phase- Mechanism of Earthworm action. Methods of vermicomposting- a) windrows system; b) wedge system; c) container system-pits, tanks & cement rings; commercial model; beds or bins-top fed type, stacked type, d) Continuous flow system.

UNIT IV:

Vermicomposting - Trouble Shooting-Temperature-Aeration- Acidity- Pests and Diseases- Ants, rodents, Birds, Centipedes, sour crop, Mite pests. Odour problems. Separation techniques- Light Separation-Sideways Separation-Vertical Separation-Gradual transfer. Harvesting Earthworms- manual method- migration method. Packing & Nutritional analysis of vermicompost.

UNIT V:

Applications of Vermiculture - Vermiculture Bio-technology, use of vermi castings in organic farming/horticulture, as feed/bait for capture/culture fisheries; forest regeneration. Application quantity of vermicompost in Agricultural fields- crops, fruits, vegetables & flowers.

By-products and value-added products- Verm wash- vermicompost tea-vermi meal-enriched vermicompost-pelleted vermicompost.

| Course Outcomes | | |
|-----------------|--|-------------------------|
| Course Outcomes | On completion of this course, students will; | |
| CO1 | Compare and contrast the uses of vermicompost to the soil. | PO1, PO4, PO5, PO9, |
| CO2 | Recommend different species of earthworms after acquiring knowledge on its biology. | PO1, PO4, PO6, PO9 |
| CO3 | Design the vermicomposting process. | PO1, PO4, PO6, PO7, PO8 |
| CO4 | Assess the Best Practices of Vermicomposting | PO6,PO7, PO8,PO9, |
| CO5 | Recommend the applications of vermicompost to different soils and for different crops. | PO1, PO4, PO5,PO6, PO7 |

| Text Books | |
|------------|---|
| 1 | Ismail S. A. (2005). The Earthworm Book, Second Revised Edition. Other India Press, Goa, India. |
| 2 | Rathoure A. K., Bharati P. K. and Ray J. (2020). Vermitechnology, Farm and Fertilizer. Vermitechnology, Farm and Fertilizer Discovery Publishing House Pvt Ltd. |
| 3 | Christy M. V. 2008. Vermitechnology, (1 st Edition), MJP Publishers. |
| 4 | The complete technology book on Vermiculture and Vermicompost with manufacturing Process, machinery equipment details and Plant Layout. AB Press. |
| 5 | Keshav Singh (2014). A Textbook of vermicompost: Vermiwash and Biopesticide. |

| References Books | |
|------------------|---|
| 1 | Roy D. (2018). Handbook of Vermitechnology. Lambert Academic Publishing. |
| 2 | Kumar A. (2005). Verms and Vermitechnology, A.P.H. Publishing Corporation, New Delhi. |
| 3 | Lekshmy M. S., Santhi R. (2012). Vermitechnology, Sara Publications, New Delhi, India. |
| 4 | <u>Edwards CA, Arancon NQ ShermanRL. (2011) Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management 1st edn.CRC Press.</u> |
| 5 | <u>Ismail, S.A. (1997). Vermicology-The Biology of Earthworm.1st edn. Orient longman.</u> |

| Web Resources | |
|---------------|---|
| 1. | https://en.wikipedia.org/wiki/Vermicompost |
| 2. | http://stjosephs.edu.in/upload/papers/9567411a78c63d4ccfbbe85e6aa22840.pdf |
| 3. | https://www.kngac.ac.in/elearning- |

| | |
|----|---|
| | portal/ec/admin/contents/4_18K4ZEL02_2021012803204629.pdf |
| 4. | https://composting.ces.ncsu.edu/vermicomposting-2/ |
| 5. | https://rodaleinstitute.org/science/articles/vermicomposting-for-beginners/ |

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 | | | | | | | |

SEMESTER III

| Course Code | Course Title | L | T | P | C |
|-------------|-------------------------------------|---|---|---|---|
| 23216AEC31 | Soil and Environmental Microbiology | 5 | 1 | 0 | 4 |

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 the 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.

Course Details:

UNIT 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

UNIT 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.

UNIT 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 distribution of microorganisms in various environments. Predisposing factors for Environmental diseases – infectious (water and air borne) and pollution related, spread and control of these diseases. Treatment and safety of drinking (potable) water, methods to detect potability of water samples. Space microbiology - Microbiological research in space environment.

UNIT 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

UNIT 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

| 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. (4 th Edition). Prentice–Hall of India Pvt. Ltd. |
| 4. | Sharma P. D. (2010). Microbiology and Plant pathology. (2 nd Edition). Rastogi Publications. |
| 5. | Subba Rao. N.S. (2005). Soil microorganisms and Plant Growth. (4 th Edition). Oxford and IBH Publishing Pvt. Ltd. |

| References Books | |
|------------------|---|
| 1. | Pepper I. L., Gerba C. P. and Gentry T. J. (2014). Environmental Microbiology (1 st Edition). Academic Press, Elsevier. |
| 2. | Bitton, G. (2011). Wastewater Microbiology. (4 th 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 |

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 | | | | | | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|--|---|---|---|---|
| 23216AEC32 | Recombinant DNA Technology and Biotechnology | 4 | 1 | 0 | 4 |

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.

Course Details:

UNIT 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.

UNIT II:

Gene regulation and expression – Lac operon, arabinose and tryptophan operons. Gene regulation in eukaryotic systems - repetitive DNA, gene rearrangement, promoters, enhancer elements. Molecular basis of gene mutation - Types of mutations - base substitutions, frame shift, 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).

UNIT 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, animal, plant, algae and fungi – merits and demerits.

UNIT IV:

Genomic DNA and cDNA library - Construction and Screening. Substrative 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 micro array. 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.

UNIT 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-vivo Gene Therapy. In-vivo Gene Therapy. Vectors in Gene Therapy-Viral and Non-Viral Vectors. Transgenic Plants.

| 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 on 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. (4 th Edition). Narosa Publishing House, New Delhi. |
| 2. | Snusted D.P. and Simmons M. J. (2019). Principles of Genetics. (7 th 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. (3 rd Edition). John Wileys and Sons Ltd. |
| 4. | Primrose S.B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics. (7 th Edition). Blackwell Publishing. |
| 5. | Maloy S. R. Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2 nd Edition). Narosa Publishing House Pvt. Ltd. |

| References Books | |
|------------------|--|
| 1. | Brown T. A. (2016). Gene Cloning and DNA Analysis- An Introduction. (7 th Edition). John Wiley and Sons, Ltd. |
| 2. | Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5 th Edition). ASM Press. |
| 3. | Russell P.J. (2010). Genetics - A Molecular Approach. (3 rd Edition). Pearson New International Edition. |
| 4. | Snyder 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. (3 rd Edition). John Wileys and Sons Ltd. |

| Web Resources | |
|---------------|---|
| 1. | https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/ |
| 2. | https://geneticeeducation.co.in/what-is-transcriptomics |
| 3. | https://www.molbiotools.com/usefullinks.html |
| 4. | https://geneticeeducation.co.in/what-is-transcriptomics |
| 5. | https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/ |

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 | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|---|---|---|---|---|
| 23216AEC33 | Fermentation Technology and Pharmaceutical Microbiology | 4 | 1 | 0 | 4 |

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.

Course Details:

UNIT 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.

UNIT II:

Fermenter – Design, types and construction, Instrumentation and control. Productivity. Yield coefficients. Heat production. Aeration and agitation. Gas exchange and mass transfer. Computer Applications in fermentation technology. Fermentation Economics.

UNIT 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.

UNIT 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.

UNIT V:

Production of pharmaceutical products and quality assurance – Vaccines, immunodiagnosics, 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.

| 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. (2 nd Edition). Laxmi Publications, New Delhi. |
| 2. | Casida L. E. J. R. (2019). Industrial Microbiology. New Age International Publishers. |
| 3. | Sathyanarayana U. (2005). Biotechnology. (1 st Edition). Books and Allied (P) Ltd. |
| 4. | Reed G. (2004). Prescott and Dunn's Industrial Microbiology. (4 th 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. (3 rd Edition). Pergamon Press. NY. |
| 2. | Handa S. S. and Kapoor V. K. (2022). Pharamcognosy, (4 th Edition). Vallabh Prakashan Publishers, New Delhi. |
| 3. | Kokate C. K., Durohit A. P. and Gokhale S. R. Pharmacognosy. (2002). (12 th Edition). Nirali Prakasham Publishers, Pune. |
| 4. | Hugo W. B. and Russell A. D. (2004). Pharmaceutical Microbiology. (7 th Edition). Blackwell Scientific Publication, Oxford. |
| 5. | Wallis, T.E. (2005). Text book of Pharmacognosy. (5 th 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/ |

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 | | | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|--|---|---|---|---|
| 23216AEC34L | Environmental Microbiology & rDNA Technology Lab | 0 | 0 | 4 | 4 |

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

Course Details:

UNIT I:

- ❖ Artificial Transformation
- ❖ Detection of Antibiotic resistant mutants
- ❖ Identification of mutants by replica plating method

UNIT II:

- ❖ Amplification of DNA by PCR
- ❖ Western blotting - Demonstration
- ❖ Southern blotting – Demonstration

UNIT III:

- ❖ Detection of Water hardness
- ❖ Microbiological analysis of water
- ❖ A) Total Heterotrophic Count
- ❖ B) Test for indicative organisms
- ❖ 1) MPN
- ❖ 2) Membrane Filtration
- ❖ Physical, chemical, assessment of water
- ❖ Physical - Color, pH,
- ❖ Chemical - alkalinity, acidity, DO, BOD, COD
- ❖ Enumeration of bacteria and fungi from air – Air sampler
- ❖ Isolation of free-living nitrogen fixers from soil and *Rhizobium* from root nodules of leguminous plants. Isolation and enumeration of phosphate-solubilizing bacteria from soil

UNIT IV:

- ❖ Preparation of Biofertilizers and testing the efficiency of prepared biofertilizers
- ❖ R:S ratio of soil microbes
- ❖ Estimation of soil enzymes- urease and phosphatase
- ❖ Study of phylloplane microflora by leaf impression method
- ❖ Isolation of cellulose degrading bacteria
- ❖ Preparation of a vermicompost
- ❖ Isolation of VAM fungi from soil
- ❖ Isolation of plant pathogen - *Alternaria* & *Curvularia* spp.,
- ❖ Cultivation of edible mushroom from solid waste
- ❖ Cultivation of *Azolla*

UNIT V:

- ❖ Visual examination, observation, and identification of some common plant infections.
- ❖ To test Koch postulates using plant pathogens
- ❖ Collection of 5 herbarium specimens of infected leaves.

| 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 (3 rd Edition). Pearson Education, Inc. |
| 2. | Glick B. R. and Patten C. L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA (5 th 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. (5 th Edition). The Benjamin publishing company. New York. |
| 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. (3 rd Edition). American Society for Microbiology. |

| References Books | |
|-------------------------|---|
| 1. | Sambrook J. and Russell D.W. (2001). Molecular Cloning: A Laboratory Manual. (7 th Edition). Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press. |
| 2. | Brown T.A. (2016). Gene Cloning and DNA Analysis. (7 th 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. (3 rd Edition). John Wileys and Sons Ltd. |
| 4. | Pepper I., Gerba C. and Brendecke J. (2004). Environmental Microbiology - A Laboratory Manual. (2 nd Edition). Academic Press, Elsevier. |
| 5. | Yates M.V., Nakatsu C.H., Miller R.V. and Pillai, S.D. (2016). Manual of Environmental Microbiology. (4 th 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 |

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 | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|------------------------------|---|---|---|---|
| 23216DSC35A | Biosafety, Bioethics and IPR | 4 | 1 | 0 | 3 |

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

Course Details:

UNIT 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.

UNIT 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.

UNIT 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.

UNIT 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.

UNIT 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 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. The Nuremberg code.

| 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 | Apply bioethics 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. (1 st Edition). Notion Press. ISBN-101645878856 |
| 2. | Satheesh M. K. (2009). Bioethics and Biosafety. (1 st Edition). J. K International Publishing House Pvt. Ltd: Delhi. ISBN: 9788190675703 |
| 3. | Goel D. and Parashar S. (2013). IPR, Biosafety and Bioethics. (1 st Edition). Pearson education: Chennai. ISBN-13: 978-8131774700 |
| 4. | Raj Mohan joshi. Biosafety and Bioethics. Wiley Publications. |
| 5. | Sibi. GIntellectual, 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/intell_e.htm |

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 | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|--------------|---|---|---|---|
| 23216DSC35B | Toxinology | 4 | 1 | 0 | 3 |

Course Objectives

CO1:Recognize the various categories of environmental toxins and their hazardous consequence

CO2:Enhance the knowledge of underlying etiology of diseases

CO3:Strengthen the evidence for a causal link between the exposure of hazardous agent 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 the deep understanding of medicinal and industrial applications

Course Details:

UNIT I:

General Introduction - Definition of toxins, different categories of toxins and venoms, recent trends in venom and toxin research.

UNIT 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.

UNIT III:

Plant toxins & Toxins from snake venom - Natural toxins in plants, Plant toxic proteins, impact of plant toxin on human, natural toxins in food, plants, allelopathy. Toxins from snake venom Snakes and Biological significance of their venoms, composition of snake venom, evolution of venom, 3D structure of some important venom constituents and their mechanism of action (phospholipase A2, cardiotoxin, neurotoxin) three-finger toxins, anti-venom and medicinal plants in treatment of snakebite patients.

UNIT 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.

UNIT V:

Medicinal and industrial applications of venoms and toxins. Use of toxins in neurobiology and muscular research, anticancer drugs, diagnosis of haemostatic disorders, antibacterial agents, bioinsecticides and other industrial applications.

| 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 actions 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 Toxinology. CRC Press. ISBN 9780824783747. | |
| 3. | Wilson K. and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. (7 th Edition). Cambridge University Press India Pvt.Ltd. ISBN 1-4051-3544-1. | |
| 4. | Pholtan Rajeev S.R. (2021)Pictorial handbookfor toxinology. Rudra Publications. | |
| 5. | Cora Lancaster. (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. (2 nd 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 | |

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 | | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|---|---|---|---|---|
| 23216DSC35B | Water Conservation and Water Treatment Technologies | 4 | 1 | 0 | 3 |

Course Objectives

CO1: Explain how societal and climatic changes will distress water supply and water demand in future

CO2: Ascertain promising elucidations to the global water crisis and assess the pros and cons

CO3: Acquire knowledge to identify the quality of water by standard method

CO4: Illustrate the methods of water treatment technologies and assessing the impact of HWTS

CO5: Describe the application and uses of various emerging water treatment technologies

Course Details:

UNIT I:

Water Scarcity; Major Causes of Water Scarcity, Types of Water Scarcity, Water Footprint- Effects of Water Scarcity Across the Globe-, Water Scarcity in India; Effects of Water Scarcity in India - Social and Political Effects and Economic Risks of Water Scarcity in India.

UNIT II:

Multi-pronged approach to Prevent Water Scarcity; Aquifer Recharging, Water reuse and Zero-Liquid Discharge Technology, Coastal Reservoir, Desalination Plants-Measures for Preventing Water Scarcity in India - Jal Shakti Abhiyan Campaign, Atal Bhujal Yojana, Adoption of Composite Water Management Index (CWMI), Water conservation resource management, Rain Water Harvesting.

UNIT III:

Water Quality and Pollution; Impurities in the water, Characteristics of different water sources Vulnerability of the water sources to contamination, Water quality criteria - Quality of surface waters, flowing waters, impounded waters, Groundwater, Water quality standards, Microbiological quality of drinking Water, Chemical quality of drinking water.

UNIT IV:

Water Treatment Technologies; Sedimentation, Filtration, Coagulation and flocculation, Water softening and adsorption processes, Membrane filtration, Microfiltration, Ultrafiltration and Nanofiltration, Water disinfection, Activated carbon filtration, Household Water Treatment and Safe Storage (HWTS). Methods for household water treatment Safe water storage, Household water treatment and safe storage decision tree, Assessing the impact of HWTS, Government policies for HWTS.

UNIT V:

New and Emerging Drinking Water Treatment Technologies; Nanotechnology, Acoustic nanotube technology, Photocatalytic water purification technology, Aquaporin Inside™ technology, Automatic Variable Filtration (AVF) technology, Sun Spring System, Desalination.

| Course Outcomes | | |
|-----------------|---|--------------------------|
| Course Outcomes | On completion of this course, students will; | |
| CO1 | Appraise issues of water scarcity, stress, and conflict on global population. | PO1, PO2, PO4, PO5, PO10 |

| | | |
|-----|---|--------------------------------|
| CO2 | Apprehend the multiple approaches against water scarcity and to understand various government schemes for water conservation. | PO1, PO2, PO5, PO10, PO14 |
| CO3 | Relate the connection between water quality and public health. | PO4, PO6, PO10 |
| CO4 | Design and execute standard strategy for successful HWTs implementation. | PO4, PO5, PO6, PO9 |
| CO5 | Cogitate the purpose, principles, operation, and limitation of various modern water treatment technologies. | PO5, PO7, PO8, PO9, PO10, PO11 |

Text Books

| | |
|----|--|
| 1. | Vasileios A., Tzanakakis N. Paranychianakis V. and Angelakis A. N. (2020). Water Supply and Water Scarcity. MDPI, ISBN 978-3-03943-306-3 (Hbk). ISBN 978-3-03943-3070. |
| 2. | Pannirselvam M., Shu Li, Griffin G., Philip L., Natarajan A. and Hussain S. (2019). Water Scarcity and Ways to Reduce the Impact. ISBN: 978-3-319-75199-3. |
| 3. | Tiwari A., Kumar A., Singh A., Singh T.N., Suozzi E., Matta G. and Russo S. (2022). Water Scarcity, Contamination and Management. Elsevier. ISBN: 9780323853781. |
| 4. | Daniel, C.J. (1996). Environmental Aspects of Microbiology, 1 st edn. Bright Sun Publications. |
| 5. | Maier RM, Pepper IL, Gerba CP (2008). Environmental Microbiology, 2 nd edn. Academic Press |

References Books

| | |
|----|---|
| 1. | Fujita K. and Mizushima T. (2021). Sustainable Development in India -Groundwater Irrigation, Energy Use, and Food Production. ISBN 9780367460976. |
| 2. | Gupta R. (2008). Water Crisis in India. Atlantic Publishers. ISBN: 9788126909582, 9788126909582. |
| 3. | Ahuja S. (2013). Monitoring Water Quality-Pollution Assessment, Analysis, and Remediation. Elsevier. Book ISBN: 9780444594044. Hardcover ISBN: 9780444593955. |
| 4. | Saeid Eslamian ., Faezeh Eslamian ., (2021) Water harvesting and conservation – Basic Concepts and fundamentals, Wiley Publications. |
| 5. | Buckley RG. (2016) Environmental Microbiology 1 st edn. CBS Publishing. |

Web Resources

| | |
|----|---|
| 1. | https://link.springer.com/book/10.1007/978-1-59745-278-6 |
| 2. | https://apps.who.int/iris/handle/10665/206916?show=full |
| 3. | https://www.acs.org/content/acs/en/policy/publicpolicies/sustainability/water- |

| | |
|----|---|
| | statement.html |
| 4. | https://www.toftigers.org/best-practice/water-conservation-and-treatment/ |
| 5. | https://doh.wa.gov/community-and-environment/wastewater-management/site-sewage-systems-oss |

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 | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|-------------------|---|---|---|---|
| 23216GEC36 | Nanobiotechnology | 4 | 1 | 0 | 3 |

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.

Course Details:

UNIT 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.

UNIT 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, Vapour/Gas phase synthesis-Inert gas condensation, flame pyrolysis, Laser ablation and plasma synthesis techniques. Microbial synthesis of nanoparticles

UNIT 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).

UNIT 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.

UNIT 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.

| 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 | PO1, PO9 |

| | | |
|-----|--|--------------------------|
| | medicine and environment. | |
| 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 |

Mapping with Programme Outcomes

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PO 13 | PO 14 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|----------|----------|----------|----------|----------|
| C01 | S | | | M | | | | | M | | | | | |
| C02 | S | | | | | | | | S | | | | | |
| C03 | S | | | | | M | | | | | S | | | |
| C04 | S | | | | S | | M | | S | | | | | |
| C05 | S | | | | S | | M | | S | | S | | | |

SEMESTER -IV

| Course Code | Course Title | L | T | P | C |
|-------------|---------------------------|---|---|---|---|
| 23216AEC41 | Food & Dairy Microbiology | 4 | 1 | 0 | 4 |

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.

Course Details:

UNIT 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.

UNIT 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

UNIT 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.

UNIT 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, bacto-fugation, and membrane filtration..

UNIT 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.

| 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. (6 th Edition). McGraw Hill Education. |
| 3. | Jay J. M., Loessner M. J. and Golden D.A. (2006). Modern Food Microbiology. (7 th Edition). Springer. |
| 4. | Doyle M. P., Buchanan R. L. (2012). Food Microbiology: Fundamentals and Frontiers. (4 th Edition). American Society for Microbiology Press. |
| 5. | Ray B. and Bhunia A. (2013). Fundamentals of Food Microbiology. (5 th Edition). CRC Press. |

| References Books | |
|------------------|---|
| 1. | Robinson R. K. (2000). Dairy Microbiology 3 rd edn, Elsevier Applied Science, London. |
| 2. | Adams M.R, and Moss M.D, (2005). Food Microbiology 4 th edn, New Age International Pvt. Ltd., Publishers. First edition. |
| 3. | Banwarst. G.J. (2003). Basic Food Microbiology 2 nd edn, CBS Publishers and distributors. |
| 4. | Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7 th edn. Edward Arnold: London. |
| 5. | Vijaya R K, (2004). Food Microbiology 1 st 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 |

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 | | | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|---------------------|---|---|---|---|
| 23216DEC42 | Marine Microbiology | 4 | 1 | 0 | 3 |

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 sea foods.

CO5: Describe the applications of marine biotechnological products and their future role in a rapidly changing planet.

Course Details:

UNIT 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.

UNIT 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.

UNIT III:

Marine extremophiles: Mechanism of survival at extreme environments – Adaptive mechanisms in thermophilic, alkalophilic, osmophilic, barophilic, psychrophilic hyperthermophilic and halophilic microorganisms – Importance in biotechnology

UNIT IV:

Marine Microbial Diseases: Aqua culture pathogens & Water borne pathogens - *Aeromonas*, *Vibrio*, *Salmonella*, *Pseudomonas*, *Leptospira*, *Corynebacteria* and viral diseases. Rapid diagnosis of contamination in sea foods and aquaculture products.

UNIT 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.

| 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. (3 rd 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. (5 th Edition). Benjamin Cummings. ISBN:0321030761 9780321030764. | |
| 5. | Veena. (Understanding marine biology. Discovery Publishing. | |

| References Books | | |
|------------------|--|--|
| 1. | Maier R. M., Pepper I. L. and Gerba C. P. (2006). Environmental Microbiology. (2 nd 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 Oceans. (3 rd 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 | |

Mapping with Programme Outcomes

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

| Course Code | Course Title | L | T | P | C |
|-------------|------------------------|---|---|----|---|
| 23216PRW43 | Project with Viva Voce | 0 | 0 | 10 | 4 |

OBJECTIVES OF THE COURSE

To impart advanced practical knowledge to conduct a research project. To plan and design statistically, retrieve relevant literature, organize and conduct, process the data, photograph relevant observations, evaluate by statistical programmes. Present the project in any regional/national conference/seminar during the second year of the course and submit for final semester examinations. The work has to be conducted in department under the guidance of the project supervisor. Interdisciplinary collaborations from external departments / institutions can be organized only for essential areas of the project. Industrial visit has been included along with the project work as a report (minimum of 10 pages) possibly with geo-tagged photographs. The method of valuation of the project and Industrial visit report submitted by the candidate is outlined as follows:

| Course Code | Course Title | L | T | P | C |
|-------------|--------------|---|---|---|---|
| 23216DEC44A | Bioenergy | 4 | 1 | 0 | 3 |

Course Objectives

CO1:Acquire knowledge on bioenergy utilizing organic wastes for energy recovery.

CO2:Discuss methods and strategies of exploiting microbes for the production technology of biodiesel.

CO3:Describe resources and techniques for the production and estimation of eco-friendly biofuels and the extent of their use potentially.

CO4:Gain knowledge for executing biogas plant in communities.

CO5:Explain possibility of using microbes for the production of bio-hydrogen as a source of future fuel.

Course Details:

UNIT I:

Bioenergy – Biomass Energy Resources. Biomass conversion methods. Microbes as bioresources for bioenergy products (Bacteria, fungi, yeast and microalgae) - Bioprospecting of microbial strains for biofuel production.

UNIT II:

Biodiesel – Microbes and Biodiesel. Production and feed stock. Techniques of lipid extraction and conversion to biodiesel. Biodiesel quality and its assessment. Strategies of genetic engineering of organisms for biodiesel production. Biodiesel production from single cell organisms (*Cryptococcus*, *Cunninghamella*, *Mortierella*).

UNIT III:

Alcoholic Fuels from microorganisms: Biochemical conversion to ethanol: Biomass pre-treatment, Starch to sucrose conversion and Sucrose to ethanol fermentation. Role of enzymes and their applications in ethanol production. Distillation and Quantification of ethanol. Production and Estimation of biobutanol, biomethanol, biopropanol and bioglycerol.

UNIT IV:

Biogas - Microbes and Biogas production, Biogas plants – types – design – construction– Biogas Bottling Technology and Development in India, Biogas appliances – burner, luminaries and power generation – effect on engine performance. Application of Biogas slurry in agriculture.

UNIT V:

Biohydrogen– Production from bacteria and algae. Commercialized microalgae (*Spirulina*, *Dunaliella*, *Hematococcus* and *Chlorella*) and their production. Economics of microalgae production. Cultivation of seaweeds. Microbial fuel cells.

| Course Outcomes | | |
|-----------------|--|----------------------|
| Course Outcomes | On completion of this course, students will; | |
| CO1 | Evaluate the various aspects of biomass production and their implementation. | PO1, PO5, PO6 |
| CO2 | Design and construct a biodiesel plant. | PO5, PO7, PO8, PO11, |

| | | |
|-----|---|----------------------|
| CO3 | Carry out the process of fermentation for bio – alcohol fuels. | PO1, PO4, PO5, PO7, |
| CO4 | Identify the nature of biogas as a biofuel and their technologies and applications. | PO5, PO7, PO8, PO11. |
| CO5 | Design, execute and extract biohydrogen from algae. | PO4, PO5, PO7, PO8. |

Text Books

| | |
|----|---|
| 1. | Dahiya A. (2014). Bioenergy- Biomass to Biofuel. (1 st Edition). Academic Press Editor. |
| 2. | Brown R. C. (2003). Biorenewable Resources: Engineering New Products from Agriculture. (1 st Edition). Wiley Blackwell Publishing. |
| 3. | Jawaid M., Hakeem K. R. and Rashid U. (2014). Biomass and Bioenergy: Processing and Properties. (1 st Edition). Springer Cham. |
| 4. | Caye M. Drapcho, Tery H. Walker (Biofuels Engineering Process Technology. McGraw Hill. |
| 5. | Teri. Bio energy Powering the Future. Pearson Longman Publications. |

References Books

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|----|---|
| 1. | Konur O. (2018). Bioenergy and Biofuels. (1 st Edition). CRC Press. |
| 2. | Lee J. W.(2012). Advanced Biofuels and Bioproducts. (13 th Edition), Springer. |
| 3. | Khanal S. (2008). Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. (8 th Edition). Wiley-Blackwell Publishing. |
| 4. | Pradeep Chaturvedi.(1995). Bioenergy Resources. Concept Publishing Company. |
| 5. | Lee S. (2018). Biofuel and Bioenergy. Taylor and Francis |

Web Resources

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|----|---|
| 1. | https://www.elsevier.com Biofuels and Bioenergy |
| 2. | https://www.sciencedirect.com › book › bioenergy |
| 3. | https://www.un.org/en/climatechange/what-is-renewable-energy?gclid=EAIaIQobChMIqriN2Nao-wIV2HwrCh2pfA5mEAAYASAAEgI-p_D_BwE |
| 4. | https://www.energy.gov/eere/bioenergy/bioenergy-basics |
| 5. | https://www.iea.org/fuels-and-technologies/bioenergy |

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 | | | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|---|---|---|---|---|
| 23216DSC44B | Herbal Technology and Cosmetic Microbiology | 5 | 1 | 0 | 3 |

| 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. |

Course Details:

UNIT 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.

UNIT II:

Collection and authentication of selected Indian medicinal plants: *Emblica officinalis*, *Withania somnifera*, *Phyllanthus amarus*, *Tinospora cordifolia*, *Andrographis paniculata*, *Piper longum*, *Ocimum sanctum*, *Azadirachta indica*, *Terminalia chebula*, *Allium sativum*. Preparation of extracts- Hot and cold methods. Preparation of stock solutions

UNIT III:

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

UNIT IV:

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

UNIT V:

Cosmetic microbiology test methods - Antimicrobial preservative efficacy, microbial content testing and biological toxicological testing. Validation methods - bioburden and Pharmacopeial microbial assays. Preservatives of cosmetics - Global regulatory and toxicological aspects of cosmetic preservatives.

| 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

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|----|--|
| 1. | Lee R.E. (2008). Phycology. Cambridge University Press. |
| 2. | Sharma O.P. (2011). Algae. Tata McGraw-Hill Education. |
| 3. | Shekh A., Schenk P., Sarada R. (2021). Microalgal Biotechnology. Recent Advances, Market Potential and Sustainability. Royal Society of Chemistry. |
| 4. | Lele. S.S., Jyothi Kishen Kumar (2008). Algal bio process technology. New Age International P(Ltd) |
| 5. | Das., Mihirkumar. Algal Biotechnology. Daya Publishing House, New Delhi. |

References Books

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|---|--|
| 1 | Indian Herbal Pharmacopoeia (2002). Vol. I &II Indian Drug Manufacturers Association, Mumbai. |
| 2 | British Herbal Pharmacopoeia.(1990).Vol.I. British Herbal Medicine Association.ISBN: 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. (2 nd 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

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|---|---|
| 1 | https://www.academia.edu/50236711/Modern_Extraction_Methods_for_Preparation_of_Bio_active_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/ |

Mapping with Programme Outcomes

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

| Course Code | Course Title | L | T | P | C |
|-------------|---|---|---|---|---|
| 23216DEC44B | Life Science for Competitive Examinations | 4 | 1 | 0 | 3 |

Course Objectives

CO1:Impart knowledge on 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.

Course Details:

UNIT 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.

UNIT 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.

UNIT 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.

UNIT 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).

UNIT V:

Evolution and Behaviour- Evolution - Theories- Darwin's, Lamarck's, Oparin Haldane. Paleontological, Embryological and Molecular evidences. 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.

| 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, relate with natural selection, adaptation and speciation. | PO4, PO6, PO9 |

| Text Books | |
|------------|--|
| 1. | Nelson D. L. and Cox M. M. (2008). Lehningers Principles of Biochemistry. (5 th Edition). W.H. Freeman and Company. |
| 2. | Chapman J. L. (1998). Ecology: Principles and Applications. (2 nd 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., Abba I. Terr, Parslow T.G. (1997). <u>Medical Immunology</u> . 9 th Edn, Prentice-Hall Inc. |

| References Books | |
|------------------|---|
| 1. | Pontarotti P. (2018). Origin and Evolution of biodiversity. (1 st Edition). Springer. |
| 2. | Verma P. S. and Agarwal V. K. (2004). Cell biology, Genetics, Molecular Biology, Evolution and Ecology. (2 nd Edition). S Chand publication. |
| 3. | Lewin R. and Foley R. (2004). Principles of Human Evolution. (2 nd Edition). Black well Publishing Company. |
| 4. | Boyer R.F. (2002) <u>Modern Experimental Biochemistry</u> 3 rd Edition. Pearson Education. |
| 5. | Wilson K., Walker J., Clokie S and Hofmann A. (2018) <u>Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology</u> 8 th Edition Cambridge University Press. |

Web Resources

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|----|---|
| 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 |

Mapping with Programme Outcomes

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| 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 | | | | |

| Course Code | Course Title | L | T | P | C |
|-------------|---------------------------------------|---|---|---|---|
| 2321DSC45 | Microbial Quality Control and Testing | - | - | - | 2 |

Course Objectives

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

CO2: Discuss collection, processing and preservation of water samples from industries in different areas.

CO3: Enumeration and isolation of microorganisms from the water samples.

CO4: Enumeration and isolation of microorganisms from the air samples.

CO5: Gain knowledge on sterility testing of different components in industries and quality control techniques.

Course Details:

UNIT 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.

UNIT II:

Wastewater 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.

UNIT 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.

UNIT 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.

UNIT 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. Quality assurance framework, assessment of pharmaceutical quality, determinants of pharmaceutical quality, practical approaches to quality assurance.

| 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 harvesting and 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. (2 nd Edition). Royal Society of Chemistry. |
| 3. | Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand. |
| 4. | Cappuccino, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6 th 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. (2 nd Edition). - Taylor & Francis. |
| 2. | Sundararaj T. (2003). Microbiology Laboratory Manual. (2 nd 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. (3 rd 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

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| 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 |

Mapping with Programme Outcomes

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| 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 | | | | | | |