**UNIVERSITY OF RAJSHAHI**

**RAJSHAHI 6205, BANGLADESH**

**Curriculum for M.Phil. / Ph.D. Course**

 **Session: 2023-2024**



**DEPARTMENT OF MICROBIOLOGY**

**FACULTY OF BIOLOGICAL SCIENCES**

**Department of Microbiology**

**PART A: Introduction**

1. **Title of the Academic Program:**

Master of Philosophy / Doctor of Philosophy in Microbiology

**Abbreviated form of the Degree:** M.Phil. / Ph.D. in Microbiology

**Name of the Program Offering Entity (POE):** Department of Microbiology

**Name of the Faculty:** Biological Sciences

**Name of the Awarding Institute/ University:** University of Rajshahi

**Location:** 4th Floor, Agriculture Faculty Building, Rajshahi 6205, Bangladesh

**Language of Study:** English

**Applicable Session:** 2023–2024 and onwards

1. **Vision of the University:**

To pursue enlightenment and creativity for producing world-class human resource to cater for the needs of changing time.

1. **Mission of the University:**

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| **M1** | To ensure an excellent curriculum with talented academicians and conducive academic and research environment for generation and dissemination of knowledge. |
| **M2** | To maintain international standards in education with focus on both knowledge and skills, and humanitarian and ethical values to meet the needs of the society and state. |
| **M3** | To develop strategic partnerships with leading national and international universities, and organizations for academic as well as research collaborations. |

 **M= Mission of the University**

1. **Vision of the Program Offering Entity:**

The vision of the present program of the Department of Microbiology is to produce high-quality microbiologists with academic and scientific excellence to meet home and abroad demand in the manufacturing, research, service industries and medical sectors.

1. **Mission of the Program Offering Entity (POE):**

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| **M1** | Providing high quality education to professionals offered by the entity. |
| **M2** | Creating research facilities that enables the students grasp the standard practices of formulation, manufacturing and regulatory affairs. |
| **M3** | To assist the health sector by applying their knowledge of industrial microbiology and create an eco-friendly environment for human welfare |
| **M4** | Offering various co-curricular activities and environment that help to develop potential leaders ready to undertake the challenge of building the society |
| **M5** | To establish a close connection with alumni, international academics and employers to collaborate and interactive relation with the professionals. |
| **M6** | Producing graduates who can serve the community with their leadership for sustainable growth to meet the needs of the twenty-first century challenges. |

**M= Mission of the Department**

1. **Program Offering Entity (POE):**

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| **O1** | To be recognized as a national and international leader in the progression of microbiology education and research. |
| **O2** | To assist in establishing rational diagnoses of diseases to achieve better health outcomes |
| **O3** | To improve microbial practice for providing quality health services to the community members |
| **O4** | To contribute the controlling pathogens and drugs development exploiting national resources to meet the needs of the upcoming challenges. |

**O= Objectives of the Department**

1. **Description of the Program:**

The Master of Philosophy (M.Phil.) and the Doctor of Philosophy (Ph.D.) degrees are research degrees. Postgraduate courses in the Department of Microbiology leading to M.Phil. and Ph.D. degrees, include successful completion of necessary theoretical course works and successfully defending a thesis.

There shall be one compulsory and one optional paper each carrying 100 marks and four hours end-of-the-year written examination. Candidates have to obtain at least 45% marks to qualify for the completion of the thesis.

Research degrees typically involve independent study, directed by a supervisor and or co-supervisor/s/s, and the production of a thesis. The essential difference between the Master and Doctoral levels, aside from the length of the registration period, lies in the quality of a successful MPhil/PhD thesis, which must be judged to be the result of original research, to be an addition to knowledge and to be worthy of publication, either in full or in an abridged form in a refereed journal.

The award of a M.Phil./ Ph.D. also requires the candidate to defend his/her thesis at a public oral examination. Many research degrees now contain a taught elements. The intention of these taught courses is to provide students with research techniques and skills that will not only assist them to complete their current research topic, but will also stand them in good stead for life after university.

The Candidate having proper qualification for admission has to select a supervisor and or co-supervisor/s for carrying out the research. Following consultation with the supervisor the candidate will submit the plan of study as required for registration and the name of courses he/she wants to opt for, the course’s must be relevant to his research topic and within the scope of the department. The submitted plan of work has to be approved by the Research Committee and Academic Committee; the candidate may change or modify his /her title and plan of study approved by the Department as per University rules.

1. **Mission of the Program Offering Entity:**

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| **M1** | To prepare Postgraduate with cutting-edge knowledge in the advance fields of microbiology in order to fulfill the requirements of export skilled manpower. |
| **M2** | To equip Postgraduate with front-line research facilities for advanced knowledge and leadership development opportunities, in order to make them internationally standard competent. |
| **M3** | To train the Postgraduate based on local and international requirements in order to promote innovation, capacity building, entrepreneurship, and the emergence of infectious diseases or the health of other environmental ecosystems. |

**M= Mission of the Department**

1. **Program Educational Objectives (PEOs):**

The PEOs of the Department are set as follows:

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| **PEOs** | **Description** | **Domain** |
| **PEO1** | The Postgraduate will have successful professional careers as innovative microbiologists in government, academia, and institutions, eager to serve society locally and globally. | **Fundamental** |
| **PEO2** | Postgraduate will continue to study and enhance their professions by participating in professional organizations and pursuing higher education. | **Fundamental** |
| **PEO3** | Postgraduate will be versatile and adaptive in the industry, with the ability to accept new chances in developing technologies, as well as opportunities for leadership and teamwork, all of which will lead to long-term research jobs. | **Thinking** |
| **PEO4** | Postgraduate will be able to act with the ethical, socio-ecological awareness that practical microbiological experts are expected to have in home and abroad. | **Personal** |
| **PEO5** | Instilling a sense of bioethical and socio-economical commitment in the personal and professional lives of management Postgraduate to contribute to country. | **Social** |

**PEO = Program Educational Objective (s)**

**Department of Microbiology**

**PART B: Description of Compulsory Courses**

**Course Code: MIC 601**

**Course Title: Research Methodology**

**Course Type: Compulsory**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** This course is designed to provide PhD students with a comprehensive understanding of the principles and applications of microbiology. The knowledge of research methodology provides a basic knowledge of good design concept, development of research plan, sampling strategy, simulation, interpretation of primary data, and selection of appropriate data. The course also discloses the rules of quotation and bibliography, scientific reports, reviews, short communication, and publication research articles in scientific journals.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the candidate will be able to-

**CLO1:** Learn a knowledge of research objectives, importance, types and limitations.

**CLO2:** Know about literature review, methodology and types of design.

**CLO3:** Gain knowledge on methods of primary data analysis and graph designing.

**CLO4:** Apply the methods of participation, handling data and research funds.

**CLO5:** Acquire knowledge of research ethics and research article publication ethics.

**CLO6:** Apply knowledge of thesis preparation and presentation.

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| **SI No.** | **Course Contents** |
| **1.** | **Concepts and Approaches:** Concept, objectives, characteristics, types, importance and limitation of research.  |
| **2.** | **Literature Review:** Learning objectives and uses of literature review. Organization of information on index cards and exercises. |
| **3.** | **Research Design:** Research methodology. Attributes of research. Features of good design and development of research plan. Types of program design. |
| **4.** | **Data Analysis:** Data collection and selection. Data analysis and interpretation. Problems, graphical representation and tabulation. |
| **5.** | **Guidelines for Communication:** General principles and methods in people’s participation. Concept of surveys. Preparation of questionnaire, probability and non-probability sampling, sampling with and without replacement, sampling technique. Study of sampling. |
| **6.** | **Research Ethics:** Fund collection and managing public research funds. Data collection, handling and management. Rules for collaborative research. |
| **7.** | **Publication Ethics:** Authorship. Plagiarism. Rules of quotation and bibliography. Ethical issues on scientific papers writing. |
| **8.** | **Thesis Preparation and Presentation:** Common computer programs. Interpretation. Different steps in report writing. Layout of research report. Presentation of research results. Writing thesis and papers. Oral presentation.  |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy | Assessment Strategy |
| **1-6** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation and Final examination. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

 1. Niglas K. The Multidimensional Model of Research Methodology. 215–236, 2010.

 2. Bright EW. Jr.An Introduction to Scientific Research. Dover Publications. 1991.

 3. Petter L. Research Methodology in the Medical and Biological Sciences. Elsevier. 2007.

 4. Thomas K. The Structure of Scientific Revolutions. University of Chicago Press. 1962.

 5. Ranjit K. Research Methodology: A step-by-step Guide for Beginners. Sage Pub.2012.

**Course Code: MIC 602**

**Course Title: Advanced Microbiology**

**Course Type: Compulsory**

**Credits: 4**

**Total Marks: 100**

**Rational of the Course:** This course is designed to provide PhD students with a comprehensive understanding of the principles and applications of microbiology. Introductory microbiology is the fundamental course for learning on microbiology. This course teach the basic knowledge of microbes, bacteria, archaea, algae, fungi and protists. This course explores the basic knowledge of microorganism’s characteristics, microbiological fields and applications in biological sciences.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Gain knowledge on microbial concepts, scope, and importance.

**CLO2:** Evaluate the bacteria, fungi, virus and algae classification and characterizations.

**CLO3:** Know different techniques of biotechnology using microbes and major features.

**CLO4:** Apply different types of molecular factors for antimicrobial resistance.

**CLO5:** Achieve a clear concept on pharmaceutical microbiology for drugs production.

**CLO6:** Apply the modern process in medical microbiology, immunology and medicine.

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| **SI No.** | **Course Contents** |
| **1.** | **Microbiology and Microbes:** General characteristics. Microbial groups. Microbial cells. Microbial growth and control. Techniques in microbiology. Microbial ecology. |
| **2.** | **Bacteriology:** Bacterial systematic. Bacterial cytoplasm, endospore and reproduction. Archaebacteria and eubacteria. Purple bacteria and relatives.  |
| **3.** | **Mycology and Phycology:** Introduction of mycology and phycology. Life cycle of fungi and algae. Molecular mycology and phycology. Applications of fungi and algae. |
| **4.** | **Virology:** Virus in human physiology systems. Herpes and hepatitis viruses. Non-oncogenic retroviruses-HIV. Oncogenic viruses. Human papilloma and influenza viruses. Prevention and treatment. |
| **5.** | **Microbial Biotechnology:** Microbes and biotechnology. Chemistry and microbiology. Materials and microbiology. Bioprocess engineering. Biotechnology and biosafety. |
| **6.** | **Antimicrobial Resistance:** Mechanisms of drug resistance. Fungal, viral and bacterial drug discovery. Impact of natural products. |
| **7.** | **Pharmaceutical Microbiology:** Microbial spoilage. Drugs test. Metabolisms and absorptions of drugs. Quality test. |
| **8.** | **Medical Microbiology and Immunology:** The human microbiome. Process of infection. Epidemiology and public health. Emerging infectious diseases. The future of chemotherapeutic agents. Immunemechanisms. Diagnostic immunology. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-6** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, Continuous Internal Evaluation (3CIE) and Semester End Examination (4SEE). |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

* + 1. Chung K, Liu J. Pioneers in Microbiology: The Human Side of Science. W. Sci. Pub. 2017.
		2. Madigan MT, Martinko JM. Brock Biology of Microorganisms.12th edi. 2009.
		3. Stanier RY, Ingraham JL, Wheelis ML. GEd Microbiology. McMillan. 2005.
		4. Tortora GJ, Funke BR, Case CL. Microbiology: An Introduction. 2008.
		5. De A. Practical and Microbiology. The National Book Depot. 5th Edition. 2020.
		6. Flint J. Principles of Virology. 4th edi. Asm Press Exclusive (Us), 2015.
		7. Vanmeter K.C. Microbiology for the Healthcare Professional. 3rd edi. 2021.

**Department of Microbiology**

**PART C: Description of Optional Courses**

**Course Code: MIC 603**

**Course Title: Food and Beverage Microbiology**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** Main objectives of this course design to production and applications of food, food products, food ingredients, fruit processing, spoilage of food, food processing and preservation, dairy products, bakery and confectionary food product, genetically modified foods, and canned foods following the foods rules and regulations in Bangladesh. Graduates would be able to create the employment opportunities in order to achieve the SDG goal of Bangladesh.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Conceptualized food microbiology and survival factors of microbes in foods.

**CLO2:** Learn aboutprevent food spoilage and ensure the process of food preservation.

**CLO3:** Apply dairy foods, fermented products and probiotics in home and industry.

**CLO4:** Evaluate food-borne diseases, food contaminants, sanitation and prevention.

**CLO5:** Ensure the implement of foods law and regulations for food safety and security.

**CLO6:** Apply the advanced techniques for beverages production and management.

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| **SI No.** | **Course Contents** |
| **1.** | **Foods and Microbes:** Food and food microbiology. Growth and survival factors of microbes in foods. Microbes and heavy metals in foods. |
| **2.** | **Spoilage of Foods:** Spoilage of vegetables, fruits, meat, eggs, milk, butter, bread and canned foods. |
| **3.** | **Food Preservation:** Food preservation. Methods of food preservation. Microwave processing and aseptic packaging. Effect of freezing/thawing of foods. |
| **4.** | **Dairy Foods:** Dairy foods production. Dairy starter cultures. Fermented products and probiotics. |
| **5.** | **Food Borne Diseases:** Concept of food borne diseases**.** Food and microbes intoxications. Food-borne diseases causing and effects. |
| **6.** | **Food Sanitation and Control:** Types of food contaminants, sanitation, management and prevention. HACCP in sanitation. Quality assurance for sanitation. |
| **7.** | **Foods Laws and Regulations:** Foods standards, codex alimentary, FDA, WHO, BSTI. Laws and regulations in international trade. Recent Concerns in food safety of emerging diseases. Genetically modified food. New trends in food packaging and technology. |
| **8.** | **Beverage:** Carbonated and non-alcoholic beverages. Stimulating beverages. Alcoholic beverages. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-6** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. James MJ. Modern food microbiology. 7th Edi. 2021.
2. Adams MR, Moss MO. Food microbiology. 3rd Edi. 2007.
3. Banwart G. J. Basic Food Microbiology. 2nd edin. Cbs, 2004.
4. Jay J. M. Modern Food Microbiology. 4th edin. Cbs. 2005.
5. Hutkins R.W. Microbiology and Technology of Fermented Foods. Wiley, 2014.

**Course Code: MIC 604**

**Course Title: Agricultural Microbiology**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** This course interprets microbial disease formation process, plant immune responses, signal integration, and manage agricultural diseases. The course explores the knowledge of crops plants and microbial symbionts and plants and pathogens relationship and their effects in crops production as well as agricultural microbiology. The course provides the basic intensive knowledge on biofertilizers and biopesticide production and uses in agricultural crops with a specific focus on ecofriendly environment.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Gain basic knowledge of microbes in agricultural and in soil.

**CLO2:** Learn about plants and microbial symbionts, and rhizosphere in microflora.

**CLO3:** Evaluate the knowledge of the crops processing and preservation.

**CLO4:** Analyze the pathogens, disease diagnosis, microbial fertilizers and controlling.

**CLO5:** Explain the uses of bio-fertilizer, bio-pesticides research in agriculture.

**CLO6:** Application of modern techniques for crops production and development.

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| **SI No.** | **Course Contents** |
| **1.** | **Agriculture and Microbes:** Importance of microbiology in agriculture. Good agricultural practices. Progress through multidisciplinary research. |
| **2.** | **Soil and Microorganisms:** Major groups of microorganisms in soil. Role of microbes in soil fertility plant nutrition and plant growth promotion. |
| **3.** | **Beneficial Microbes:**  Plants and mycorrhizal fungi, Microorganisms as fertilizers and nitrogen fixation. Overcoming barriers to successful agricultural microbiology research.  |
| **4.** | **Microbiological Challenges:** Microbial threat to agriculture. Disease formation process, the disease triangle, strategies of pathogenicity and plant immune responses. Prevent and manage plant diseases. |
| **5.** | **Microorganism in Agro-processing:** Preservation and storage of forage crops. Role of microbes in foods producing, processing and preservation. |
| **6.** | **Biofertilizer:** Biofertilizer – plant growth promoting rhizobacteria (PGPR); bioinoculant mass production using Rhizobium. Compost- green manure, town compost. Vermicompost production and applications.  |
| **7.** | **Biopesticides:** Biopesticides concept. Biopesticides of microbial origin. Biology and application of *Bacillus thuringiensis* (Bt) in pest control. Bt transgenic plants and foods: risks and benefits. |
| **8.** | **Transgenic Crops:** Genetically modified crops. Genetic engineering for abiotic and biotic factors resistance in crops. New genes introduction for multiple traits development. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. Shaista N, Iqra A, Yuanda S. Microbes as Biofertilizers, a Potential Approach for Sustainable Crop Production. Sustainability. 13 (4), 1868. 2021.
2. Choudhury ATMA, Kennedy IR. Prospects and potentials for systems of biological nitrogen fixation in sustainable rice production. Biol. Fertil. Soils. 39, 2004
3. Mukherjee, Ghosh T. Agricultural Microbiology. 2nd Edt. Kalyani Publishers, 2020.
4. Vieira. Bacterial colonization of minerals in grassland soils is selective and highly dynamic. Environmental Microbiology. 2020.
5. Falkowski PG, Fenchel T, Delong EF. The Microbial Engines That Drive Earth's Biogeochemical Cycles. Science. 2008.

**Course Code: MIC 605**

**Course Title: Biosafety and Biosecurity**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** The course provides an overview of biosafety, biosecurity and bioethics on laboratory. These are very important issues for ensuring safety, security and responsible behavior in biological research laboratories. This course describes the safe and secure handling of transgenic organisms and dangerous pathogens in a laboratory setting. This course also incorporates ethical questions that are at the heart of medicine, law, biology and public policy.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Describe the ways to treat a laboratory with proper safety.

**CLO2:** Know the biosafety levels required to maintain the risks and PPE use.

**CLO3:** Apply the knowledge of laboratory practice and decontamination processes.

**CLO4:** Describe the laboratory security systems to develop own environment

**CLO5:** Ensure the national and international biosecurity programs in laboratory.

**CLO6:** Apply the international bioethics standards, and guidelines for GMOs.

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| **SI No.** | **Course Contents** |
| **1.** | **Biosafety and Risk Assessment:** Biosafety and biorisk management. Important of biosafety. Risk assessment concept and techniques. Aerosol hazards and it’s minimizing in the laboratory. |
| **2.** | **Biosafety Cabinet:** Building Automation systems. Mistakes in facility design. Fire detection and control systems. Effluent decontamination systems. Biosafety levels and animal biosafety levels. |
| **3.** | **Personal Protective Equipment:** Types of PPE. Selection and proper fit, use of PPE. Cross contamination and proper doffing, disposal of PPE. Poor combinations of PPE. |
| **4.** | **Facilities and Safety Equipment:** Good laboratory practices (GLPs). Laboratory safeguards and procedures. Biological safety cabinets. Emergency procedures. |
| **5.** | **Biosafety Practices:** Disinfection and decontamination. Spill cleanup, waste disposal, selection of disinfectants. Mechanisms of action and categories of disinfectants. |
| **6.** | **Biosecurity and Emergency Response:** Personnel suitability. Insider threat awareness. Mental health awareness. Physical security. Emergency response. Lab animal and chemical handling practice. |
| **7.** | **Biosecurity Program:** Inventory process. Physical security. A personal reliability program. Transport programs. Information security processes. |
| **8.** | **Bioethics:** Principles of bioethics, ethical dilemma. Ethical considerations in microbial research area, medical sciences and GMOs. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-6** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. Michael JS. Gain-of-Function Research: Ethical Analysis, SciEng Ethics. 2016.
2. Miller JM, Astles R, Baszler T, Chapin K, Wiedbrauk D. Guidelines for Safe Work Practices in Human and Animal Medical Diagnostic Laboratories. 2012.
3. [Ned-Sykes R](https://www.ncbi.nlm.nih.gov/pubmed/?term=Ned-Sykes%20R%5BAuthor%5D&cauthor=true&cauthor_uid=25974716), [Pollock A](https://www.ncbi.nlm.nih.gov/pubmed/?term=Pollock%20A%5BAuthor%5D&cauthor=true&cauthor_uid=25974716), [DeBoy JM](https://www.ncbi.nlm.nih.gov/pubmed/?term=DeBoy%20JM%5BAuthor%5D&cauthor=true&cauthor_uid=25974716). Competency Guidelines for Public Health Laboratory Professionals. 2015.
4. Farida K. Enhancing Responsible Science Research. NSAB for Biosecurity. 2013.
5. Fleming DO, Debra L. Biological Safety: Principles and Practices, 4th Edition.
6. Centers for Disease Control and Prevention (U.S.). Biosafety in Microbiological and Biomedical Laboratories 5, 5th edition, 2009.

**Course Code: MIC 606**

**Course Title: Fermentation Technology**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** The field of modern microbiology belongs with fermentation technology that processes, bioreactor types, carbon sources, regulators to media, oxygen requirements and solid state fermentations. It describes the tropics of inoculums preparation for bacterial, yeast and fungal processes with suitable process of medium, fermenter, feed and continuous culture processes.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Learn about basic knowledge of fermentation as well as their function.

**CLO2:** Explain the bioreactor design, associated of instrument and services.

**CLO3:** Apply the energy and carbon sources, inoculums preparation and sterilization.

**CLO4:** Analyze the growth kinetics in fermentation and monitoring bioreactors.

**CLO5:** Apply the potential microbes and marketing locally and globally.

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| **SI No.** | **Course Contents** |
| **1.** | **Introduction to Fermentation:** Process and components of fermentation. Chronological development of the fermentation industry. |
| **2.** | **Bioreactor Design:** Bioreactor configuration. Impeller designs and baffles agitation and aeration. Fermentor associated instrument and services. |
| **3.** | **Media Development:** Precursors and metabolic regulators to media. Oxygen requirements, submerged, surface and solid state fermentations. |
| **4.** | **Sterilization:** Media sterilization, sterilization processes. Sterilization of the fermenter; feed and air. |
| **5.** | **Microbial Growth:** Rate equations for cell growth, substrate utilization and product formation.  |
| **6.** | **Instrumentation and Control:** Agitation and aeration, foam sensing, measurement. Control of dissolved oxygen.  |
| **7.** | **Fermentation Economics:** Isolation and strain improvement of potential microbes. Market potential, legislation, and recycling, effluent treatment. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. Stanbury PF, Hall SJ. Principle of Fermentation Technology. 3rd Edi. 2020.

2. EI-Mansi EMT, Bryce CFA. Fermentation Microbiology and Biotechnology. 2012.

3. Mclaughlin L. Fermentation Microbiol. and Biotechnol. Kaufman Press, 2022.

4. McNeil B, Harvey L. Practical Fermentation Technology. Wiley, 2008.

5. Srivashava ML. Fermentation Technology. Alpha Science Intl Ltd. 2008.

**Course Code: MIC 607**

**Course Title: Environmental Microbiology**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** The course focuses on the utilization of microbial processes in waste and water treatment, microbial removal, degradation of organics, phytoremediation of soil, water contaminated with toxic metals. It also deals with microbial waste utilization, microbial degradation of heavy metals, bio deterioration, environmental pollution and role of genetically engineered organisms for controlling environmental pollution. To provide the insights and tools to create new bio products and the utilization of microbial processes in wastewater treatment, bio deterioration, and bioremediation. The course also discuss about the role of genetically engineered microbes in industrial and environmental sectors.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Gain basic knowledge on modern environmental microbiology.

**CLO2:** Identify the global problems and solving for sustainable development.

**CLO3:**  Evaluate the concerns of waste and sewage treatments.

**CLO4:** Gain knowledge on the process ofbiodeterioration.

**CLO5:** Identify degradation microbes and bioengineering approaches of bioremediation.

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| **SI No.** | **Course Contents** |
| **1.** | **Introduction:** Modern environmental factors, effects, pollution and pollutants.Environmental pollution control measures. |
| **2.** | **Global Environmental Problems:** Global environmental problems and role of microbes for solutions. Microbial pollutants detection. |
| **3.** | **Sustainable Development:** Important of sustainable development for the environment. Role of microbes in sustainable development. |
| **4.** | **Water and Waste Treatment:** Water, waste and sewages treatments. Biodegradable recalcitrant wastes. Microorganisms and xenobiotics. |
| **5.** | **Biodeterioration:** Factors involved in biodeterioration. Biodeterioration of leather, plastics and rubber. Control of biodeterioration. |
| **6.** | **Degradative Microbes:** Recent approaches to enrich and isolate microbes having catabolic properties. |
| **7.** | **Bioremediation:** Concept, techniques and limitations of bioremediation. Environmental modification for bioremediation. Microbial seeding and bioengineering approaches. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. Bitton G. Wastewater Microbiology. 4th edi. Wiley India, 2018.
2. Mitchell R, Ji-Dong. Environmental Microbiology. W-Blackwell, 2nd Edt., 2009.
3. Vineet K, Gaurav S, Maulin S. Bioremediation for Environmental Sustainability Approaches to Tackle Pollution for Cleaner and Greener Society. 1st Edition, 2020.
4. Gaurav S, Vineet K. Bioremediation for Environmental Sustainability. 2020.
5. Kumar P. Environmental Pollution: Biodegradation and Bioremediation. 2017.
6. Ram NB. Environmental Pollutants and their Bioremediation Approaches. 2017.
7. Deep CS, Ravindra S. Bioremediation of Environmental Pollutants. Springer, 2022.

**Course Code: MIC 608**

**Course Title: Industrial Microbiology**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** Industrial microbiology is importance for manufacture of bio products, bio-energy, generate electricity, transport fuels, chemicals, pulp and paper, treating industrial waste water and reduce the adverse environmental impacts. The course also explores microbial metabolites, industrial foods and beverages.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Adoptstrain development in industrial fermentation for bio products.

**CLO2:** Apply the techniques ofDNA metabolites and recombinant DNAproduction.

**CLO3:** Produce antibiotics, insulin and industrial food and beverages using microbes.

**CLO4:** Explore the chemical applications for production of organic solvents.

**CLO5:** Explain contribution of microbes to economy, and marketing globally.

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| **SI No.** | **Course Contents** |
| **1.** | **Industrial Microbes:** Primary and secondary screening, strain development, preservation and maintenance. |
| **2.** | **Fermented Products:** Crude and synthetic media. Production of molasses, corn-steep liquor, sulphite waste liquor and yeast extract. |
| **3.** | **Molecule Products:** Production of *Taq* polymerase, restriction enzymes, and DNA ligase. Primary and secondary metabolites. Recombinant products. |
| **4.** | **Health Care Products:** Industrial production of antibiotics, vitamins, essential amino acids, enzymes and steroids. Insulin production. Metabolites identification. |
| **5.** | **Food and Beverage:** Dairy foods. Food additives and supplements.Production of beverages. Manufacture of yeast and single cell protein. |
| **6.** | **Chemical Applications:** Synthesis of L-Methionine, L-Lysine, L-Tryptophan, non-essential amino acid and L-Glutamic acid. Production of acetone, butanol, and isopropanol organic solvents. |
| **7.** | **Global Economy:** Contribution of industrial microbiology to economic growth and employment creation.  |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

## Vyan SP, Dixit VK. Pharmaceutical Biotechnology. CBS Publishers Pvt. Ltd., 2010.

## Ian FR. Culture of Animal Cells. 7th Edt., Wiley, 2016.

## Gordon N. Industrial Microbiology and Recombinant DNA Technology. 2022.

## Vanmeter K.C. Microbiology for the Healthcare Professional. 3rd edi. 2021.

## Tille P.M. Bailey and Scotts Diagnostic Microbiology. 15th edi. Elsevier, 2022.

**Course Code: MIC 609**

**Course Title: Molecular Biology**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** The course includes lectures and smaller group discussions as well as seminar, writing and data analysis exercises. The course emphasizes enhancing critical thinking and communication skills in the context of understanding research methodology, experimental design and the scientific process as applied to the field of Molecular Biology. This course is based upon the collaborative student learning model and will therefore endorse active student participation.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Understand the current trends of molecular biology and applications.

**CLO2:** Analyze the techniques of RNA extraction and expression.

**CLO3:** Acquire DNA manipulative enzymes, recombination and gene manipulation.

**CLO4:** Explore the mutagenic agents, mutagenicity and molecular mutagenesis.

**CLO5:** Apply the DNA sequencing, repairing and transposable genetic elements.

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| **SI No.** | **Course Contents** |
| **1.** | **Gene Expression:** Preparation and purification of total RNA. cDNA synthesis,RT-PCR and qRT-PCR analysis. Microarray and RNA seq analysis. |
| **2.** | **DNA Manipulative Enzymes:** Restriction endonucleases and other nucleases; ligases; polymerases; DNA-modifying enzymes, topoisomerases and ligation systems. Use of linkers and adaptors.  |
| **3.** | **Gene Manipulation:** General recombination and interactions of complementary strands of DNA molecules. Gene cloning strategies, gene transfer and genetic manipulation. Transferring recombinant plasmid. |
| **4.** | **Mutation:** Mutation types. Mutagenic agents. Mutagenesis. Mutation induced by chemical and physical agents. Effects of mutations. |
| **5.** | **Repairing:** DNA repair mechanisms, nature of DNA damage, and reversal of UV damage in prokaryotes. Mismatch repair; post replication, SOS, and error prone. Ultimate match of DNA-RNA. |
| **6.** | **Transposable Elements:** General features of transposons. Model for transposition, transposons in eukaryotes. Transposable elements, composite transposons, tn3 elements, retroviruses and retrotransposons. |
| **7.** | **Sequencing of Gene:** Sanger-Coulson, Maxam-Gilbert methods. Study of First, second and third generation sequencing.  |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. Alberts B, Raff M, Walter P. Molecular Biology of the Cell. 6th Edition. 2019.
2. Brown TA. Gene cloning and DNA analysis. Blackwell Sci. 7th Edition. 2016
3. Gurthew S, Richard S. Molecular Genetics-An Introduction Narrative.2nd Edition.2020.
4. Karp G. Cell and Molecular Biology-Concepts and Experiments. 6th Edition, 2018
5. Srivastava S, Srivastava PS, Tiwary BN. Molecular Biology and Biotechnology. 2012.
6. Khalid ZM, Sameena ML, Rovidha SR. Advanced Methods in Molecular Biology and Biotechnology. Elsevier Inc. 2021.

**Course Code: MIC 610**

**Course Title: Advanced Immunology**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** The main objectives of advanced immunology is to explore immunity and immune-system and immunoglobulin, MHC, hypersensitivity reaction, immunization, immunological techniques and genetic disorders for insure healthy life. It also apply microbial study in the area of immunology, developing vaccines for specific epidemic diseases, ontogeny immune system, immunological tolerance, hypersensitivity reactions, transplantation immunology and vaccination for healthy life.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Learn the ontogeny of immune system and immunological tolerance procedure.

**CLO2:** Explain the different types of hypersensitivity reactions.

**CLO3:** Gain knowledge in histocompatibility complex and vaccination process.

**CLO4:** Apply immunology of tumors and administration of vaccines in human.

**CLO5:** Learn about autoimmune diseases and management systems.

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| **SI No.** | **Course Contents** |
| **1.** | **Immune System:** Origin of hematopoietic stem cells. Immunological status of the newborn. Ontogeny of T and B cell. |
| **2.** | **Immunological Tolerance:** Mechanisms of tolerance. Thymic tolerance of self-antigens, B cell, and artificially induced tolerance. |
| **3.** | **Hypersensitivity:** Hypersensitivity definition. Gell and Coombs classification. Hypersensitivity types and reactions. Treatment of hypersensitivity reactions. |
| **4.** | **Transplantation Immunology:** Barriers of transplantation. Law of transplantation. Role of T lymphocytes and prevention of rejection. |
| **5.** | **Histocompatibility Complex:** Discovery of MHC molecules, General features of MHC genes and binding of peptides to MHC molecules. |
| **6.** | **Immunology of Tumors:** Surface markers of tumor cells. Immune response to tumor cells. Lympho-proliferative disorders. Cancer immunotherapy. |
| **7.** | **Antibody-mediated Autoimmune Diseases:** Systemic lupus erythematosus (SLE). Autoimmune Bullous Skin Diseases – Pemphigus. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. David MJB. David I. Immunology. 8thEdition. Saunders, 2012.
2. Ivan R. Roitt's Essential Immunology. 9thEdition. John Wiley & Sons, 1997.
3. Ivan MR, Peter JR. Essential Immunology. 13thedition Delves .W-Blackwel, 2016.
4. David M, Brian C, Anne C, Michael O. Lippincott Advanced Immunology. 1991.
5. Tizar I R. Immunology. An introduction. Saunders College Publication, 1995.
6. Abbas AK, Andrew HL. Basic Immunology. 4thEdition. Saunders, 2012.

**Course Code: MIC 611**

**Course Title: Public Health and Epidemiology**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** The course is helpful to explain the basic information on epidemiology uses, and Major epidemiologic functions, concepts of disease occurrence, epidemic disease occurrence and investigating on disease outbreak. The course is design to achieve the millennium development goal implementing community involvement in health, public health surveillance, and interpretations. The course makes the students awareness to bioethics debates, autonomy, non-malfeasance, beneficence and justice.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Know the information on infection chain and Major epidemiologic functions.

**CLO2:** Learn about disease outbreak and surveillance system to control disease.

**CLO3:** Explain the design of epidemiology and measures of potential impact.

**CLO4:** The awareness of health in development in millennium development goal.

**CLO5:** Know the physical and mental health information for improving health.

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| **SI No.** | **Course Contents** |
| **1.** | **Introduction:** Difference of endemic, epidemic and pandemic. Causes, types and importance. |
| **2.** | **Disease Outbreak and Control:** Disease outbreak. Notable outbreaks. Infection chain and disease occurrence. Prevention and managements. |
| **3.** | **Study Design:** Intervention or experimental studies. Randomized, non-randomized, controlled clinical, field and community trials.  |
| **4.** | **Statistical Methods in Epidemiology**: Basic incidence measures, risk and rate. Prevalence measures. Measures of association. Exposure odds ratio. Measures of potential impact and attributable risk |
| **5.** | **Health Development:** Role of health in development, and millennium development goal. Health professionals care. Home and community care. Health services. Health information technology. |
| **6.** | **Public Health Surveillance:** Characteristics of public health surveillance. Identifying health problems and evaluation. Improving health surveillance. |
| **7.** | **Mental Health:** History and importance. Mental health problems symptoms, diagnosis and solutions. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation and semester final |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. Aschengrau A, Seage GR. Essentials of Epidemiology in Public Health. 2021.
2. Goldsteen L, Goldsteen K, Dwelle T. Introduction to Public Health. 2nd Edi. 2021.
3. Spellman F.R. Fundamentals of Wastewater Based Epidemiology Biomonitoring of Bacteria Protozoa Covid 19 and other Viruses. Taylor & Francis, 2021.
4. Schneider M. Introduction to Public Health. 4th Edition. 2014.
5. Fleming ML and Parker E. Introduction to Public Health. 3rd Edition. 2015.
6. Georgia A. Principles of Epidemiology in Public Health Practice. 3rd Edition. 2012.

**Course Code: MIC 612**

**Course Title: Clinical and Medical Microbiology**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** Medical microbiology focuses on the nature and causes of diseases in human, emphasizing the diagnosis and treatment practices for pathogenic diseases in human body. Due to the change of environment microbes are evolving that make difficulties for clinical diagnosis and medical measures for infectious diseases. To combat such worst situation of various pathogens, this course offer modern knowledge of pathogens, diseases and their medical measures for infectious diseases in human health.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Achieve of human pathogens and host-pathogen interactions.

**CLO2:** Acquire knowledge of disease transport, culturing, and diagnostic tests**.**

**CLO3:** Learn about clinical manifestation, pathogenesis and antimicrobial therapy.

**CLO4:** Explain the human microbiome project, microbes and diseases.

**CLO5:** Gain knowledge of regenerative medicine, and methods of gene therapy.

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| **SI No.** | **Course Contents** |
| **1.** | **Human and Microbes:** Normal microbial population of healthy human body-skin, mouth, upper respiratory, intestinal, urino-genital tract and eye. |
| **2.** | **Host-Pathogen Interaction:** Pathogenicity, toxigenicity, virulence, carriers and their types. Nosocomial and opportunistic infections, septicemia, septic shock, transmission and spread of infection. |
| **3.** | **Samples Diagnosis:** Collection, transport and culturing of clinical samples, principles of different diagnostic tests. |
| **4.** | **Microbes and Diseases:** Clinical manifestation, pathogenesis, virulence factors, and control of diseases causing microbes. |
| **5.** | **Antimicrobial Therapy:** General properties of antimicrobial agents. Selective toxicity, spectrum of activity, modes of action, side effects and resistance of microorganisms. |
| **6.** | **Human Microbiome:** Human microbiome project. Microbes to human body. Disease and death, environmental health and migration. |
| **7.** | **Regenerative Medicine:** Present aspects of regenerative medicine. IPS cells. Cell therapy. Methods of gene therapy. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. Atlas RM. Principles of Microbiology. W.C. Brown Publishers. 2014.
2. Chakraborty P. A Text book of Microbiology. New central book agency Ltd. 2009.
3. Madigan MT. Biology of Microorganisms. Pearson. 12th Edition, 2009.
4. Schlegel G. GEd Microbiology. Cambridge Uni. Press.7th Edition, 2009.
5. Tortora FC. Microbiology an Introduction. Pearson Higher ED Pub. 2016.
6. Marchesi JR, Ravel J. The vocabulary of microbiome research: a proposal. 2015.

**Course Code: MIC 613**

**Course Title: Antimicrobial Resistance**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** The course focuses on the utilization of microbial processes in waste and water treatment, microbial removal, degradation of organics, phytoremediation of soil, water contaminated with toxic metals. It also deals with microbial waste utilization, microbial degradation of heavy metals, bio deterioration, environmental pollution and role of genetically engineered organisms for controlling environmental pollution. To provide the insights and tools to create new bio products and the utilization of microbial processes in wastewater treatment, bio deterioration, and bioremediation. The course also discuss about the role of genetically engineered microbes in industrial and environmental sectors.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Describe the concepts, history and importance of antimicrobial resistance.

**CLO2:** Apply general mechanisms of drug resistance and designing in laboratories.

**CLO3:**  Discovering new drug targets using bioinformatics knowledge.

**CLO4:** Describe the antibiotics' intrinsic actions, and mechanisms against pathogens.

**CLO5:** Understand the antimicrobial drug discovery and impact of natural products.

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| **SI No.** | **Course Contents** |
| **1.** | **Introduction:** History of drug-resistant microbes. Evolutionary biology of drug resistance. Importance of drug resistance in medical. |
| **2.** | **General Mechanisms of Drug Resistance:** Genetic mechanisms of drug resistance. Target-mediated antibacterial resistance. Antibiotic inactivation and modification. |
| **3.** | **Bacterial Drug Resistance Mechanisms:** Mechanisms of action and resistance. Resistance in bacteria. Mechanisms and resistance of antimycobacterial agents. |
| **4.** | **Fungal Drug Resistance Mechanisms:** Fungal drug resistance. Treatment and resistance mechanisms. Antifungal targets. Mechanisms of action and fungal resistance. |
| **5.** | **Viral Drug Resistance Mechanisms:** Mechanisms of resistance of antiviral drugs active against the human diseases. Molecular mechanisms. Hepatitis B virus and antiviral drug resistance, patterns and mechanisms. |
| **6.** | **Antibacterial Drug Discovery:** Screening strategies. Computational chemistry. Structure and fragment-based drug design. Problems and possibilities of antimicrobial resistance. |
| **7.** | **Role of Natural Products:** Natural products for drug discovery. Microbial natural products. The challenge of finding novel antibiotics. Antimicrobial activities and continuing source for inspiration. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. Prichard, R. K. Antimicrobial Drug Resistance. Mc Gill University, 621-628. 2017.
2. Gualerzi C. O., Brandi L., Fabbretti A. Antibiotics. John Wiley & Sons. 2013.
3. Tortora, G. J., Funke, B. R., Case C. L. Microbiology. PB Cummings. p. 912. 2007.

**Course Code: MIC 614**

**Course Title: Microbial Enzyme Biotechnology**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** Microbial enzyme biotechnology is the study of enzymes, their kinetics, composition and function, as well as their relation to each other. This course focus on the basic understanding of enzyme, its structure and function, classification, nomenclature, active site structure and mechanism, enzymatic reactions and regulation, isolation and purification of enzyme and use of enzyme in practice.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:** Explain the concept, general characteristics and actions of enzymes.

**CLO2:** Describe the enzymes catalysis and enzyme kinetics activities.

**CLO3:** Identify the procedure of enzyme inhibition and deactivation.

**CLO4:** Interpret the enzymes for uses as metal degradation and immobilization.

**CLO5:** Explores the applications of enzymes in medical and clinical sectors.

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| **SI No.** | **Course Contents** |
| **1.** | **Enzymes:** Enzymes and enzymology. Characteristics of enzymes and co-enzymes. Enzyme producing microbes and their applications. |
| **2.** | **Action of Enzymes:** Enzyme substrate complex. Concept of active center, binding sites, stereo-specificity and ES formation. Enzyme activities. |
| **3.** | **Enzymes Catalysis:** General acid-base catalysis; covalent catalysis; non-protein catalytic groups and metal ions. Chymotrypsin and lysozyme. |
| **4.** | **Enzyme Kinetics:** Factors influencing catalytic activity; simple enzyme kinetics with single and multi-substrate. Michaelis-Menten kinetics. |
| **5.** | **Inhibition and Deactivation**: Reversible enzyme, competitive, uncompetitive, mixed and noncompetitive inhibition. Irreversible inhibition and suicide in-activators. |
| **6.** | **Industrial Enzymes:** Uses of proteolytic and metal degrading enzymes. Enzymes as thrombolytic agents. Enzymes immobilization. |
| **7.** | **Medical Enzymes:**  Importance of enzymes in medical device cleaning. Applications of enzymes in medicine and to treat disorders. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. Albert L, David LN, Michael MC. Lehninger Principles of Biochemistry. 5th Edition. Freeman & Co. 2008.

2. Nicholas CP, Lewis S. Fundamentals of Enzymology. Oxford Press.2010.

3. Takahashi N, Isobe T. Proteomic Biology Using LC-MS. Wiley Interscience, 2008.

4.  Mateo C, Fernandez-Lorente G, Guisan J, Fernandez-Lafuente R. Improvement of enzyme activity, stability and selectivity via immobilization techniques. 2007.

5. Buchholz K. A breakthrough in enzyme technology to fight penicillin resistance—industrial application of penicillin amidase. App. Microbiol. Biotechnol. 2016.

6. Devasena T. Enzymology. 1st Edition, World Rights, 2010.

**Course Code: MIC 615**

**Course Title: Bioinformatics**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** Bioinformatics is an interdisciplinary field that develops methods and software tools dealing with the statistical knowledge of biological data presentation and analyses. The course explores chemo-informatics tools for drug discovery and designing. It also discloses the knowledge of molecular modeling, protein, drug, and DNA relationship in microbial, agricultural and medical sectors.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:**  Acquire knowledge of bioinformatics in the fields of microbiology.

**CLO2:** Know about the databases searching and sequence alignment.

**CLO3:** Learn about experimental design for bioinformatics.

**CLO4:** Show computational data integration and molecular dynamics simulations.

**CLO5:** Analyze chemo-informatics tools and drug development.

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| **SI No.** | **Course Contents** |
| **1.** | **Fundamental of Bioinformatics:** Types of databases, pitfalls of biological databases, global bioinformatics centers and servers. Bioinformatics tools. |
| **2.** | **Databases Searching and Sequence Alignment:** Nucleotide sequence databases, Genome Biology. Protein sequence databases. Protein databases. Multiple Sequence Alignments. |
| **3.** | **Experimental Design:** Bioinformatics pipeline to explore transcriptional regulation, differential expression analysis, transcriptomic analysis, compare and contrast microarray and RNA-seq methods. |
| **4.** | **Computational Microscopy:** Computational image processing in microscopy, systems biology and molecular biology. Complex systems and data integration. Molecular docking and dynamics simulations. |
| **5.** | **Chemical Research:** Structure representation, SMILES; Chemical Databases, 2D and 3D structures, reaction databases and searching techniques. Chemo-informatics tools for drug discovery. |
| **6.** | **Drug Design:** Concepts of molecular modeling. Molecular structure and internal energy. Application of molecular graphics. |
| **7.** | **Applications of Bioinformatics:**  Literature analysis. High-throughput image analysis. Biodiversity informatics. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. Harisha S. Fundamentals of Bioinformatics. I. K. International Pvt Ltd, 2010.
2. Ikoma H. Computational microscopy for sample analysis. PhD diss., MIT. 2014.
3. Madsen U, K-Larsen P. Textbook of Drug Design and Discovery. 2002.
4. Reynolds CH, Ringe D. Drug Design. Cambridge Uni Press. 2010.
5. Fosgerau K, Hoffmann T. Peptide therapeutics. Drug Discovery Today. 2015.

**Course Code: BMIC 616**

**Course Title: Nanobiotechnology**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** Nanobiotechnology and nano materials. Conversion of any material in nano scale results in alteration of its physicochemical, biological, mechanical, optical, electronic, etc. properties. Conversion for different useful activities. It is relevant for diverse sectors, such as chemicals, health, energy, industries and the environment. The use of this technology is increasing exponentially in the microbiological sector.

**Course Learning Outcomes (CLOs):**

At the end of the Course, the Student will be able to-

**CLO1:**  Acquire knowledge on nanomaterials and nanoparticles synthesis.

**CLO2:** Evaluate the microbial applications in nanotechnology.

**CLO3:** Gather knowledge uses of Quantum dots and BioMEMS**.**

**CLO4:** Apply NPs in biosensors, drug delivery and diagnostics in medical sciences.

**CLO5:** Understand the values of nano products in local and global market.

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| **SI No.** | **Course Contents** |
| **1.** | **Introduction: A**pplications of nanobiotechnology. Interdisciplinary relationship of nanobiotechnology. Green nanobioteechnology.  |
| **2.** | **Nanomaterial and Nanoparticles:** Modern biomaterials and nanoparticles. Green synthesis of nanoparticles. |
| **3.** | **Microbes in Nanobiotechnology:** Microbial cells factories. Microbes in food nanobiotechnology and microbial food safety. |
| **4.** | **Quantum Dots and BioMEMS:** Concept of Quantum dots and BioMEMS**.** Quantum dots and cellular imagine. Recent developments in BioMEMS. |
| **5.** | **Biosensoring:** Definition and different types of biosensors. Techniques and functions of different biosensors. Biosensors to monitor blood glucose. |
| **6.** | **Nanomedical Engineering and Drug Delivery:** Manufacturing of nanomedicine. Drugs design and delivery. Lyposomes as nanocarriers.  |
| **7.** | **Future Prospects:** Future prospects of nanobiotechnology. Challenges for nanobiotechnology. Potential hazards of nanoparticles. Nanobiotechnoligical products and global market. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. Boisseau P, Houdy P, Lahmani M. Nanoscience, Springer, 2009.
2. Gazit E, Mitraki A. Plenty of Room for Biology at the Bottom. 2nd Edition. 2013.
3. Krishna VS. Comprehensive Nanobiotechnology. 2011.
4. Niemeyer M, HYPERLINK "http://as.wiley.com/WileyCDA/Section/id-302477.html?query=Chad+A.+Mirkin"MirkinCA. Nanobiotechnology.HYPERLINK http://as.wiley.com/WileyCDA/Section/id-302477.html?query=Christof+M.+NiemeyerWiley-VCH, 2004.
5. Rathi R. Nanotechnology. S. Chand Publishing, 1st Edition, 2009.
6. Zuccheri G. DNA Nanotechnology: Methods and Protocols. Humana, 2nd Edition. 2018.

**Course Code: MIC 617**

**Course Title: Genomics and Proteomics**

**Course Type: Major**

**Credits: 2**

**Year/ Semester: 4th Year 2nd Semester**

**Academic Session: 2022-2023**

**Course Teacher:** Two Teachers Assigned by the Academic Committee

**Contract Hours: Minimum 26**

**Full Marks: 50** (Class attendance 5+Class assessment 10+Theory 35)

**Rational of the Course:** Genomics and proteomics deals with a rapidly evolving scientific area of genomes, proteomes and databases that store various data about genes, proteins, genomes and proteomes. This course provides a broad overview of the historical development, methods, and applications of genomics and proteomics in the life science. The course also explores the molecular structure of protein, protein engineering techniques and application of quantitative proteomics, human genomics and functional genomics biology.

**Course Learning Outcomes (CLOs):**

**A**t the end of the Course, the Student will be able to-

**CLO1:** Describe the principles and structure with emphasis on genomics organization.

**CLO2:** Analyzethestudy ofgenomics in prokaryotes, eukaryotes and organelle.

**CLO3:** Gain knowledge in molecular proteomics and modified genes**.**

**CLO4:** Apply protein engineering techniques, proteins analyzing and sequencing.

**CLO5:** Gain skills in proteomics and human genomics for diseases identification.

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| **SI No.** | **Course Contents** |
| **1.** | **Genomics Concept:** Definition and development of genomics. Physical mapping of genomes, whole genome sequencing project. Applications of genome sequencing. |
| **2.** | **Organization and Structure:** Structure of viruses, prokaryotes, organelle and eukaryotic genome. Chromatin structure to chromosome organization.  |
| **3.** | **Comparative Genomics:** Orthologoues, paralogoues and gene displacement. Bacterial genome assembly, annotation, genome submission to repository and MLSTs.  |
| **4.** | **Proteomics:** Concept, function and structure of commonly used peptide. Protein structures, identification and proteome analysis. Peptide mass fingerprinting. |
| **5.** | **Molecular Proteomics:** Factors for protein folding. Constructing bacterial expression plasmids for natural and modified genes. Designing modifications to change the protein’s properties. |
| **6.** | **Protein Engineering:** Protein engineering and construction. Proteins analyzing and comparing protein sequence data. Functions of individual amino acids. Protein sorting in *P. falciparum*. |
| **7.** | **Proteomics Applications:** Protein interactions and linkage maps. Quantitative proteomics applied to biomarker detection. Validation and human disease studies.  |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

1. Pevsner J. Bioinformatics and Functional Genomics. Wiley-Blackwell, 2009.
2. Twyman RM. Principles of Proteomics. Garland Science, 2014.
3. Hubert R. Protein Biochemistry and Proteomics. Academic Press, USA, 2006.
4. Arndt KM, Müller KM. Protein Engineering Protocols. Humana Press, 2010.
5. Veenstra TD, Yates JR. Proteomics for Biological Discovery Wiley-Liss, 2006.
6. Primrose SB, Twyman RM. Principles of Gene Manipulation and Genomics. 7th Edition. Blackwell Publishing. 2006.

**Course Code: MIC 618**

**Course Title: Genetic Engineering**

**Course Type: Optional**

**Credits: 4**

**Full Marks: 100**

**Rational of the Course:** Genetic engineering refers to the genetic modification, and novel organism’s production. Benefiting human beings it combine various technologies to living cells, agriculture, industry, medicine and nutrition. Genetic tools used in biotechnology to modify genetic structure of improve plants and animals products. Molecular basis of epigenetic, chromatin remodeling in gene regulation and diseases are important part of this course which are apply to modification of different organisms.

**Course Learning Outcomes (CLOs):**

**A**t the end of the Course, the Student will be able to-

**CLO1:** Know about different tools of genetic engineering and DNA manipulating.

**CLO2:** Explain the features of a cloning vectors, and expression of a cloned gene.

**CLO3:** Apply the techniques of mapping and RFLP, AFLP, SSR, RAPD and SNP.

**CLO4:** Acquire knowledge of epigenetic inheritance patterns and applications.

**CLO5:** Apply know of tropical diseases and applications in human welfare.

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| **SI No.** | **Course Contents** |
| **1.** | **Molecular Tools:** Recombinant DNA production. Amplification of recombinant DNA. Molecular analysis of DNA, RNA and protein. |
| **2.** | **Cloning Vector:** Competent cells preparation. Plasmid cloning vector production, Features of a cloning vector-cloning site, selectable marker, reporter gene and elements for expression. Screening of blue white.  |
| **3.** | **Analysis of Cloned Gene:** Recombinant DNA technology for human genes and human diseases. Human gene therapy. Transgenic animal and plant production. Inhibiting gene expression. |
| **4.** | **Gene Expression Analysis:** Transcription of cloned gene. Identifying protein binding sites on a DNA molecule. Identifying the translation product of a cloned gene.  |
| **5.** | **Gene Linkage and DNA Markers:** Gene linkage, chromosomes and gene mapping of human. Applications of RFLP, AFLP, SSR, RAPD and SNP. |
| **6.** | **Epigenetic:** Definitions, molecular basis, mechanisms, functions and consequences. Epigenetic and health. |
| **7.** | **Metagenomics:** Definition, types and importance. Tools and programs for genomic and metagenomics study. Basic linux commands, Anaconda, programs installation and maintenance, programs repository. Study of SARSCoV-2, Chikungunya, Dengue and Monkey pox. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-5** | Lecture, group discussion, open discussion and assignment | Assignment, tutorial, class test, quiz, presentation, CIE and SEE. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

* + - 1. Old RW, Primrose SB. Principle of Gene Manipulation. California Press, 2012.
			2. Watson JD, Baker TA. Molecular Biology of the Gene. Pearson, Boston.2009.
			3. Peter SD, Simmons MJ. Principles of Genetics. Wiley, New Jersey. 2011.
			4. Brown TA. Gene Cloning: An Introduction –Wiley Blackwell. 2020.
			5. Sambrook J. Russell D.W. Molecular Cloning: a laboratory manual, NY. 2008.
			6. Ausubel FM, Smith JA. Current Protocol in Molecular Biology. 2019.

**M.Phil. / PhD. Research Dissertation**

**Rational of the Course:** In professional life, microbiologists need to develop different project profiles. This course was designed to make the students compatible to develop a target-oriented research project.**Course Learning Outcomes (CLOs):**

At the end of the Course, the candidate will be able to-

**CLO1:** Formulate a research-project on a specific topic.

**CLO2:** Write-up a project paper, implement existing theoretical knowledge

**CLO3:** Learn how to present work in scientific seminar and laboratory work in a team.

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| **Course Contents** |
| The students will undertake a project involving literature survey, an experimental investigation, and the final preparation of a thesis on a selected topic.Research projects planned by researcher and supervised by the assigned supervisor/s or the following tropics- Food microbiology, Biotechnology,Industrial microbiology,Fermentation technology,Molecular biology,Environmental microbiology,Clinical microbiology, Immunology, Virology, Bacteriology, Phycology, Mycology, Plant and animal pathology, Pharmacology, Bioinformatics, Drug designing, Nanobiotechnology, Agricultural microbiology, Recombinant DNA technology, Graminology, Forest microbiology,Marine, aquatic and fish microbiology,Epidemiology,Antimicrobial resistance and so on. |

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| **Mapping CLOs with Teaching –Learning and Assessment Strategy** |
| **CLOs** | Teaching-Learning Strategy  | Assessment Strategy |
| **1-3** | Workshop on research proposal writing, discussion and feedback. Supervision, discussion and feedback. Group presentation, question session and feedback. | Synopsis presentation, research proposal writing, and lab works. Thesis paper submission. Defense of the research. |

**Learning Resources (Text Books, Reference Book, Online Resources and Other):**

Relevant journals and books/book chapter of the renowned publisher such as-

Nature, Elsevier Publisher, Springer Publisher, Taylor and Francis Publisher, SAGE Publisher, ACS Publisher, Wiley, Cell Press, MDPI etc.