Department of Microbiology

School of Life Sciences

Proposed Syllabus for

Pre-PhD Course Work

Microbiology

(Academic session 2022-2023)

Central University of Rajasthan NH-8, Bandarsindri, Kishangarh-305817

Dist. Ajmer

Name of the Program: PhD Microbiology

A. Program Eligibility

- A consistently good academic record possessing a Master's Degree in the subject concerned or in a cognate / allied subject with minimum of 55% marks or equivalent grade from a recognized University at both undergraduate and postgraduate levels; 5% relaxation in minimum requirement of marks is granted to SC/ST/OBC/PWD candidates

B. Program Objectives

- Imparting skills and knowledge in advance research methodologies
- Solving the existing scientific problems in area of basic and applied microbiology
- Creating a highly skilled professionals with expertise in current trends of research in area of microbiology
- Imparting hand on experience to students of different techniques and instrumentations of advance biological sciences
- Generating independent researchers who are capable of translating the research developed at laboratory scale to the industrial level.
- Imparting skills needed to become a successful academician, scientists or entrepreneur
- Inculcating the scientific ethics, temperament to contribute to field of science and help in nation building

C. Program outcomes

The Students successfully completing the course will have following skills

- Solid basic knowledge of research methodologies in area of modern biological sciences
- Contributing new methodologies and results in area of the basic and advanced microbiology for taking the research to next level
- Innovative scientists, skilled workforce to work in specialized area of microbiology
- Independent researchers who can contribute through fulfilling responsibility of academicians, scientist and entrepreneur
- Can start an independent research and can contribute in solving new problems faced in current science or in future.

D. Employability

- As academicians in different university or colleges at national and international levels
- As a researcher at different research institute at national and international level where they can initiate their independent research
- They can be absorbed by R& D sector of different biotechnological based company

Course Content: Pre-PhD Microbiology

(Implemented from academic session 2022- 2023 onwards)

Semester I

Course Code	Title of the course	Type of Course	Credits
MBY-701	Research methodology, biostatistics, computer application, bioinformatics and general techniques used in microbiology	Core	4
Any two electives from MBY-702 to MBY-709: Advanced specialized areas			
MBY-702	Energy Bioengineering and Geo-microbiology	Elective	4
MBY-703	Current Concept & Trends in Microbiology	Elective	4
MBY-704	Bioprocess Engineering	Elective	4
MBY-705	Current Perspectives on Infectious diseases and Cancer biology	Elective	4
MBY-706	Microbial Process and Enzyme Engineering	Elective	4
MBY-707	Frontiers in Cyanobacteriology	Elective	4
MBY-708	Enzyme technology, Metabolomics and Biomass based Bio-refinery	Elective	4
MBY-709	Molecular basis of infectious diseases and techniques	Elective	4
	Compulsory core courses (as UGC guidelines and NEP 2020)		
MBY-710	*Research and Publication Ethics (RPE) (The detailed curriculum was given by the UGC vide circular in August 2019 and also accepted by the University)	Core	2
MBY-711	#Pedagogy for Higher Education [NEP 2020 (15.9)]	Core	3
MBY-712	@Practice-Based Teaching Skills **[** The research scholar will support teaching/practical sessions for part of one or more courses as may be approved by the HOD on the recommendation of the Doctoral research committee (DRC)]. {NEP 2020 (15.9)}	Core	3

*Students will take this course from SWAYAM/NPTEL (MOOCS) or same course offered by any department.

School of Education will facilitate this course with the help of internal expert and a few experts and a similar course if available on SWAYAM/NPTEL (MOOCS)

@ Practice-Based Teaching Skills will be offered after completion of Pedagogy for Higher Education.

Total Credits: 20 (12 core + 8 elective)

MBY-701 Research methodology, biostatistics, computer application, bioinformatics and general techniques used in microbiology **Credits 4**

Course Objectives

- To understand the basic of research methodologies adapted for designing a project till completion and sharing of the observed results through publications.
- To learn basics of statistics for qualitative and quantitative analysis and deduce inferences from the observed biological data.
- To understand the structure of proposals, thesis and research publication.
- To learn basic tools in microbiological sciences which will be utilized during the course of PhD

Learning Outcomes

- Solid basic knowledge of research methodologies in area of modern biological sciences
- Innovative scientists, skilled workforce to work in specialized area of microbiology
- Independent researchers who can contribute through fulfilling responsibility of academicians, scientist and entrepreneur
- Can start an independent research and can contribute in solving new problems faced in current science or in future.

Course Structure

Unit I

Research Methodology: Definition, purpose and types (qualitative, quantitative, cross sectional, longitudinal, pure, applied, action, evaluation, historical, survey, exploratory and case study), Process of Research: Objectives and Dimensions, Design Tools: Library, Field, Laboratory. Systematic literature review, Features of good research study. Preparation of Research proposal/ synopsis, Research Ethics (Issues relating to referencing and documentation, copyrights, plagiarism etc), Impact Factor, H-Index, Citation Index, references/ bibliography Structuring the Ph.D. Thesis

Unit II

Biostatistics: Data Collection, presentation, data processing, classification and tabulation. Measures of Central tendency and Dispersion, Probability distribution: Binomial, Poisson and Normal, Confidence Interval, Errors, Sampling: types, steps; sampling errors Quantitative Techniques: Levels of significance, Regression and Correlation, Interpolation and Extrapolation, Sampling of attributes (including chi square test), Sampling of small and large sample variables (including Anova), fundamentals of hypothesis testing. Statistical decision theory Parametric vs. non-parametric tests

Unit III

Scientific Writing: Literature survey, compiling records. Definition and kinds of scientific documents. Components of a research paper– the IMRAD system, title, authors and addresses, abstract, acknowledgements, references, tables and illustrations. Dealing with publishers – submission of manuscript, Oral and poster presentation of research papers in conferences/symposia, Preparation and submission of research project proposals to funding agencies

Unit IV

Research Techniques: Computer Based techniques: Spreadsheet tools: Introduction to spreadsheet applications, features, Using formulas and functions for Statistical data analysis, Generating charts / graph. Power point Presentation, Tools for digital image processing

Laboratory Based Techniques: Microbial cell culture, sampling, microbial diversity analysis: Fundamental of microscopy, qualitative and quantitative assay of different biochemicals, Cell lysis and product extraction, various techniques used for fractionation and chromatography of biomolecules. Fundamental of electrophoresis and Sequencing based studies.

Suggested Readings

1. Marder M P (2011) Research Methods for Science, Cambridge University Press
2. Rosner B (2010) Fundamentals of Biostatistics, 7th Edition, Brooks/Cole Cengage Learning Publication

3. Dunleavy P (2003) Authoring a PhD: How to Plan, Draft, Write and Finish a Doctoral Thesis or Dissertation. Palgrave Macmillan

Elective MBY 702 to MBY 709 Advance Specialized Subject Credits 4

Any two out of MBY 702 to MBY 709

Course Objectives

- The course is designed to learn the advances in different specialized subjects of applied microbiology.
- To understand the specialized knowledge of the elected subject from research area such as Bioprocess, Bioengineering, Geo-microbiology, Infectious diseases, Enzyme Engineering, Cyanobacteriology and Metabolomics and Biomass based Biorefinery

Learning Outcomes

- Capable of understanding different fundamentals concepts and specialized knowledge of different applied microbiology area
- Can apply the knowledge gained in developing the project proposal during PhD dissertation work.
- Independent researchers who can contribute through fulfilling responsibility of academicians, scientist and entrepreneur
- Can start an independent research and can contribute in solving new problems faced in current science or in future.

Course Structures

MBY 702 A. Energy Bioengineering and Geo-microbiology

Unit I

Energy Systems: Introduction to Energy Systems and resources; Geo-energy systems and their types of formations; Renewable energy systems- Overview to Wind, Wave ad Tidal, Solar – Thermal and Geothermal Energy; Alternative Energy Systems (Biodiesel and Biofuels); Energy, conservation, sustainability and the environment. Greenfield chemistries for energy systems

Unit II

Geo-energy systems: Introduction to Oil Field Systems; Types of Geological energy formations: Oil Reservoirs, Shale Gas, Oil Sands and Coal Bed Methane; Energy Efficiency and sustainability, Oil formation composition, traditional recovery methods, novel discovery in recovery methods. Calculation of original oil in place, recoverable oil in place and residual oil in place, limitation of recovery methods and procedures to overcome, Description of reservoir souring and microbial influenced corrosion.

Unit III

Bioreactors in Bioengineering: Introduction to Enhanced Oil Recovery and Microbial Souring, Types of Bioreactors for simulating oil reservoir conditions: Glass Bioreactors, Syringe Bioreactors, Acrylic Bioreactors, Core Flooding Columns; Experimental Studies and Operations of Oil. Additional recovery and efficiency calculations, Bioreactor Simulation studies with simulation software

Unit IV

Alternative Energy Systems (Biofuels): Introduction to Biofuels – Attributes and History; Biodiesel and Alcohol Fuels –Ethanol Production (Characteristics and Energy Value); Cellulosic Ethanol, Methanol and Butanol (Enzymes and Fermentation); Biogas and Anaerobic Digestors. Biohydrogen production, Bioreactors for biofuels production.

Suggested Readings

1. Petroleum Microbiology, Ed.Michel Magot, Bernard Ollivier, Published 2005
2. Introduction to Biofuels, Author. David M. Mousdale, Published 2010

3. Bioreactor Design Fundamentals, Author. Norton G. McDuffie, Published 1991
4. Comprehensive Energy Systems, Author. Ibrahim Dincer, Published 2018

MBY 703. Current Concept & Trends in Microbiology

Unit I

Antimicrobial resistance: An overview of the history and development of antimicrobials, Introduction and impact of antimicrobial resistance, Antimicrobial agents-Antibiotics, Anti-fungal, Anti-viral, anti-protozoan; Antibiotic classification and mechanisms of their action, Evolution and molecular mechanisms of antimicrobial resistance, multi-drug resistance, superbugs, Global emergence of antimicrobial resistance, Factors contributing the emergence of antimicrobial resistance Antimicrobial susceptibility testing, Preventive and control strategies to control antimicrobial resistance, One Health approach.

Unit II

New methods for antimicrobials: Antimicrobial Discovery and Developments: Antimicrobials and their usage in human medicine, veterinary, and plant/animal agriculture. Biochemistry and molecular genetics of Antimicrobial resistance, Requirements to novel antimicrobial or alternatives, antibiotic resistance breakers or antibiotic adjuvants, antimicrobial peptides, drug-repurposing, natural products as a source for novel antimicrobials, Screening and development approaches for new microbial natural product, High-content screening methods, antimicrobial in-vitro and in-vivo screening Assays

Unit III

Microbiome: An introduction of human microbiome project, Human gut/oral/skin microbiota, current research methods of microbiome analysis including culture-dependent and culture-independent tools, whole genome vs. 16srRNA gene analysis of microbiome, role of human microbiome in health and communicable or non-communicable diseases (Cancer, Diabetes, Malnutrition etc), human gut microbiota and immunity, Role of microbiome in therapeutic and diagnostic. A brief overview of plant and animal microbiome

Unit IV

Food Safety and Security: Microbiology of food of animal and plant origin, Major Foodborne diseases, Biological, chemical, and physical hazards of food, Microbiological testing of food, Hazard analysis and critical control points (HACCP), Agricultural and animal food production and manufacturing practices, Food legislation and standards, ISO 22000, Food and Drug Administration (FDA), Food Safety and Standards Authority of India (FSSAI), Basic concept & issues food security, genetically modified foods, climate change and food security, Nutrition and food security, Nutrition and infectious/non-communicable diseases.

Suggested Readings

1. Stefan Schwarz &Lina Maria Cavaco, Jianzhong Shen (2018). Antimicrobial Resistance in Bacteria from Livestock and Companion Animals, ASM Press
2. Scott H. Podolsky (2015) The Antibiotic Era: Reform, Resistance, and the Pursuit of a Rational Therapeutics, Johns Hopkins University Press
3. Susan L. Prescott & Alan C. Logan (2017). The Secret Life of Your Microbiome: Why Nature and Biodiversity are Essential to Health and Happiness,New Society Publishers
4. Angela E. Douglas (2018) Fundamentals of Microbiome Science: How Microbes Shape Animal Biology,Princeton University Press.
5. Ian C. Shaw (2012).Food Safety: The Science of Keeping Food Safe, Wiley-Blackwell
6. Hal Kin (2013) Food Safety Management: Implementing a Food Safety Program in a Food Retail Business, Springer
7. Lewis H Ziska (2017). Agriculture, Climate Change and Food Security in the 21st Century Our Daily Bread, Cambridge Scholars Publishing.

MBY 704 . Bioprocess Engineering

Unit I

Bioprocess Engineering; Bioprocess Development: An Interdisciplinary Challenge; Introduction to Engineering Calculations; Presentation and Analysis of Data; Unit Operations; Material Balances: Unsteady-State Material Balances and Energy balance equations; Solving Unsteady-State Mass Balances; Unsteady-State Energy Balances; Energy Balances: General Energy-Balance Equations; Enthalpy Change in Non-Reactive Processes; cooling in downstream processing; Heat of Reaction for Processes with Biomass Production; Energy-Balance Equation in Fermentation.

Unit II

Fluid Flow and Mixing: Fluid Flow and Mixing-Fluids in Motion; Momentum Transfer; Non-Newtonian fluids; Viscosity measurements; Rheological Properties of Fermentation Broths; Mixing in bioreactor.

Heat Transfer: Heat-Transfer Equipment-Bioreactor and General Equipments used in and across bioreactor, mechanism of heat transfer, heat transfer between fluids, Design Equations for Heat-Transfer Systems, Mass Transfer: Application of the Design Equations; Mass Transfer: Molecular Diffusion, Role of Diffusion in Bioprocessing, Convective mass transfer, Oxygen Transfer, dissolution and solubility in bioreactors.

Unit III

Homogeneous Reactions: Homogeneous Reactions: Basic Reaction Theory, Calculation of Reaction Rates, Reaction Kinetics for Biological Systems, Growth Kinetic Constants From Batch and continuous growth, Yields in Cell growth, Cell Growth Kinetics, Kinetics of Substrate Uptake by Cell, Effect of Maintenance on Yields, Kinetics of Cell Death. Heterogeneous Reactions: Heterogeneous Reactions in Bioengineering, Concentration Gradients and Reaction Rates in Solid Catalysts, Internal Mass Transfer and Reaction, Effectiveness Factor, External mass transfer, Liquid-Solid Mass-Transfer Correlations, Minimizing Mass-Transfer Effects, Evaluating True Kinetic Parameters.

Unit IV

Reactor Engineering: Bioreactor Configurations-stirred tank, bubble column and air-lift reactor, Practical Considerations for Bioreactor Construction, Monitoring and Control of Bioreactors, Ideal bioreactor Operation, sterilization; Engineering Principles for Bioprocesses; Scale-up, Operation, and Control of Bioreactors

Suggested Readings

1. Bioprocess Engineering principles by Pauline M Doran, Elsevier Science and technology Books.
2. Bioprocess Engineering- Basic Concepts by Michael L Shuler and FikretKargi, Pearson Education,Inc.
3. Bioprocess Technology: Volume 1 by P T Kalaiselvan and I Arul Pandi MJP Publishers.
4. Bioprocess Engineering: Systems, Equipment and Facilities by Bjorn K. Lydersen, Nancy A. D'Elia,
5. Kim L. Nelson, Wiley India Pvt Ltd.

MBY 705. Current Perspectives on Infectious diseases and Cancer biology

Unit I

Emerging diseases: Disease outbreaks, integrated disease surveillance program by National Centre for disease control, Biology of Emerging Diseases: Ebola, Swine Flu, SARS, Plague, Dengue, Zika, Chikungunya; CDC outbreak list, IDSP weekly outbreak mapping by NCDC.

Unit II

AMR and Epidemiology: Anti-microbial resistance, Case studies on Tuberculosis with emergence of MDR, XDR and TDR TB. Case study on *Salmonella* and *E. coli* O157:H7. Epidemiology and

epidemiology research: current perspectives. Diverse approaches for tackling AMR, Host directed therapies, WHO Emergencies preparedness and response mechanism.

Unit III

Cancer Mechanisms: Incidence and Etiology of cancer, common cancers types, cellular hallmarks of cancer, genetics of cancer: genetic variation, mutation and genomic instability, metastasis of cancer cells.

Unit IV

Cancer therapeutics and vaccinology: Adjuvant therapy, Radiation therapy, antibody based immune therapy, macrophage tumour responses to anticancer therapies, disrupting protein-protein interaction for cancer therapeutics, Targeting tumour cell motilities, Recombinant viral vaccines against cancer, T cell based therapy and personalized medicine.

Suggested Readings

1. Emerging Infectious Diseases: A Guide to Diseases, Causative Agents, and surveillance; By Lisa A. Beltz, Wiley Publication.
2. Cell Press Reviews: Cancer Therapeutics, Cell press 2013
3. Novel Designs of Early Phase Trials for Cancer Therapeuticsby Shivaani Kumar and Chris Takimoto

MBY 706. Microbial Process and Enzyme Engineering

Unit-I

Operation mode of bioprocesses- batch, fed-batch and continuous cultivation, sterile operations, design of experiment for bioprocess optimization, industrial synthetic biology, high throughput bioprocess design, bioseparation and downstream processing- membrane separation techniques, chromatographic separation techniques, water purification etc., interactions and integration of microorganisms, bioreactor and downstream processing, experimental basis and methods for biosystems analysis, modelling of bioreactors, dynamic behaviour of bioprocesses, analysis, modelling and simulation of biological networks.

Unit-II

Development of reactors and processes for stabilization of organic and industrial wastes, miniaturisation of bioreaction systems, miniplant technology for integration of biosynthesis and downstream processing, technical and economic assessment of bioproduction processes, application of bioinformatics for development of bioprocesses, biocatalysis for the sustainable synthesis of chemicals and pharmaceuticals from renewable resources, rational engineering of biological systems for sustainable bioprocessing, small mimics, microfluidics and mathematical models for process understanding, scale-translation.

Unit-III

Industrial enzymes, kinetics of enzyme reactions, biochemical characterization of enzymes, graphical analysis of kinetic data, pH and temperature dependence, development of recombinant clones for overproduction of enzymes and metabolites, development of expression systems in bacteria and yeasts, bioenergetics and biological molecular machines, protein conformation study and structure-function relationship using biophysical methods, protein engineering by combinatorial methods.

Unit-IV

Enzyme engineering and design: substitution, insertion, hybrid proteins, genes for novel enzymes- Aequorin and Enviropig, directed evolution and site directed mutagenesis approaches to improve industrial enzymes, engineering more stable enzymes, analysis and design of microbial and enzyme reactors for production of industrially important products such as biofuels, industrial enzymes, biopolymers, etc., development of bio-sensors for detection of various analytes, development of cell culture techniques for cultivation of plant and animal cells in specialized reactors for production of therapeutic compounds.

Suggested Readings

1. Yoo YJ et al (2017) Fundamentals of Enzyme Engineering, Springer
2. Stanbury et al (2003) Principle of Fermentation technology, Butterworth-Heinemann

MBY 707. Frontiers in Cyanobacteriology

Unit I

Cyanobacterial Diversity and Distribution: Origins of life and photosynthesis; General characters of cyanobacteria (cell structure, physiology, reproduction and genome organization); Ecological and Structural Diversity; Cyanobacteria in Extreme environments; Cyanobacterial diversity-alpha, beta and gamma; Diversity indices; Problems and limitations in cyanobacterial diversity studies; Culturable and unculturable cyanobacterial diversity; Exploration of unculturable cyanobacterial diversity

Unit II

Cyanobacterial Taxonomy and Systematics: Concepts of taxonomy (characterization, classification and nomenclature); Isolation and culturing of cyanobacteria; Conventional characterization cyanobacteria (Morphometry, Biochemistry and Ecology); Molecular characterization (16S rRNA gene, G+C content, DNA-DNA hybridization); DNA bar-coding; Concept of Systematics; Polyphasic taxonomy; Methods for describing novel cyanobacteria; Culture collections and their significance

Unit III

Cyanobacterial Biotechnology: Outdoor and indoor mass cultivation of cyanobacteria; Cyanobacteria as a source of biomolecules (polysaccharides, pigments, antioxidants, polyunsaturated fatty acids); UV-protecting compounds; Cyanobacteria for Biofuel; Cyanobacteria for Bioremediation; Nutraceutical and pharmaceutical uses, Bioactive compounds (antimicrobial, anti-cancer); Green synthesis of nanoparticles; Cyanobacteria as biofertilizer for paddy cultivation. Hydrogen production by cyanobacteria

Unit IV

Cyanobacterial Bloom and Cyanotoxins: Types of aquatic habitat; Bloom forming cyanobacteria; Factors responsible for cyanobacterial bloom; Types of Cyanotoxins; Cyanobacterial taxa responsible for cyanotoxins production; Hazardous effects of cyanotoxins; Molecular regulation of cyanotoxins; Monitoring and management of cyanobacterial bloom

Suggested Readings

1. Whitton, B. A. (Ed.). (2012). Ecology of cyanobacteria II: their diversity in space and time. Springer Science & Business Media
2. Flores, E. (Ed.). (2014). Cell Biology of Cyanobacteria. Caister Academic Press.
3. Zinicovscaia, I., &Cepoi, L. (Eds.). (2016). Cyanobacteria for bioremediation of wastewaters. Switzerland: Springer.
4. Hallenbeck, P. C. (2012). Hydrogen production by cyanobacteria. In Microbial technologies in advanced biofuels production (pp. 15-28). Springer, Boston, MA.
5. Sharma, N. K., Rai, A. K., &Stal, L. J. (2013). Cyanobacteria: an economic perspective. John Wiley & Sons.
6. Sarma, T. A. (2012). Handbook of cyanobacteria. CRC Press.
7. Newcombe, G. (2012). International guidance manual for the management of toxic cyanobacteria. IWA Publishing.
8. Chauvat, F., &Cassier-Chauvat, C. (2012). Genomics of cyanobacteria (Vol. 65). Academic Press.
9. Borowitzka, M. A., &Moheimani, N. R. (Eds.). (2013). Algae for biofuels and energy (Vol. 5). Dordrecht, The Netherlands: Springer.
10. Borowitzka, M. A. (2015). Algal biotechnology. In The Algae World (pp. 319-338). Springer, Dordrecht.
11. Mishra, A. K., Tiwari, D. N. &Rai, A. N. (Eds) 2019. Cyanobacteria: From Basic Science to Applications. Academic Press.

MBY 708. Enzyme technology, Metabolomics and Biomass based Biorefinery

Unit I

Enzyme Production & Purification: Methods for large scale production of enzymes, Protein engineering: mutagenesis, computational protein design and directed evolution concept. Protein expression systems: Prokaryotic and Eukaryotic, Recombinant cloning and overproduction of enzyme. Extraction of enzymes, Strategy for purification of enzymes: Precipitation, dialysis, ultracentrifugation, chromatography techniques e.g. Gel filtration, Ion Exchange, gel filtration, hydrophobic interaction and reverse phase chromatography using FPLC. Selection of purification methods, Parameters to assess the purification efficiency, Concentration of purified enzyme: lyophillization and ultra-centrifugation, Test of homogeneity of enzyme preparation. Characterization of purified enzymes: methods of enzyme analysis and test of catalytic activity, stability of enzyme at different physical (temperature pH) and chemical parameters. Suitability of Enzyme for different applications

Unit II

Recent advances in enzyme based technologies: Immobilization of enzymes, various methods of enzyme immobilization, Immobilized enzyme reactors. Application of Immobilized and soluble enzyme in biomass to bioenergy production. Enzyme based bioreactors. Application of enzymes development of biosensors, biofilms, biopolymers, biofuels and value added chemicals (xylooligosaccharides, cellooligosaccharides). Application of enzymes in paper and pulp, food processing, textile. Leather, detergents, bio-remediation and wastewater treatments. Enzymes in pharmaceutics and biomedicine

Unit III

Metabolomics: Microbial Metabolite, metabolomics, metabolite turn-over rate, extraction of microbial metabolites: simultaneous sampling and sequential sampling and its advantages and disadvantages, Quenching protocols for microbial cells metabolic activity: exometabolome, endometabolome from bacterial, fungal and yeast sources, Extraction methods for intracellular metabolites. Analytical techniques used for metabolites: electrospray ionization (ESI) and matrix assisted laser desorption ionization electrospray ionization (MALDI), mass spectrometers; Quattro LC, Quattro Time of light (Q-TOF) and Fourier transform-ion cyclotron resonance (FT-ICR), liquid chromatography-mass spectrometry (LC-ESI/MSn)

Unit IV

Biomass based Biorefinery: Basics of Biomass to bioenergy conversion, different type of biomass available for biofuel and value added product generation: Lignocellulosic and algal biomass, Second and Third generation biofuels, Algal biomass production and harvesting strategies. Pretreatment: Physical, chemical, biological, physico-chemical and combined, inhibitory product generation and strategies to minimize their effect. Strategies for hydrolysis of the biomass, fermentation technologies, stepwise and combined saccharification and fermentation for bioethanol and biogas production. Circular bioeconomy and carbon sequestration, Concept of Waste to watt: Generation of electricity and simultaneous waste treatment through microbial fuel cells. Integrated biorefineries concept and its socio-economic impacts

Suggested Readings

1. Price N, Stevens L (1999) Fundamentals of Enzymology Cell and Molecular Biology of Catalytic Proteins Third Edition, Oxford University Press
2. Palmer T , Bonner P L (2007) Enzymes: Biochemistry, Biotechnology, Clinical Chemistry Second edition Woodhead Publishing
3. Weckwerth (2007)Metabolomics: Methods and Protocols, Humana Press, New Jersey
4. Mussatto SI (2016) Biomass Fractionation technologies for a Lignocellulosic Feedstock Based Biorefinery. Elsevier Academic Press.

MBY 709. Molecular basis of infectious diseases and techniques

Unit-I

Molecular basis of infectious diseases: Current topics in fungal, bacterial and viral genetics (with the emerging knowledge of sequence databases available and ongoing projects). Understanding the mechanisms available for genetic variability in different pathogens to defy host immune system. Host signaling in response to infections.

Unit-II

Bacterial adhesions, virulence factors. Protein and DNA secreting systems and pathogenicity island (*Helicobacter pylori, Mycobacterium tuberculosis etc.*). Molecular basis of antimicrobial resistance and its detection. Molecular approaches in clinical microbiology.

Unit III

Molecular mechanism of gene transfers. Natural transformation and competence. Molecular basis of natural transformation: DNA uptake competence systems Importance of natural transformation. Artificially induced competence. Phase variation system in pathogenic bacteria.

Unit IV

Techniques in Molecular Biology: Cloning and overexpression of recombinant proteins, Protein purification by different techniques, Protein precipitation, Analysis of protein-DNA and protein-protein interactions: Electrophoretic mobility shift assay (EMSA), DNA footprinting by DNase I, Yeast two hybrids, system, Co-immunoprecipitations, pull-downs assay. Plasmids, Agarose gel electrophoresis, ethidium bromide staining. Blotting techniques: Southern, Northern, Western Blotting. Ultracentrifugation, Polymerase Chain Reaction (PCR) and Reverse Transcriptase PCR.Use and analysis of radioisotopes.

Suggested Readings

Recent reviews and research articles published on relevant topics like International Review of Cell and Molecular Biology, Nature reviews Molecular Cell Biology, TRENDS journals/ Trends in Cell Biology/ Trends in Biochemistry/Trends in Molecular Medicine/ Trends in Biotechnology/ Trends in Genetics

F. Mapping Table for PhD Microbiology (Percentage)

Course	Program Outcomes		
	Pre PhD Course Work	**Dissertation**	**Total**
Solid basic knowledge of research methodologies in area of modern biological sciences	10%	90%	**100%**
Contributing new methodologies and results in area of the basic and advanced microbiology for taking the research to next level		100%	**100%**
Innovative scientists, skilled workforce to work in specialized area of microbiology	10%	90%	**100%**
Independent researchers who can contribute through fulfilling responsibility of academicians, scientist and entrepreneur	10%	90%	**100%**
Can start an independent research and can contribute in solving new problems faced in current science or in future.	10%	90%	**100%**

F. Mapping Table for PhD Microbiology

Course	Program Outcomes	
	Pre PhD Course Work	**Dissertation**
Solid basic knowledge of research methodologies in area of modern biological sciences	X	X
Contributing new methodologies and results in area of the basic and advanced microbiology for taking the research to next level		X
Innovative scientists, skilled workforce to work in specialized area of microbiology	X	X
Independent researchers who can contribute through fulfilling responsibility of academicians, scientist and entrepreneur	X	X
Can start an independent research and can contribute in solving new problems faced in current science or in future.	X	X