छत्रपति शाहू जी महाराज विश्वविद्यालय, कानपुर

CHHATRAPATI SHAHU JI MAHRAJ UNIVERSITY, KANPUR

(पूर्ववर्ती कानपुर विश्वविद्यालय कानपुर)

Formerly Kanpur University, Kanpur – 208024

A Documentary Support

For

Metric No. – 1.1.1

Programme Outcomes & Course Outcomes

Under the

Criteria - I

(Curriculum Design and Development)

Key Indicator - 1.1

In

Metric No. – 1.1.1

M.Sc. Microbiology

Co-ordinator
Internal Quality Assurance Cell
CSJM University, Kanpur

(Registrar)
C.S.J.M.University
Kanpur

REGISTRAR
C.S.J.M. UNIVERSITY
KANPUR

Learning Outcomes based CurriculumFramework

For

M.Sc. Microbiology

Department of Microbiology

Institute of Biosciences & Biotechnology

Chhartapati Shahu Ji Maharaj University Kanpur

M.Sc. Microbiology

(Introduced from Academic Year 2004 – 2020)

1. Preamble-

Microbiology is the study of organisms, most of which are too small to be seen with the naked eye, their interactions with humans, animals, plants, and the environment, and their applications. These microorganisms have vital significance in human development as they can be exploited for several beneficial aspects while many cause devastating damage and sufferings affecting health and causing destruction. Understanding the intercellular interactions and behavioral physiology of these microorganisms through basic sciences such as genetics, cellular & molecular biology as well as their biochemical analysis has burgeoned a number of applied microbiology fields such as Agriculture Microbiology, Industrial Microbiology, Medical and Clinical Microbiology, Infectious Immunobiology, Microbial Biotechnology, Pharmaceutical Microbiology, Food & Beverage Microbiology and Environmental Microbiology. Syllabus helps in qualifying CSIR -JRF/NET, and after completion of course students peruse research in various fields and different industries. The post graduate course has been developed under the Learning Outcome Curriculum Framework under the recommendations and guidance of the University Grants Commission (UGC). Keeping in view the post graduate attributes of the subject, the learning outcomes were envisioned. The curriculum was based on the learning outcomes. It is envisaged that the students obtaining training under this curriculum will develop the necessary skill sets, technical knowledge and ethics taught under this program, keeping in view the postgraduate attributes.

MSc Microbiology program is a two-year duration with 4 semester system. There are 4 compulsory theory courses and one practical course offered in each semester. Final assessment is in the form of external examination. Within the semester, assessment tasks associated with each unit of the coursework learning of the knowledge and skills will enhance the teaching – learning process. Students perform a research project in Semester IV that will enable them to address research problems relevant to society as well as the field of microbiology. To comply with the education policy of Govt. of India namely access, equity and quality we have included Online Courses (OLC) which are available on NPTEL or SWAYAM portals under MOOCS programme being developed by MHRD to provide opportunity to the most disadvantaged students and to bridge the digital divide. The online courses would also inculcate the habit of self-study at their own pace by the students and also acclimatize them to future technologies of learning processes.

2. Learning Outcomes based approach to Curriculum Planning:

The learning outcomes based curriculum framework for MSc Microbiology defines understanding and knowledge of the subject as well as the technical and practical aspects such as students graduating in microbiology demonstrate the requisite skills required to function as a competent microbiologist after acquiring the degree. The students are also trained in such a way that they develop critical thinking and problem solving as related to the microbiology which can be applicable in any field of research, industry as well as academia. The curriculum developed, teaching –learning outcomes and the assessment strategies are such that the students are able to apply their knowledge and training of microbiology to solve the problems of microbiology as these exist or appear from time to time in the society.

3. Postgraduate Attributes in Microbiology:

- Develop highly skilled and knowledgeable members of the society that can use their enhancements for solving real life problems
- Develop outlook and attitude, develop the current skills and abilities, learnnew capability to contribute as global citizens.
- Develop a research oriented, problem and critical thinking outlook towards to different problems and have ability to think through in out of box innovative manner using skills and training imparted to them.
- Enhance student's academic career of the students, increase their employability, train them as entrepreneurs
- Enhance abilities to develop a positive approach and requisite soft skills, socialistic approach, team contributors and leadership qualities for successful career and personal life choices.
- Provide highly skilled and knowledgeable human resources for all domains of scientific quests such as agricultural sector, food industry, dairy industry, medical and paramedical field, pharmaceutical, space research and research institutes.

4. Vision Statement Of MSc program

The M.Sc. Microbiology Course if offered with the aim to produce microbiologists of excellent caliber, with good research, teaching and technical skills and at the same time being sensitive to the needs of the society and environment

5. Mission Statement

The mission of the Department of Microbiology is to provide:

1. A learning environment that encourages post graduate student about microbiology and the its applications in different fields of science
2. Fundamental research training for students who will become future leaders in science, medicine, and industry;
3. Create awareness about the significance and scope of Microbiology amongst students and local and global citizens through research, awareness programs, conferences, seminar organizations
4. Conduct research that advances the frontiers of knowledge in the field of microbiology

6. Objectives of the course:

The aim and objectives of the M.Sc. Microbiology course program essentially focus todevelop skills of student for a successful career.

A. The course structure emphasizes to put enough efforts in theory as well as laboratory work so as to gain thorough knowledge of the subject.
B. The course includes project work that would develop and nourish the scientific approach and research attitude of the students.
C. Genetic engineering, Biotechnology, Bioinformatics, Immunotherapy are the new horizons of the interdisciplinary subject Microbiology which might provide solutions to various problems of the society. The course work is essentially framedto acquaint the students with all the recent advances in this field.
D. It is compulsory & essential for the students to read research papers, publications and deliver seminars that would better help them to know the recent advances in thesubject and also develop the communication skills.
E. The program is designed in such a way that it is essential for the students to read original publications, put enough efforts in laboratory work for practicals and project, be acquainted with all the recent advances in the field like Bioinformatics,drug designing and develop all the skills for a successful career.

7. Eligibility

A candidate who has passed the

- Bachelor of Science from any recognized university with Microbiology as Principle subject (Major) or Microbiology (Honors).
- Bachelor of Science from any recognized university with Botany/Zoology/Biochemistry/Biotechnology/Environmental science as major subjects with Microbiology as subsidiary subject.
- The candidate who has secured aggregate of 50% marks (45 % marks in case of SC/ST) in the graduate course as well as in the MicrobiologySubject shall be eligible for admission to the First Year M.Sc. degree course.

Total Intake capacity: 60

Medium of Instruction: English

6. Programme Outcome:

The aim and objectives of the M.Sc. Microbiology program essentially focus todevelop skills of student for a successful career.

MSc MICROBIOLOGY PROGRAMME OUTCOME	
PO1	The course structure emphasizes to put enough efforts in theory as well as

	laboratory work so as to gain thorough knowledge of the subject.
PO2	The course includes project work that would develop and nourish the scientific approach and research attitude of the students.
PO3	Emerging areas in the field of sciences pertaining to Microbiology which might provide solutions to various problems of the society are covered in the syllabi.
PO4	The program is designed in such a way that it is essential for the students to read original publications, put enough efforts in laboratory work for practicals and project, be acquainted with all the recent advances in the field like Bioinformatics,drug designing and develop all the skills for a successful career.
PO5	The students will be well versed in research methodology, conducting literature surveys and research projects

8. Programme Specific Outcomes:

At the end of this course the students will be able to:

MSc MICROBIOLOGY PROGRAMME SPECIFIC OUTCOMES	
PSO1	Able to apply the knowledge and skill based microbiological training for addressing research problems related to any discipline
PSO2	Demonstrate knowledge and understanding of microbiological problems and solve scientific and technological issues.
PSO3	Perform duties as research fellows/scientist/ microbiologist in biological sciences.
PSO4	Learn desired microbiological skills and techniques through research project training
PSO5	Eligible for jobs as microbiologist in food and beverages industry, pathology laboratories, microbial testing of any product to certify quality control and assurance
PSO6	Contribute to the development of innovative and creative scientific knowledge, technology development and creators of entrepreneurs and self sustainable individuals

2015-2020 SYLLABUS: MSc MICROBIOLOGY, CSJM UNIVERSITY, KANPUR

COURSE	TITLE	MARKS
SEMESTER I		
MIC 101	GENERAL MICROBIOLOGY	100
MIC 102	BACTERIOLOGY	100
MIC 103	BIOSTATISTICS, COMPUTER APPLICATIONS	100
MIC 104	BIOCHEMISTRY	100
MIC 105	PRACTICALS	100
	TOTAL	**500**
SEMESTER II		
MIC 201	MICROBIAL PHYSIOLOGY	100
MIC 202	VIROLOGY	100
MIC 203	MICROBIAL GENETICS	100
MIC 204	ANALYTICAL TECHNIQUES	100
MIC 205	PRACTICALS	100
	TOTAL	**500**
SEMESTER III		
MIC 301	AGRICULTURE AND ENVIRONMENTAL MICROBIOLOGY	100
MIC 302	FUNDAMENTALS OF MOECULAR BIOLOGY	100
MIC 303	RECOMBINANT DNA TECHNOLOGY	100
MIC 304	FUNDAMENTALS OF INFECTION AND IMMUNITY	100
MIC 305	PRACTICALS	100
	TOTAL	**500**
SEMESTER IV		
MIC 401	MICROBIAL TECHNOLOGY	100
MIC 402	MEDICAL MICROBIOLOGY	100
MIC 403A (Elective)	FOOD MICROBIOLOGY	100
MIC 403B (Elective)	BIOINFORMATICS	100
MIC 403C	MICROBIAL GENOMICS AND PROTEOMICS	200
MIC 405	PROJECT	Grade
	TOTAL	**500**
	GRAND TOTAL	**2000**

MIC 101: GENERAL MICROBIOLOGY	Semester I	
Marks: 100	**Total Credits: 4**	**60 h**

Course Objectives: The primary objective of the course is to provide a wide coverage and introduction to students regarding the scope, types of organisms and working principles in microbiology.

Course Learning Outcomes:

Upon successful completion of the course, the student

1. Will be able to describe the morphological features, cell arrangement and structural components of different microbial forms

2 Will have gathered detailed information regarding different structural features of prokaryotic and eukaryotic cells

3. Will have gained knowledge methods of measuring microbial growth, calculating growth kinetic parameters, understanding of steady state and continuous growth.

4. Will have gained knowledge about physical and chemical control of micro-organisms

Course Contents :

Unit 1. The History, development and scope of microbiology. The study of microbial structure. Microscopy and specimen preparation. Isolation of pure culture, cultivation of aerobic and anaerobic bacteria. Preservation, maintenance, patenting and conservation of microbial cultures. Role of culture collection.

Unit 2. General nature of microbial world. Cell structure and function of eukaryotes and prokaryotes. Differentiating features, habitats, reproduction and classification of aubacteria and archaebacterial. Protista: Mollicutes, slime molds and algae

Kingdom Fungi: structure, preorduction and classification of fungi. General characteristics and life cycle of Zygomycetes, Ascomycetes, Basidiomycetes, Dueteromycetes.

The Viruses: General properties, composition, structure, classification. Difference between cellular organisms, prions, viroides and virusoides.

Unit 3. Structure and physiological significance of cell wall, cell membrane, capsule, flagella, pilli, cilia, tactic movements.

Storage granules: metabolism of volutin, glycogen, polyhydroxybutyrate. Organization of nucleus. Asexual spores, endospores, sporulation process, germination andits regulation.

Unit 4. Nutritional requirements of microorganisms. Microbial growth; definition, measurement of growth, generation time, growth kinetics, growth phases, diauxic growth, synchronous and continuous cultures, factors affecting growth.

Unit 5. Physical control of microorganisms: Heat, filtration, radiation, Chemical control of microorganisms-halogen, phenols and phenolic compunds, heavy metals, alcohols, ethylene oxide, aldehydes and hydrogen peroxides. Sterilization by soaps, detergents and dyes. Antimicrobial chemotherapy.

Suggested readings:

1. Prescott's Microbiology by J. Willey, L. Sherwood, C. J. Woolverton. 10th edition. McGraw Hill Education. 2017.
2. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D.Stahl. 15th Edition. Pearson Education. 2018.
3. Alcamo's Fundamentals of Microbiology by J. C. Pommerville. 10th Edition. Jones and Bartlett Learning. 2013.
4. The Physiology and Biochemistry of Prokaryotes by D. White, J. Drummond, C. Fuqua. 4th Edition. Oxford University Press. 2011.

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Understand Scope and history of microbiology, pure culture isolation, microscopy and specimen preparation	Explain history interms of developments in microbial culture techniques and different microscopy tehcniques	Fill in the blank type test
2	Will have gathered detailed information regarding different microbial types and be able to differentiate between them	Powerpoint pictorial depiction of different microbial growth forms. Augmented by practicals	Assessment based on picture identification of different microbes. Microscopy exercises
3	Will have gained knowledge About structural features of microbes.	Provide knowledge about different cell subcellular structures	Ten-minute MCQ quiz after lecture
4	Student gets acquainted with methods of measuring microbial growth, calculating growth kinetic parameters with understanding of steady state and continuous growth.	Class room lecture on growth, growth, factors and measurement of growth	Mathematical quiz on calculations of growth yields and kinetic constants.
5	Understand different physical and chemical control methods of microbial control	Power point presentation/ video demonstrations for different disinfection and sterilization techniques	Ten-minute MCQ quiz after lecture

MIC 102: BACTERIOLOGY		Semester I
Marks: 100	**Total Credits: 4**	**60 h**

Course Objectives:

The primary objective of the course is to build a strong foundation in the area of bacterial cell structure, division, survival and propagation.

Course Learning Outcomes:

Upon successful completion of the course, the student

1 Will be able to describe the morphological features, cell arrangement and structural components of bacterial cell in detail

2 Will have gathered detailed information regarding bacterial cell division and endospore formation.

3. Will have gained knowledge about reserve food granules.

4. Student gets acquainted with methods of measuring microbial growth, calculating growth kinetic parameters with understanding of steady state and continuous growth.

5. Can enlist the characteristics of archaea that differentiate it from eubacteria. Will have gained knowledge about classification of bacteria according to Bergey's Manual of Determinative Bacteriology

Contents :

Unit 1. Morphology and ultrastructure of bacteria –morphological types, cell walls of archaebacteria, Gram –negative and Gram positive eubacteria, L forms, cell wall synthesis, cell membranes-structure, composition, properties. Antigenic properties, structure and capsule, flagella, cilia, pilli.

Unit2. Structure and function of gas vesicles, carboxysomes, magnetosomes and phycobilisomes, nucleod, cell division, spores.

Unit3. Reserve food materials- Poly polyhydroxybutyrates, polyphosphate granules, oil droplets, cyanophycin granules and sulphur inclusions.

Unit4. Cultivation of bacteria: aerobic anaerobic, maintenance and preservation of cultures, shaker, still, Nutritional types, culture media used, Growth curve, generation time, growth kinetics, synchronous, asynchronous batch, and continuous culture; Measurement of growth and factors affecting growth, Control of bacteria –physical and chemical agents, preservation methods.

Unit 5. Classification of phylogeny of bacteria: Introduction- salient features of bacteria according to Bergey's Manual of Determinative Bacteriaology, Comparative study of archaebacteria, photosynthetic bacteria, chemoautotropic, methophilic, aerobic and anaerobic bacteria, Gram positive and Gram negative eubacteria. Rickettsiae, chlamydiae, spirochaetes actinomycetes with reference to their general characteristics , structure, reproduction and economic importance.

Suggested readings:

1. Prescott's Microbiology by J. Willey, L. Sherwood, C. J. Woolverton. 10th edition. McGraw Hill Education. 2017.
2. Brock Biology of Microorganisms by M. Madigan, K. Bender, D. Buckley, W. Sattley, D.Stahl. 15th Edition. Pearson Education. 2018.
3. Alcamo's Fundamentals of Microbiology by J. C. Pommerville. 10th Edition. Jones and Bartlett Learning. 2013.
4. Archaea Molecular and Cellular Biology by Ricardo Cavicchioli. American Society of Microbiology. 2007.
5. The Physiology and Biochemistry of Prokaryotes by D. White, J. Drummond, C. Fuqua. 4th Edition. Oxford University Press. 2011.

Facilitating the achievement of Course Learning Outcomes

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Will be able to describe the morphological features, cell arrangement and structural components of bacterial cell in detail. Is able to differentiate between Gram positive and Gram-negative bacteria.	Detailed discussion on the general morphology of bacteria and the basic differences in gram-positive and gram-negative cell structure and the detailed structure of gram negative and gram-positive bacterial cell walls and extracellular appendages through diagrammatic representations.	Fill in the blank type test based on function and occurrence of bacterial locomotory organs and extracellular capsules
2	Will have gathered detailed information regarding bacterial cell division and endospore formation.	Provide knowledge about structure and development of endospores.	Assessment based on rearranging the order of pictures with respect to stages in endospore development in bacteria
3	Will have gained knowledge About reserve food granules.	Provide knowledge about synthesis and importance of reserve food materials	Ten-minute MCQ quiz after lecture
4	Student gets acquainted with methods of measuring microbial growth, calculating growth kinetic parameters with understanding of steady state and continuous growth.	Class room lecture on growth, growth physiology, cell division. Detailed talk on measurement of microbial growth, growth yields, growth kinetics, steady state growth and continuous growth.	Mathematical quiz on calculations of growth yields and kinetic constants.
5	Can enlist the characteristics of archaea that differentiate it from eubacteria, and will have learnt key features of some	Familiarizing students with the general characteristics of archaea: *Halobacterium, Pyrococcus,*	Ten-minute MCQ quiz after lecture

	model archaeal organisms.Will have gained knowledge about classification of bacteria according to Bergey's Manual of Determinative Bacteriology	*Sulfolobus and Methanococcus.* Familiarizing students with the general characteristics of different groups of bacteria.	

MIC 103 Analytical Techniques & Biostatistics (2020-2021)

Course Objectives:

To introduce the student to the variety of biophysical and biochemical techniques currently available to probe the structure and function of the biological macromolecules, make them aware of the physical principles behind each technique and the instrumentation involved, make them familiar with various methods of analyzing the output data.

Course Learning Outcomes:

Upon successful completion of the course, the student will:

CO1: Be able to carry out the gel electrophoresis , understand and correctly interpret the migration of protein molecule on PAGE under native and SDS conditions

CO2: Be familiar with the different chromatography techniques like TLC ,HPLC,Affinity chromatography.

CO3: Be able to understand separation of molecules by centrifugation techniques.

CO4: Be able to carry out the analysis of the data from CD and Fluorescence experiments to monitor the stability of the protein,spectroscopic techniques like spectrofluorometry,NMR ,ESR.

CO5: Follow the safety precautions while using radioactive methods,measurement of radioactivity.

CO6: Will familiar with biostatistical tools.

Course content

Unit 1: Electrophoretic techniques- Theory and application of polyacrylamide and agarose gel electrophoresis, native and SDS PAGE, IEF

Unit 2: Chromatography techniques – TLC, paper, column chromatography, gel filtration, ion exchange, HPLC, GLC, partition, affinity, adsorption chromatography

Unit 3: Centrifugation techniques – basic principle, type of centrifuge, micro-centrifuge, high speed, ultracentrifuge, preparative centrifugation, (differential and density gradient), analytical centrifugation

Unit 4: Spectroscopy techniques – basic principle, instrumentation and biological application of UV-visible spectroscopy, spectrofluorometry, CD, ORD, atomic spectroscopy (absorption and emission), NMR, ESR

Unit 5: Radioactivity – radioactive and stable isotopes, radioactive decay, unit of radioactivity, measurement of radioactivity- Geiger muller, solid and liquid scintillation counting, SPA, autoradiography; application of radioisotopes in biochemistry, clinical application

Unit 6: Introduction to statistics: mean, median, mode, standard deviation, standard error, probability distribution, chi-square test, t- test, f- test, analysis of Variance.

Suggested Reading:

1. Wilson K and Walker J. Principles and Techniques of biochemistry and molecular biology. Cambridge.
2. J. D. Seader and E. J. Henley, Separation Process Principles, 1st Edition (1998), John Wiley & Sons. Inc., New York.
3. Fundamentals of Biostatistics. Khan and Khanum, Shiba Khan. Ukaaz publications
4. Fundamentals of Biostatistics. Veer Bala Rastogi.3 Ed.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Should be able to carry out the gel electrophoresis , understand and correctly interpret the migration of protein molecule on PAGE under native and SDS conditions	Discussion about the types of electrophoretic methods available for separation of biomolecules with emphasis on differences between the methods.	Group discussion on interpreting data presented in selected research papers where electrophoresis techniques have been used
2.	Be familiar with the different chromatography techniques like TLC ,HPLC,Affinity chromatography	Familiarizing students with the commonly used chromatographic matrices which separate proteins based on size, affinity tag and pI.	Oral quiz after the lecture
3.	Be able to understand separation of molecules by centrifugation techniques.	Discuss about the basis principle of centrifugation & types of centrifuge	Group discussion

4.	Be able to carry out the analysis of the data from CD and Fluorescence experiments to monitor the stability of the protein,spectroscopic techniques like spectrofluorometry,NMR ,ESR.	Detailed discussion on origin of CD/ Fluorescence signals in protein Using PPT to understand about NMR,ESR in detail	Oral quiz after the lecture
5.	Follow the safety precautions while using radioactive methods,measurement of radioactivity.	Providing students with the knowledge about precautions to be used while using radioactivity based methods. Making students aware of use of alternate methods, other than radioactivity to gain similar insights into a system.	Ten-minute MCQ quiz after lecture about radioactive decay and safety precautions.
6.	Will familiar with biostatistical tools.	Using whiteboard & PPT to understand about biostat and do different numerical problems.	Group discussion&Ten-minute MCQ quiz

MIC 104: BIOCHEMISTRY	**Semester I**
Marks: 100	**Duration: 60 hours (4 credits)**

Course Objectives: The primary objective of the course is to build a strong foundation in the area of structure and function of biomolecules and their metabolism.

Course Objectives:

The major objective of this paper is to develop a clear understanding of various aspects of biomolecules, their structure and function. Enzymes their kinetic behaviour along with diverse metabolic pathways to enable students to better understand courses taught later such as Molecular biology and recombinant DNA technology.

Course Learning Outcomes:

Upon successful completion of the course, the student:

1: To know the basic concept of life on the molecular level.

2: Chemical nature of biomolecules,its arrangement and interaction with other biomolecules.

3: To understand the properties of carbohydrates, proteins, lipids, cholesterol, DNA, RNA, glycoproteins and glycolipids and their importance in biological systems.

4: Understanding of concepts of acids, bases, indicators, pKa values, etc. Acquiring skill to determine pKa value of amino acids.
5: Will have learnt basic concepts of enzyme biochemistry, its kinetics and regulation.
6: Understanding the importance of high energy compounds, electron transport chain, synthesis of ATP under aerobic and anaerobic conditions.
7:Will have learnt central metabolic pathways for carbon metabolism in bacteria enlisting differences with eukaryotic systems and their regulation in diverse physiological conditions.
8:Will understand details of protein,lipid and nucleotide metabolism in E. coli and eukaryotes and its regulation.

Contents:

Unit 1. Composition of living matter, biochemistry of bacterial, animal and plant cell, specialized components of microorganisms and their structures and functions. Water- structure, physical and chemical properties, Handersson- hasselbalch equation, dissociation of water and its ionic products, dielectric constants, pH and buffers.

Unit 2. Structure, features, chemistry and function of macromolecules- carbohydrates, homo and hetero polysachharides, lipids- fatty acids, triacylglycerols, phospholipids, wax, sterols, terpenes and other biomolecules such as antibiotics, pigments, secondary metabolites. Aminoacids and proteins- primary, secondary and quaternary structure of proteins. Nucleic acids- structure of purines and pyrimidine bases, nucleosides and nucleotides.

Unit 3. Enzymes as biocatalysts. enzyme classification, specificity, activity units, isozymes, enzyme kinetics, Micheles Menton equation, determination of kinetic parameters, multistep reactions and rate limiting steps, enzyme inhibition, allosterism, kinetic analysis of allosteric enzymes, principles of allosteric regulation. Vitamins and coenzymes.

Unit 4. Biochemical energetics, laws of thermodynamics, concept of energy, oxidation- reduction potential, hydrolysis of energy rich intermediate and ATP. Molecular constituents of biological membranes, supramolecular architecture, electron microscopy, topology of membrane proteins.

Unit 5. Metabolism of: Lipids- biosynthesis, degradation, regulation; Amino acids- biosynthesis, degradation, regulation; Nucleic acids- biosynthesis, degradation, regulation.

Suggested Reading:

1. Lehninger Principles of Biochemistry, Nelson and Cox, Macmillan Higher education
2. Biochemistry.R.H. Garrett and C.J.Grisham Nelson Education ltd.
3. Biochemistry Voet and Voet

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Students will learn about dietary and storage forms of carbohydrates.	Basic models will be used to explain	Carbohydrates,Protein,lipid structure

	They will gain insight into the proteins - amino acids, peptides, primary, secondary, tertiary and quaternary structure of protein. Students will learn about protein structures and folding, about structure function relationship in protein nucleic acids –Nucleotides and nucleic acid structure. Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.) that involve in basic structure of molecules	stereochemistry and protein structures; Chalk and board teaching; Powerpoint presentations and videos for augmenting basic concepts; Interactive discussion and problem solving. discussions.	visualization; Quiz, internal assessment tests will be conducted.
2	Students will develop basic concepts related to buffers and pKa; Significance of water in the biochemistry of life; pH, buffer, Henderson Hasselbalch equation, biological buffer	Chalk and board teaching; Powerpoint presentations and videos for augmenting basic concepts; Interactive discussion and problem solving	Analytical problems related to pH, pKa, buffers;
3	Learn basic concepts of Thermodynamics endergonic and exergonic processes, enthalpy, entropy, free energy change, the law of thermodynamics, Bioenergetics, oxidative phosphorylation, coupled reaction,group transfer, biological energy transducers	Practical example-based teaching on the calculation of activation energy, enzyme kinetics, the significance of Km, catalytic efficiency, turnover number. A detailed explanation of methods for plotting enzyme kinetics data: Lineweaver – Burk plot, saturation kinetics. Class on enzyme, concept of allosteric enzymes, Inhibitors	Mathematical problems of calculation of enzyme kinetic constants by plotting the data provided. quiz
4	Learn basic concepts of Thermodynamics endergonic and exergonic processes, enthalpy, entropy, free energy change, the law of thermodynamics, Bioenergetics, oxidative phosphorylation, coupled	learning activities designed to reinforce a fundamental set of thermodynamic concepts. learning is better facilitated because it is integrated	Analytical problems related to thermodynamics, enthalpy, entropy. Group discussion for different biological energy transducer

	reaction,group transfer, biological energy transducers	known physiological phenomena. Each concept is developed within the course and students are given activities that require them to struggle with their understanding of the concept. Students pull several of these concepts together to solve thermodynamics problems.Diagramatic presentation of oxidative phosphorylation,group transfer and energy transducer	
5	Metabolism of carbohydrates (Glycolysis, Kreb cycle, Gluconeogenesis), lipids (beta oxidation, ketone bodies, biosynthesis of fatty acid), amino acids (amino acid oxidation and ureacycle) nucleotides (degradation and biosynthesis of nucleotides)	Discussion on biosynthesis and degradation of carbohydrates,proteins,lipids and its regulation in E. coli. Diagrammatic representations and explanation of Purine and pyrimidine biosynthesis; deoxyribonucleotide synthesis. Classes on the regulation of purine and pyrimidine biosynthesis; inhibitors of nucleotide biosynthesis	Quiz on identifying inhibitors of nucleotide synthesis pathway, Assignment for different metabolic pathways

MIC 105. PRACTICALS	
Marks: 100	**Credit : 4 hours**

1. Basic rules of a Microbiology Laboratory
2. Basic requirements of a microbiology
3. Study the different parts of a bright filed microscope
4. To observe using wet mount preparation for observation of pond algae
5. To perform lactophenol cotton blue staining for observation of fungi
6. Preparation of bacterial smear, fixation of suspension and simple staining for study of bacterial morphology
7. To perform Gram Staining for differentiation of bacteria
8. To study the principle and working of pH meter and preparation of phosphate buffer
9. To study principle, working and types of centrifuges and perform separation of bacterial pellet from supernatant.
10. To study the principle and working of spectrophotometer by turbidometric measurement of bacterial growth
11. To study principle and working of Thin layer chromatography by chlorophyll separation
12. Preparation of nutrient broth and its sterilization
13. Preparation of nutrient agar and pouring of plates
14. To perform serial dilution and isolation of micro-organisms using spread plate technique
15. To perform isolation of pure culture using the streak plate technique
16. To perform pour plate technique
17. Preparation of slants for the preservation of micro-organisms
18. Carbohydrate estimation
19. Protein Coagulation
20. Determination of mean, median and mode of given bacterial population

SEMESTER II

MIC 201. MICROBIAL PHYSIOLOGY	**Semester II**
Marks: 100	**Credit Hours: 60 hours**

Course Objective:
This paper aims to give a thorough introduction to bacterial metabolism and microbial physiology. This paper deals with in depth knowledge of the energetic and regulation of different metabolic processes in microorganisms, and enable students to better understand courses taught later.

Course Learning Outcomes: Upon successful completion of the course, the student:

1. Apply the knowledge to understand the microbial physiology and to identify the microorganisms.
2. Will have gained an in-depth knowledge of bacteria transport systems, simultaneously learning kinetics of solute transport.
3. Will have learnt central metabolic pathways for carbon metabolism in bacteria and their regulation in diverse physiological conditions.

4. Understand major fermentation, aerobic and anaerobic pathways for energy generation in microbial cells.
5. Will have gained the knowledge of quorum sensing and multicellular organization in bacteria.

CONTENT

Unit 1. Bioenergetics and strategy of metabolism: entropy, electron carriers, artificial electron donors, inhibitors, energy bonds, phosphorylation. Bacterial transport system, Donan equilibrium, thermodynamics of various transport systems, osmosis, plasmolysis, osmotic pressure of electrolytes and non-electrolytes, transport proteins, PEP-PTS system

Unit 2. Brief account of photosynthetic and accessory pigment: chlorophyll, bacteriochlorophyll, rhodopsin, carotenoids, phycobillic proteins, carbohydrate anabolism, autotrophy, oxygenic and anoxygenic photosynthesis, autotrophic generation of ATP, fixation of CO_2- Calvin cycle, C3 & C4 pathways, chemolithotrophy, S, Fe, H, N oxidations. Methanogenosis, luminescence synthesis of polysaccharides, peptidoglycans, biopolymers as cell components.

Unit 3. Respiratory metabolism, EMP pathway, Entenr Duodroff pathway, Glyoxylate pathway, Krebscycle, oxidative and substrate level phosphorylation. Electron transport, reverse TCA cycle, Gluconeogenesis, Pasteur effect: fermentation of carbohydrates, homo and heterolactic fermentation.

Unit 4. Dinitrogen fixation: free living and symbiotic diazotrophs. Biochemistry of nitrogen fixation – nitrogenase complex, regulation of nitrogenase by oxygen and combined nitrogen sources. Symbiotic N fixation, genetics of nitrogen fixation-nif genes and their regulation, strategies of the transfer of nif genes in higher plants, nitrification and denitrification, pathways of nitrate and ammonia assimilation.

Unit 5. Methylotrophs and pathways of methane oxidation, sulphur reducing bacteria and pathways of sulphate reduction, microbial development, sporulation and morphogenesis, hyphae as yeast forms and their significance, multicellular organization of selected microbes, Dormancy.

Suggested Readings:

1. Moat A.G. Foster J.W. Spector M.P. 2002. Microbial Physiology (4th ed). Wiley.
2. Caldwell, D.R. 1995 Microbial Physiology and Metabolism, Wm. C. Brown Publishers, U.S.A.
3. White, D., 2003 The Physiology and Biochemistry of Prokaryotes, second edn, Oxford University Press 4. Gottschalk,G. 1985 Bacterial Metabolism, second edn, Springer

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks*
I	Students will gain an in-depth knowledge of bioenergetics and metabolism. Learn the primary, secondary and group translocation transport systems existing in bacteria and kinetics of transport systems.	Detailed discussion and pictorial presentations on bioenergetics of metabolism, primary and secondary transport and kinetics of solute transport.	MCQ test

II	Learn the mechanism of sun light capture by photoautotrophic bacteria and utilization of its energy to synthesize organic compounds from inorganic substances such as CO2. Students will learn about the bacteria that can obtain all their energy required from the oxidation of inorganic compounds such as hydrogen (H_2), hydrogen sulfide (H_2S), and reduced metals; methane generation pathways.	Theory class on oxygenic and anoxygenic photosynthesis; chemolithotrophy; Methanogens.	Problem solving situation-based test on pathway mutants.
III	Learn central metabolic pathways for carbon metabolism in bacteria enlisting differences with eukaryotic systems.	Detailed discussion on glycolysis, gluconeogenesis and its regulation; EntnerDoudoroff pathway; citric acid cycle; alternate TCA; glyoxylate pathway and its regulation; fermentation of carbohydrate. Employ video lectures to demonstrate electron transport chain and generation of ATP.	Ten minute MCQ after lecture
IV	Gather an understanding of biochemistry of nitrogen fixation, assimilative and dissimilative nitrate reduction, nitrate and ammonia assimilation, and its regulation.	Detailed discussion on biochemistry nitrogen fixation and assimilation	MCQ, Practical assessment of nitrogen fixing microbial communities.
V	Student is conversant with methylotrophs and sulphate reducing microorganisms, and multicellular organization in bacteria.	Discussion on methane oxidation and sulphate reduction pathways. Introduction to quorum sensing.	Group based activity and seminar on microbial growth and intracellular signalling.

MIC 202: VIROLOGY	**Semester II**
Marks: 100	**Duration: 60 hours (4 credits)**

Course Objective:
The purpose of the course is to enable students to understand viral structure, replication strategies and their importance in microbiology

Learning Outcomes

Upon successful completion of this course the student will be able to
• Know how viruses are classified
• Understand the architecture of viruses
• Know the methods used in studying viruses
• Discern the replication strategies of representative viruses from the seven Baltimore classes
• Comprehend the intricate interaction between viruses and host cells
• Understand the interactions between viruses and the host immune system
• Understand the terms Oncogenes and tumor suppressor genes, and how tumor viruses interact with these products and their intersecting pathways and cause oncogenesis.

Course content

Unit 1. General Virology, discovery, morphology and ultrastructure of viruses: the unique properties of viruses. Basis of classification and nomenclature. Envelopes, capsids and their arrangements. Virus like particle- viroids, prions., Viral genome- DNA and RNA viruses.

Uni 2. Diagnosis and serology. Cultivation of viruses in embryonated egges, experimental animals. Cell culture: primary, secondary, sustension- monolayer. Assays of viruses: physical and chemical methods of assay (Plaque-pock counting-endpoint method) Infectivity of plants. Serological methods- hemagglutination, HAI, Complement fixation, ELISA, RIA. Purification of viruses.

Unit 3. Bacteriophages- general features, structure and importantce. Life cycle- lutic nad lysogenic pathways, phage typing, phage display. Other bacteriophages- viruses M13, Mu, T3,T4, Lambda P1, ϕX174

Unit 4. Plant viruses: their impacts, classification and nomenclature. Plant viral diagnostic techniques. Common viral diseases of paddy, cotton, tomato, sugarcane. Life cycles of TMV, CaMV, PVX, PVY. Vector transmission of plant viruses, control of plant viral diseases. Cyanophages and Mycoviruses- general idea

Unit 5. Animal virus: nomenclature and classification, pathogenicity, epidemiology and life cycle of animal viruses- common RNA viruses- HIV, Rhabdo, Rota, Toga. Commom DNA viruses: Adeno, SV40, Hepatitis, Pox, Herpes Virus

Vaccine Design- common and DNA vaccines, Interferons and antiviral drugs.

Suggested Reading Material

Introduction to Modern Virology. Nigel Dimmock, Andrew Easton, Keith Leppard 8th Edition. John Wiley and Sons.

Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. Flint JS, Enquist LW, Shalka AM. 2nd Edition. American Microbiology Society.

MIC 203: MICROBIAL GENETICS **Semester II**

Marks: 100 **Duration: 60 hours (4 credits)**

Course Objectives:

The objective of this course is to understand how microorganisms can be used as tools to understand various biological phenomena. The student will become familiar with methods of transfer of genetic material in bacteria, and will understand the biology of lytic and lysogenic phages. The student will be acquainted with the different modes of gene regulation in bacteria, and the importance of bacterial transposition and its applications.

Course Learning Outcomes:

Upon successful completion of the course, the student:

1: Can discuss the importance of mutation analysis, can analyze mutations by complementation and recombination tests, and can design a strategy to create gene replacement in bacteria

2: Is able to explain how plasmid copy number is regulated, can differentiate between Hfr strains and strains carrying F plasmid, and can construct a genetic map of bacterial genome using conjugation-based method

3: Is able to compare and contrast generalized versus specialized transduction, knows how to construct genetic linkage maps using two-factor and three factor cross, is able to discuss the basis of natural competence in bacteria.

4: Is able to list the events in the lytic and lysogenic phases of lambda phage life cycle and the regulatory factors and events involved.

5: Can list the outcomes of transposition events, can design strategies to mutagenize bacteria using transposons, can explain the construction of conditional knockouts

6: Can differentiate between positive and negative regulation of gene expression, inducible and repressible systems. Can describe the regulation of the lac, trp, gal,ara and tol operons.

7: Will have learnt about the model organisms used in biological studies.

Contents:

Unit 1. Genes as units of mutation and recombination, molecular basis of mutation, mutagens, spontaneous mutation- origin. DNA damage and repair: types of DNA damage, repair pathways- mismatch repair, excision repair, recombination repair and SOS repair.
Unit 2. Gene transfer mechanisms, transformation, transduction, conjugation and transfection, mechanisms and applications. Genetic analysis of microbes- bacteria and yeast- Fine structure analysis and recombination analysis.
Unit 3. Plasmids, F Factor description and their uses in genetic analyses, colicins and Col Factor, plasmids as vectors for gene cloning, replication of selected plasmids, compatibility, transposons and their uses in genetic analyses.
Unit 4. Bacteriophages- lytic phages T4 & T7, lysogenic phages P1, MU and $X 174, life cycles and their uses in microbial genetics, prions and their genetic composition, disease caused by prions
Unit 5. Microbial genetics and design of vaccines, BCG and design of vaccines for TB and leprosy, DNA vaccines — design and advantages.

Suggested Reading:

1. Snyder L and Champness W. Molecular genetics of bacteria. ASM Press.
2. David Freifelder. Microbial genetics. Jones & Bartlett Publ.

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
I	Can discuss the importance of mutation analysis, can analyze mutations by complementation and recombination tests, and can design a strategy to create gene replacement in bacteria	The student will be explained the importance of genetic analysis using bacterial mutants with the help of specific examples. The student will learn how to use complementation and recombination to map genes as well as to clone out genes. Through group discussion the student will be made to come up with a strategy for bacterial gene knockout	The student will be asked to solve problems based on complementation test and recombination tests. The student will have to solve problems on deletion-based mapping of point mutations.
II	Is able to explain how plasmid copy number is regulated, can differentiate between Hfr strains and strains carrying F plasmid, and can construct a genetic map of bacterial genome using conjugation-based method	Using slideshow as well as a whiteboard, the students will be taught the bases of copy number control of three different classes of plasmids. The student will be taught the importance of conjugation, and the role of Hfr strains in creating genetic diversity among bacteria.	The student will have to solve problems involving the mapping of the bacterial genome based on Hfr transfers. A quiz based on different mutants will be given to assess their understanding of the different copy number control mechanisms

III	Is able to explain the mechanism of Transformation, conjugation ,compare and contrast generalized versus specialized transduction, knows how to construct genetic linkage maps using two factor and three factor cross, is able to discuss the basis of natural competence in bacteria. Can list the outcomes of transposition events, can design strategies to mutagenize bacteria using transposons, can explain the construction of conditional knockouts	Students will learn to distinguish between transformation mechanisms in gram positive and gram negative bacteria. Students will be taught the importance of transduction in the transfer of genetic material between bacteria. Through class discussion the student will learn to distinguish between generalized and specialized transduction. Two-factor and three-factor crosses will be worked out collectively on the whiteboard. The importance of bacterial transposition, the mechanisms by which they occur, bacterial mutagenesis using transposons, strategies to clone out specific genes using transposons	The student will be made to create genetic maps based on conjugation,cotransduction frequencies in two-factor and three-factor crosses. apply transposition to various problems by a short written assignment
IV	Is able to list the events in the lytic T4 &T7 and lysogenic phases of lambda and P1 phage life cycle and the regulatory factors and events involved.	The entire regulatory circuits of T4 &T7 ,P1 phage lambda will be explained with the help of a whiteboard as well as slide show.	Students will have to figure out the plaque phenotypes obtained with different lambda mutants in a class test.
V	Is able to explain the mechanism of Acquired and adaptive immunity in bacteria, antiphage defence system, programmed Genetic variation, Epigenetics	Mechanism of Acquired and adaptive immunity in bacteria, antiphage defence systems will be explained with the help of a whiteboard as well as slide show.	The students will be assessed in their abilities to understand Acquired and adaptive immunity in bacteria, antiphage defence systems. quiz on programmed genetic variation, Epigenetics

MIC 204. ANALYTICAL TECHNIQUES

Course Objectives:

To introduce the student to the variety of biophysical and biochemical techniques currently available to probe the structure and function of the biological macromolecules, make them aware of the physical principles behind each technique and the instrumentation involved, make them familiar with various methods of analyzing the output data, and to build a strong foundation in the area of bacterial cell structure, division, survival and propagation.

Course Learning Outcomes:

Upon successful completion of the course, the student will:

CO1: Be able to understand the microscopic analysis.

CO2: Be familiar with the different chromatography techniques like TLC ,HPLC,Affinity chromatography. Be able to carry out the gel electrophoresis , understand and correctly interpret the migration of protein molecule on PAGE under native and SDS conditions

CO3: Be able to understand separation of molecules by centrifugation techniques.

CO4:Be able to familiar with spectroscopic techniques like spectrofluorometry,NMR ,ESR. Follow the safety precautions while using radioactive methods,measurement of radioactivity.

CO5: Be able to carry out the analysis of the data from CD and Fluorescence experiments to monitor the stability of the protein ,IR Spectroscopy & X-ray crystallography.

Course content

Unit 1. Microscopy: Light microscope,Phase contrast microscope and flurorescence microscope,Electron microscopy(SEM & TEM)

Unit 2. Principles and applications of chromatography-adsorbtion,ion exchange,gel filtration and affinity chromatography,paper chromatography ,thin layer and gas chromatography,HPLC,chromatofocussing.
Electrophoresis: Principles,PAGE,agarose gel electrophoresis ,isoelectric focusing dielectrophoresis

Unit 3. Centrifugation-Introduction and principles of laboratory centrifuges,ultracentrifugation,density gradient centrifugation Sedimentation cofficientand application

Unit4. Photometry: Basic principles instrumentation and application of spectrophotometry (UV,visible,ESR,AAS) flurometry,polarometry, circular dichorism, Ph metry.Tracer techniques :autoradiography ,preparation ,labeling,detectionand measurement of radioactivity.

Unit 5. Methods in biophysical analysis ,CD,ORD,fluorescence spectroscopy,Raman spectroscopy,IR Spectroscopy- principles and instrumentation,NMR principle and instrumentation,X ray crystallography-principles & instrumentation.

Suggested Reading:

1. Wilson K and Walker J. Principles and Techniques of biochemistry and molecular biology. Cambridge.
2. J. D. Seader and E. J. Henley, Separation Process Principles, 1st Edition (1998), John Wiley & Sons. Inc., New York.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Be able to understand the microscopic analysis.	Using PPT Vedio lecturer to clarify the microscopic analysis.	Group discussion on interpreting data presented in selected research papers where electrophoresis techniques have been used
2.	Be familiar with the different chromatography techniques like TLC ,HPLC,Affinity chromatography. Be able to carry out the gel electrophoresis , understand and correctly interpret the migration of protein molecule on PAGE under native and SDS conditions	Familiarizing students with the commonly used chromatographic matrices which separate proteins based on size, affinity tag and pI. Discussion about the types of electrophoretic methods available for separation of biomolecules	Oral quiz after the lecture
3.	Be able to understand separation of molecules by centrifugation techniques.	Discuss about the basis principle of centrifugation & types of centrifuge	Group discussion
4.	Be able to familiar with spectroscopic techniques like spectrofluorometry,NMR ,ESR. Follow the safety precautions while using radioactive methods,measurement of radioactivity.	Detailed discussion on origin of spectroscopy . Using PPT to understand about NMR,ESR in detail Providing students with the knowledge about precautions to be used while using radioactivity based methods	Oral quiz after the lecture
5.	Be able to carry out the analysis of the data from CD and Fluorescence experiments to monitor the stability of the protein ,IR Spectroscopy & X-ray crystallography.	Using PPT &Whiteboard for detail discussion about CD & X ray crystallography	Ten-minute MCQ quiz after lecture about x ray crystallography

MIC 301 AGRICULTURE AND ENVIRONMENTAL MICROBIOLOGY
Marks: 100 **Credit Hours: 36 hours**

Course Objectives: The major objective of this paper is to impart basic understanding of environmental and agricultural microbiology including; microbial diversity in the environment in relation to environment and agricultural welfare, ecosystem wellness, microbial interactions with pollutants in the soil and environment.

Course Learning Outcomes: Upon successful completion of the course, the student:

1. Will have an overview of the till date developments in the field of environmental microbiology with special emphasis on pathogenic microbes.
2. Will develop concepts of microbial diversity, community structure and role of microorganisms in biogeochemical cycles.
3. Will be able to describe the role of soil microbes in nutrient transformation, plant-microbe interactions and biotechnology.
4. Understands the role of microorganisms in waste treatment, sustainable development and bioremediation of pollutants using microorganisms).
5. Will understand the information about inter-relationship of soil and microorganisms, different group of beneficial microorganisms in agriculture, microbes as a biofertilizer, plant pathogen and biocontrol agent.

CONTENT

Unit 1. Microbes in air-transmission and disease caused by them, preventive measures, assessment of air quality, solid and liquid impingement methods, aerosols and droplet nuclei.

Unit 2. Microbes in water-estuaries, mangroves, deep sea, fresh water, hydrothermal vents, eutrophication, major water borne diseases and their treatment.

Unit 3. Soil-microflora-rhizosphere and phylosphere, mutualism, commensalisms, competition, parasitism, predation and symbiosis. The plant-soil-microbe interaction in symbiosis-biological N fixation, nif genes, azolla and the other non symbiotic N fixers in soil.

Unit 4. Waste treatment-types. Solid and liquid wastes, methods-physical chemical biological: aerobic and anaerobic, composting, utilization of solid wastes and recycling food (SCP, mushroom, yeast), Fuel-ethanol, fertilizer (composting), bioremediation, treatment of polluted water.

Unit 5. Role of microbes in environment – positive and negative role. Biodegradation of lignin, pesticides, Bioaccumulation of heavy metals and detoxification, biopesticides, genetically modified microbes, concerns and advantages.

Suggested Readings:

1. Manual of environmental microbiology, Christon J. Hurst, Ronald L. Crawford Second edition, ASM Press.
2. Agricultural Microbiology: Subba rao
3. Microbial Ecology –Atlas and Bartha.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks*
I	Gets an overview of the various factors effecting the survival and occurrence of microorganisms in atmosphere. Also	Lecture on environmental factors effect on microorganisms.	Quiz on identifying the microbes

	knows about the methods of assessment of microbial air quality.		associated with airborne diseases
II	Gets an overview of aquatic environment conditions effecting the microbial community of habitat.	Discussion on the factors affecting the microbial community of aquatic environments	10 min MCQ after the lecture
III	Gets acquainted with various types of interactions between microorganisms and can describe of role of soil microbes in nitrogen acquisition by plants.	Explaining to students the various types of interspecific interactions and their involvement in various nutrient transformation processes, and their biotechnological applications.	Match the following type quiz regarding examples of microbial interactions
IV	Describe the role of microbes in solid and liquid waste management gaining knowledge of various methods employed in sewage treatment and solid waste treatment. Understands role of microbes in bioremediation of environmental pollutants.	Explaining different types of solid wastes and methods of its management such as composting, landfills and incineration methods and discussing challenges faced during waste management. Discussing ways of determining potability of water and its quality control. Lecture on sewage waste management including primary, secondary and tertiary treatments methods using visual aids. Explaining ways of treating Industrial effluents generated from various industries.	Group activity of designing a project from selection of microbes to application in managing and recycling different solid waste.
V	Can describe the role of microbes in environment and get knowledge of lignin, pesticides degradation and heavy metals accumulation by microbes. Gets thorough with microbial formulations to prevent and treat plant diseases and growth, and apply the knowledge of significant biochemical processes of microbes to improve agricultural practises.	Detailed discussion on microbial degradation of xenobiotic compounds, microbial antagonism and biofilm formation by microbes.	Quiz on matching the key microbes associated specific mechanism(s) of plant growth promotion.

MIC 302. FUNDAMENTALS OF MOLECULAR BIOLOGY **Semester III**
Marks: 100

Course Objectives:
The purpose of this course is to introduce the student to the advanced concepts in molecular biology. Student will gain an understanding of molecular mechanisms of DNA replication, DNA repair, transcription, translation, and gene regulation in prokaryotic and eukaryotic organisms. The students will study the techniques and experiments used to understand these mechanisms.

Course Learning Outcomes: Upon successful completion of the course, the student:

CO1: Is able to describe structure of DNA and RNA, organization of eukaryotic genome
CO2: Is able to compare and contrast the mechanisms of bacterial and eukaryotic DNA replication, DNA repair, transcription
CO3: Is able to explain concepts in DNA repair mechanisms, and recombination as a molecular biology tool
CO4: Is able to explain various levels of gene regulation in both prokaryotic and eukaryotic organisms
CO5: Is able to describe post-transcriptional processes, RNA editing, RNAi and miRNA
CO6: Is able to describe translation mechanism in prokaryotes and eukaryotes, regulation of translation, and post-translational processing
CO7: Is able to describe post-translational processes

Contents:

Unit 1. Genetic information and nucleic acids. DNA as the genetic blueprint- experimental evidence, DNA structure, various modes of DNA replication, DNA polymerase. action of DNA topoisomerases.

Unit 2. DNA replication- intiation, replication fork, lagging and leading strands, inhibitors, proof reading, DNA damage and repair pathways.

Unit 3. Transcription, types of RNA and RNA polymerases. Class I, Class II and Class Ill genes. Initiation, elongation and termination complexes, inhibitors

Unit 4. Regulation of gene expression- operon concept, positive and negative regulation, eatabolite repression, the lac operon, ara operon of E.coli. Antitennination and attenuation, transcription factors, enhancers, promoters and heat shock response, stringent response, Methylation, capping,' polyadenylation and splicing of RNA, catalytic RNA, ribozymes.

Unit 5. The genetic code, steps in protein synthesis, initiation, elongation and termination. inhibitors, *in* vitro transcription and translation systems.

Suggested Reading:

1. George M Malacinski. Freifelder's Essentials of molecular biology. Jones & Bartlett Learning
2. Krebs JE, Goldstein ES, Kilpatrick ST. Lewin's Essential Genes. Jones & Bartlett Learning

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
I	Is able to describe structure of DNA and RNA, organization of eukaryotic genome	Learn about structure of DNA and RNA, super-helicity, organization of microbial and eukaryotic genome, chromatin arrangement, nucleosome formation	Multiple choice questions to asses knowledge of structure of DNA and RNA
II	Is able to compare and contrast the mechanisms of bacterial and eukaryotic DNA replication, DNA repair, Is able to explain concepts in DNA repair mechanisms, and recombination as a molecular biology tool	Learn about various modes of replication, various replication enzymes, replication fork, features of DNA replication in prokaryotes and eukaryotes, chromatin assembly,Learn about DNA mismatch repair, double stranded break repair, CRISPR-Cas systems for DNA editing	Fill the blanks type questions to asses understanding of concepts related to DNA replication,True False questions to asses knowledge regarding DNA repair mechanisms
III	Is able to describe transcription in prokaryotes and eukaryotes,posttranscriptional processes, RNA editing, RNAi and miRNA Is able to describe posttranscriptional processes, RNA editing,	Learn about transcription machinery of prokaryotes, various transcription enzymes, transcription machinery in eukaryotes, various RNA polymerases, Learn about RNA processing, splicing, capping, polyadenylation, RNA editing,	Prepare and present presentation on relation between structure and function in polymerases Prepare report on DNA and RNA editing tool

IV	Is able to describe translation mechanism in prokaryotes and eukaryotes, regulation of translation, and posttranslational processing Is able to describe posttranslational processes	Learn about genetic code and protein structure, mechanism of translation in prokaryotes and eukaryotes, in vitro translation systems, regulation of translation, RNA instability, Learn about various types of protein modifications folding, chaperones, transportation, and protein degradation	Match the following type quiz on translation mechanisms, Group discussion on post-transnational protein modification and cell signaling
V	Is able to explain various levels of gene regulation in both prokaryotic and eukaryotic organisms	Regulation of transcription,regulating the expression of prokaryotic (*lac ,trp,ara* operon) and eukaryotic genes response element ,role of chromatin in gene expression and gene silencing.	Analytical questions and quiz related to the regulation of transcription,

MIC 303. Recombinant DNA Technology

Course Objectives:

The objective of this course is to make the student familiar with the currently used techniques to manipulate/ analyze DNA, RNA and proteins. The student will be made familiar with the methods used to clone genes, make and screen libraries, and the various applications of the polymerase chain reaction. The student will be taught about the methods currently used to carry out genome- wide analyses genome sequencing and global analyses of transcription and protein expression. The student will be made familiar with how recombinant DNA technology has been exploited in the study of biology as well as in the production of pharmaceutical products, transgenic plants & animals.

Course Learning Outcomes:

Upon successful completion of the course, the student:

1. Will know about basic principle of RDT,different restriction & modifying enzymes,library construction and screening.

2. Will be familiar with the use of various cloning vectors, like plasmid ,cosmids and artificial chromosomal vectors.
3. Will be able to describe the various methods of gene transfer in both plant and animal.
4. Will be able to understand the gene library construction,use of reporter gene, Cre Lox system.
5. Will be aware of DNA is sequenced and will gain insights into how entire genomes of organisms are sequence, the many uses of the molecular markers, hybridization techniques like southern ,northern and western blotting.various applications of PCR, creation of plant and animal transgenics.

Course content

Unit 1: The recombinant DNA concept and principle of cloning, DNA manipulation enzymes, Vector constructions- ligation, transformation, selection, DNA libraries: genomic and cDNA libraries.

Unit 2: E. coli the Trojan horse of biotechnology,plasmids as vectors,derivatives of plasmids,cosmids,phasmids,phagemids,vectors for cloning of large inserts: YACs,BACs,MACs,PACs,Factors for selection of a vector.

Unit 3: Methods for introduction of recombinant DNA into host cells,Direct and indirect DNA transfer methods, Transformation ,transfection,transduction, specialized vectors for gene transfer to animals and plants cells, Agrobacterium and Ti plasmid,Binary vectors system,Animal cell transformation and Baculo virus vectors.

Unit 4: Construction of gene libraries and isolation of gene, comparative advantages of Cdna libraries over genomic libraries, the promoter,reporter,selectable and scorable marker gene, generation of marker free plants and animals,Cre Lox system.

Unit 5: Restriction enzymes and their uses,the blotting techniques, Southern,Northern and Western ,Polymerase chain reaction and its application ,RFLP, AFLP, STMS and their use in genetic mapping, DNA Sequencing methods and discovery of SNPs, Applications of Rdna technology in medicine ,environment and agriculture, potencial risks associated with r DNA technology.

Suggested Reading:

1. TA Brown. Gene cloning and DNA analysis. Blackwell Publ.
2. Old and Primrose. Principles of gene manipulation. An introduction to genetic engineering. Blackwell Scientific Publ.

Facilitating the achievement of Course Learning Outcomes

unit no.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	will know about basic principle of RDT,different restriction &	The students will be taught about the use of restriction enzymes and the use of linkers and	The student will be made to design a cloning

	modifying enzymes,library construction and screening	adaptors in cloning. The step-wise construction of DNA libraries will be explained.	strategy and detail the steps involved.
2.	Will be familiar with the use of various cloning vectors like plasmid ,cosmids and artificial chromosomal vectors.	Using whiteboard and PowerPoint slides the student will be given knowledge of the various vectors both cloning & expression	The student will be evaluated by a short class test.
3.	Will be able to describe the various methods of gene transfer in both plant and animal.	Using vedio lectures and PowerPoint slides the student will be given knowledge of the various methods of gene transfer in both plants & animals	The student will be evaluated by a short class test.
4.	Will be able to understand the gene library construction,use of reporter gene,Cre Lox system.	The student will learn about the library construction also discuss about different types of reporter gene.	Oral quiz & discussion
5.	Will be aware of DNA is sequenced and will gain insights into how entire genomes of organisms are sequence, the many uses of the molecular markers, hybridization techniques like southern ,northern and western blotting.various applications of PCR, creation of plant and animal transgenics. .	Using whiteboard and PowerPoint slides the student will be given knowledge of the various applications of polymerase chain reaction. The analysis of gene expression by real time PCR will be detailed. concepts of Shotgun sequencing methods for whole genome sequencing will be explained. The student will be initiated into the exciting and controversial area of transgenics and animal cloning with the help of examples of transgenics created and animals cloned.	Group discussion

MIC 304. FUNDAMENTALS OF INFECTION AND IMMUNITY Semester III
Total Marks :100 Credit hours 60

Course Objective: The purpose of the course is to provide a comprehensive understanding of the biochemical, cellular and molecular components of the immune response

Learning Outcomes: Upon completion of the paper, student would have the following learning outcomes

1. To distinguish between the specificity and memory of acquired versus innate immune reponse
2. To differentiate between different types of specific immune response
3. To understand generation of immune diversity and different molecular aspects of immune response generation
4. To understand different immunotechniques and their applications
5. To understand how the immune response if important in vaccine development and immunotherapy

Course Content:

Fundamentals of Infection and Immunity

Unit 1. Principles of medical microbiology; classification of medically important microorganism, normal microflora of human body- origin of normal microflora, normal microflora and human host

Unit 2. Infection: Source of infection of man: vehicles of reservoir of infection. Exogenous infection 1. Patients 2. Carriers- healthy, convalescent, contact, paradoxical and chronic. Infected animals: zoonosis 4. Soil Endogenous infections

Mode of spread of infection:1. Respiratory 2. Skin. Wound and Burn Infections 4. Venereal Infection 5. Alimentary tract infection 6. Arthopos borne blood infections 7. Laboratory infections

Pathogenesis: Microbial pathogenicity, transmissibility, infectivity and virulence. Opportunistic pathogens, True pathogens, Toxigenicity, invasiveness

Unit 3. Immune system: organs and cells involved in the immune system and immune response. Natural or innate immune response. MHC I, MHC II, lymphocytes- properties and functions, Helper T cells, Antigen types, specify and haptens. Non specific immunity. Surface and physical barriers, Complement system, Lysozymes, interferons, Leukins, Phagocytins

Unit 4. The Immune response: active- passive, humoral- cellular, immune memory, antibody structure and production, antigen recognition, autoimmunity, cell mediated immunity, immunity- suppression, vaccines

References:

1. Cruse J and R. Lewis (2004) Atlas of Immunology 2nd Edn. CRC Press.
2. David Male, Jonathan Brostoff, David B Roth, Ivan Roitt.(2006).Immunology 7th edition.
3. Goldsd by R.A. Kindt T.S. and B.A. Osborne Kuby (2000) Immunology Fourth Edition W.H. Freeman & Co New York.
4. Reed R; Holmes D; Weyers J and A Jones (1998) Practical skills in Biomolecular SciencesAdison Wesley Longman Ltd.
5. Tizard; I.R. (1995) Immunology an Introduction 4th Edn. Saunders College

Publishing.Harcourt Brace College Publishers.
6. 1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman
7. Abul Abbas, Adrew Litchman, Shiv Pillai. Cellular and Molecular Immunology.9th Edition. Elsevier.
8. Janeway et al., Immunobiology, 4th Edition, Current Biology publications.
9. Peter J. Delves (Author), Seamus J. Martin (Author), Dennis R. Burton (Author), Ivan M. Roitt (Author)
10. Roitt's Essential Immunology.13th Edition, Wiley Black Publications.

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks*
I	Understand different aspects of the normal microflora, opportunistic pathogens and true pathogens	Whiteboard and power point teaching of different lines of defense and types of immune cells, biochemical factors such as CRP, complement, cytokines and chemokines	Assignment on different immune cell types, study of differential leukocyte and blood reports
II	Learns about microbial pathogenicity, transmission, infectivity, cycle of entry and exit, reservoirs of infection and modes of transmission	Explain different aspects of microbial adhesion, invasion, toxigenecity, air, water, soil zoonotic infections and humans as reservoirs	Students are given quiz based questions
III	Understand different aspects of the innate immune response, lymphoid system and organs and differentiate it from specific immune response	Powerpoint presentation of different organs, cell types and their structure and function	Multiple choice class test
IV	Acquires knowledge about B cell and T cell/ cell mediated immunity and its various types and role in immunity	Explain different aspects of T cell immune development a and its importance in developing strong immunity, diversity repertoire and memory cells	Power point presentations and group discussion on different immune response and result interpretation
V	Understand measurement of humoral and cell mediated immune response by various techniques. Be able to explain role in immunopathology, autoimmunity and different vaccine candidates	Students learn about application of immune response development to natural and artificial antigens	Ten-minute MCQ quiz after lecture.

SEMESTER – IV

MIC 401: MICROBIAL TECHNOLOGY

Marks: 100 **Credit Hours: 36 hours**

Course Objectives: The course will enable students to impart theoretical knowledge of the role of microbes in industrial production of different biochemicals/ bio-molecules. The strategies for development of microbial strains, upstream and downstream processes optimization will be covered for industrially relevant microbial products and therapeutic proteins.

Course Learning Outcomes: Upon successful completion of the course, the student:

1. Will have gained insight on industrially important microbes
2. Will attains knowledge of various fermentation optimization strategies.
3. Learn about the concepts of processes, instruments, management, quality etc being used in industries to produce the products using microorganisms.
4. To gain knowledge about upstream and downstream processes in a fermentation process.
5. Acquires knowledge about the production process of various industrially relevant microbial products.

CONTENT

Unit 1. Strategies for isolation and screening of industrially important strains, strategies for strain improvement of industrially important strains, Fermentation technologies- principles, Bioelectronics-biochips and biosenors.

Unit 2. Fermenters- types, design, operation and application, Downstream processing of biological-Introduction, economics of downstream processing vis-a-vis fermentation process, Cell and enzyme immobiliation, Hygiene and safety in fermentation industries.

Unit 3.

Microbial production of ethanol and alcoholic beverages – beer and wine
Microbial production of vitamin B2 and B12
Microbial production of enzymes- amylase and protease
Microbial production of amino acids – L- Lysine and L-glutamic acid

Unit 4.

Microbial production of antibiotics – penicillin and streptomycin
Microbial production of interferon
Microbial production of insulin
Microbial production of vaccines

Unit 5.

Biopesticides – bacterial, fungal and viral control of insect pests
Biofertilizers – types, production and applications
Microbial production of polymers – dextran and xanthan
Microbial transformations- steroid transformations

Suggested Readings:

1. Casida, L.E., 1984, Industrial Microbiology. Wiley Eastern, New Delhi
2. Prescott and Dunn's.: Industrial Microbiology, AVI Publishing Co. USA.
3. Waites M.J. et al.: Industrial Microbiology, Blackwell Science Ltd.

4. Glazer A.N and Nikaido H.: Microbial Biotechnology, W.N. Freeman and Co.

Facilitating the achievement of Course Learning Outcomes

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks*
I	Get acquainted with the industrial aspect of the field of Microbiology and gains insight on industrially important microbes, recent development in fermentation processes and bioelectronics.	In class room students learn about the strategies of strain improvement and media design strategies to produced hyper producer strains.	Students are asked to prepare report on various microbial products of commercial use.
II	Learns about the design, types of fermenters and various critical components of bioreactors. Understand the physicochemical principles to improve the industrial processes and strategies of product recovery from a fermentation broth.	Students are taught to assemble various bioreactor components and discussed the optimization strategies. Demonstration of various processes of product recovery and chromatography techniques	Students are taken to fermentation facility and are asked to describe various fermenter parts, control instruments and their use in production of various microbial products
III	Acquires knowledge about brewing process, microbial enzymes, amino acids and vitamins production process	Students learn about the traditional and industrial strategies of beverages, vitamins and amino acids production.	Multiple choice class test
IV	Gets introduced to the production strategies of various antibiotics, hormones and therapeutic proteins.	Students are taught about the schematic strategies of antibiotics, hormones, interferon and other therapeutic proteins production.	Power point presentations and group discussion on industrially relevant products
V	Attains knowledge about microbial polymers production and recovery strategies, and learn to apply knowledge of plant growth promoting microbes into development of formulations.	Students learn about microbial products, their production strategies, FDA approval and market cost and are also taught how the process cost can be reduced further by applying the knowledge of industrial microbiology from this course	Ten-minute MCQ quiz after lecture.

MIC 403A: FOOD MICROBIOLOGY (ELECTIVE)

Course Objectives:

The course will enable students to understand the phenotypic and biochemical identification of food associated molds, yeasts, yeast-like fungi and bacteria. The course will teach the strategies to develop fermented and non-fermented milk products. The role of microbes in food spoilage, preservation and various food borne diseases will be discussed.

Course Learning Outcomes:

1: Knows traditional food preservation techniques including drying, salting, pickling, refrigeration, freezing, oxidation, vacuum packaging, canning/bottling, smoking, sugaring, chemical preservation and irradiation.

2: Gains knowledge about factors influencing microbial growth in food: extrinsic and intrinsic factors

3: Gathers information regarding microbes causing food intoxications and food-borne infections. Gains knowledge about conventional methods for food quality analysis and is able to use the most recent techniques of quantification and detection of food borne microbes and pathogens.

4: Gains knowledge about microbiology of milk and production and evaluation of the quality of starter cultures and fermented milk products such as yogurt cheese etc.

5: Knows about production of microbial biomass such as edible yeasts, mushrooms, single cell proteins.

Contents:

Unit 1: Microorganisms important in food microbiology: molds, yeasts, bacteria – General characteristics classification and importance. Principles of food preservation- Asepsis, Preservation by use of high temperature, drying and dessication, chemical preservatives and additives, preservation by radiation.

Unit 2: Factors influencing microbial growth in food: extrinsic and intrinsic factors, Microbial spoilage of food. Chemical changes caused by microorganisms during spoilage. Spoilage of fish, meat, poultry, eggs, fruits and vegetables and canned foods.

Unit 3: Classification of food borne diseases. Food borne infections- *Brucella, Bacillus ,Clostridium perfringens, Escherichia, Salmonella, Shigella, Vibrio* and *Yersinia*. Food adulteration and prevailing food standards in India.

Unit 4: Microbiology of milk: Sources of microorganisms in milk and types of microorganisms in milk. Microbial contamination of milk (SPC, direct microscopic count, reductase and phosphatase test) Dehydration and Pasteurization of milk. Dairy products from microorganisms: butter, yoghurt and cheese.

Unit 5: Microorganisms as source of food: Single cell protein, Mushrooms and food value of mushrooms, Food conversions, Microbiological estimation of food: Samplecollection , preparation and analysis techniques.

Suggested readings:

1. Food Microbiology by W.C. Frazier, D.C. Westhoff , K.N. Vanitha. 5th edition. McGraw Hill Education. 2013.
2. Modern Food Microbiology by J.M. Jay, M.J. Loessner, D.A. Golden. 7th edition. Springer. 2006.
3. Fundamental Food Microbiology by B. Rayand A. Bhunia. 5th edition. CRC press. 2013.
4. Food Microbiology by M. R. Adams, M. O. Moss, P. McClure. 4th edition. Royal Society of Chemistry. 2015.

5. Food Microbiology: Fundamentals and Frontiers by M. P. Doyle, L. R. Beuchat. 3rd edition. ASM press. 2007.
6. Food Microbiology: An Introduction by T. Montville, K. Matthews, K.Kniel. 4th edition.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Knows traditional food preservation techniques including drying, salting, pickling, refrigeration, freezing, oxidation, vacuum packaging, canning/bottling, smoking, sugaring, chemical preservation and irradiation.	Detailed discussion on the use of classical methods of food preservation including drying, salting, pickling, refrigeration, freezing, oxidation, vacuum packaging, canning, bottling, smoking, sugaring, chemical preservation and irradiation.	Quiz on conventional food preservation method to be employed for specific food groups.
2	Gains knowledge about factors influencing microbial growth in food: extrinsic and intrinsic factors	Provide knowledge about intrinsic and extrinsic factors in detail.	Group discussion
3	Gathers information regarding microbes causing food intoxications and food-borne infections. Gains knowledge about conventional methods for food quality analysis and is able to use the most recent techniques of quantification and detection of food borne microbes and pathogens.	Provide knowledge about the microbes involved in food intoxications including Staphylococcus aureus, Clostridium botulinum and fungi producing mycotoxins. Familiarization of students with common food infections. Discussion about conventional methods for food quality analysis- culture dependent methods, colony count, immunological assays and PCR-based methods. Interactive lecture on recent advances in quantification and detection of food borne microbes.	Short answer type test based on symptomatic identification of food intoxication/ food borne infection. Short student presentation on a new detection or quantification technique of food borne microbes and pathogens.
4	Gains knowledge about microbiology of milk and milk products	Making students aware of useful and pathogenic microorganisms of milk.	Group discussion
5	The student knows about production and evaluation of the quality of starter cultures and fermented milk products and oriental foods.	Use of videos and pictorial aids for familiarization of students with theproduction of starter cultures andfermented milk products and oriental foods.	Match the following type 5-minute test

6	Understands the relevance of microbial standards for food safety, quality assurance programs that revolutionize food safety and understands the use and production of probiotics, prebiotics.	Making students aware of the relevance of microbial standards for food safety. Discussion on probiotics, prebiotics.	Match the following type 5-minute test

MIC 3001: Microbial technology

Course Objectives:

The course will help students to understand various applications of microbes for the development of various products of agriculture and industrial application. The knowledge of recombinant technology, bioreactors and optimization strategies will be beneficial in development of production processes. The knowledge of IPR, patents, trademarks, copyrights will be beneficial in research and development.

1: Learns about the design, types of fermenters and various critical components of bioreactors

2: Will have gained insight on industrially important microbes, recent developments in fermentation processes and various optimization strategies at fermenter level.

3: Understands the concept of sterilization methods and principles of batch and continuous processes.

4: Understands different types of regulatory approvals required for drug development and difference between biologics, biosimilars and biobetters

5: Understands the relevance of IPR, patent ,copyright and trademarks. Quality control analysis through WHO.

Contents:

Unit 1: Fermentation technology: microbial growth kinetics in batch, continuous & fed-batch fermentation process. Solid state & submerged fermentation: their advantages & disadvantages. Immobilization of microbial enzymes, whole cells and their industrial applications. Biosensors and biochips.

Unit 2: Renewable bioenergy using microorganisms – Methane production by anaerobic digestion of waste organic materials, Bioethanol and biohydrogen production by using microorganisms, Bioleaching, Biohydrometallurgy; Industrial waste water treatment

Unit 3: Use of microbes and microbial enzymes in the improvement of nutritive quality of feed; Engineering traits in plants related to stress resistance and nutritional quality improvement; Bt gene technology; frost protection by microbes. Nanoparticle synthesis using micro-organisms.

Unit 4: Pharmaceutical Microbiology: Mode of action of antibiotics, antifungal and antiviral drugs; antitumor substances. GMP & GLP in pharmaceuticals; Sterilization of pharmaceutical products. Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. Safety in microbiology laboratory.

Unit 5: Intellectual Property Rights (IPR), Patents, Trademarks, Copyrights, Secrets; Patenting of microbiological materials and GMOs; patenting of genes and DNA sequences; Quality control through WHO, Ethics & Safety of GMO.

Suggested Readings:

1. Stanbury PF, Whitekar A. and Hall (2006). Principles of Fermentation Technology. Pergaman. McNeul and Harvey.
2. Bhosh, Fiecht er and Blakebrough (2005). Advances in Biochemical Engineering. Springer Verlag Publications.
3. Waste Water Engineering - Treatment, Disposal and Re-use by Metcalf and Eddy, Inc.,Tata MacGraw Hill, New Delhi.
4. Pharmaceutical Microbiology – Edt. by W.B.Hugo & A. D. Russell Sixth edition. Blackwell scientific Publications.
5. Bernd Rehm (2006). Microbial Bionanotechnology: Biological Self-assembly Systems and Biopolymer-based Nanostructures. Horizon Scientific Press.
6. TA Brown. Gene cloning and DNA analysis. Blackwell Publ.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment tasks
1	Attains knowledge about fermentation technology. Solid state & submerged fermentation	Students gain knowledge about running large scale fermentation processes and type of cultivation strategies	Multiple choice question test and group discussion
2	Various bioproducts produced by microorganisms such as ethanol etc.	Gain knowledge about bioleaching, bioethanol production.	Multiple choice question test and group discussion
3	Nanoparticle synthesis using micro-organisms and its applications.	Green synthesis of nanoparticles	Written test and class discussion
4	GMP & GLP in pharmaceuticals; Understands different types of regulatory approvals required for drug development	Learn about various regulatory approval procedures of ISO and development of generic	Written test and class discussion about different therapeutic biomolecules available in market

		biomolecules and phases of clinical trials	
5	Understands the relevance of IPR , patent ,copyright and trademarks. Quality control analysis through WHO.	Learn about importance of IPR, Copyright, Trademarks in research.	Written test and class discussion

MIC 204. Analytical Techniques (2015-2016)

Course Objectives:

To introduce the student to the variety of biophysical and biochemical techniques currently available to probe the structure and function of the biological macromolecules, make them aware of the physical principles behind each technique and the instrumentation involved, make them familiar with various methods of analyzing the output data, and to build a strong foundation in the area of bacterial cell structure, division, survival and propagation.

Course Learning Outcomes:

Upon successful completion of the course, the student will:

CO1: Be able to understand the microscopic analysis.

CO2: Be familiar with the different chromatography techniques like TLC ,HPLC,Affinity chromatography. Be able to carry out the gel electrophoresis , understand and correctly interpret the migration of protein molecule on PAGE under native and SDS conditions

CO3: Be able to understand separation of molecules by centrifugation techniques.

CO4: Be able to familiar with spectroscopic techniques like spectrofluorometry, NMR, ESR. Follow the safety precautions while using radioactive methods, measurement of radioactivity.

CO5: Be able to carry out the analysis of the data from CD and Fluorescence experiments to monitor the stability of the protein ,IR Spectroscopy & X-ray crystallography.

Course content

Unit 1. Microscopy: Light microscope, Phase contrast microscope and fluorescence microscope, Electron microscopy(SEM & TEM)

Unit 2. Principles and applications of chromatography-adsorbtion, ion exchange, gel filtration and affinity chromatography, paper chromatography ,thin layer and gas chromatography, HPLC, chromatofocussing. Electrophoresis: Principles, PAGE, agarose gel electrophoresis, isoelectric focusing dielectrophoresis

Unit 3. Centrifugation-Introduction and principles of laboratory centrifuges, ultracentrifugation, density gradient centrifugation Sedimentation coefficient and application

Unit4. Photometry: Basic principles instrumentation and application of spectrophotometry (UV,visible,ESR,AAS) flurometry, polarometry, circular dichorism, Ph metry.Tracer techniques :autoradiography ,preparation ,labeling,detectionand measurement of radioactivity.

Unit 5. Methods in biophysical analysis ,CD,ORD,fluorescence spectroscopy,Raman spectroscopy,IR Spectroscopy- principles and instrumentation, NMR principle and instrumentation,X ray crystallography-principles & instrumentation.

Suggested Reading:

1. Wilson K and Walker J. Principles and Techniques of biochemistry and molecular biology. Cambridge.
2. J. D. Seader and E. J. Henley, Separation Process Principles, 1st Edition (1998), John Wiley & Sons. Inc., New York.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Be able to understand the microscopic analysis.	Using PPT Vedio lecturer to clarify the microscopic analysis.	Group discussion on interpreting data presented in selected research papers where electrophoresis techniques have been used
2.	Be familiar with the different chromatography techniques like TLC ,HPLC,Affinity chromatography. Be able to carry out the gel electrophoresis , understand and correctly interpret the migration of protein molecule on PAGE under native and SDS conditions	Familiarizing students with the commonly used chromatographic matrices which separate proteins based on size, affinity tag and pI. Discussion about the types of electrophoretic methods available for separation of biomolecules	Oral quiz after the lecture
3.	Be able to understand separation of molecules by centrifugation techniques.	Discuss about the basis principle of centrifugation & types of centrifuge	Group discussion
4.	Be able to familiar with spectroscopic techniques like spectrofluorometry,NMR ,ESR. Follow the safety precautions while using radioactive methods,measurement of radioactivity.	Detailed discussion on origin of spectroscopy . Using PPT to understand about NMR,ESR in detail Providing students with the knowledge about precautions to be used while using radioactivity based methods	Oral quiz after the lecture
5.	Be able to carry out the analysis of the data from CD and Fluorescence experiments to monitor the stability of the protein ,IR Spectroscopy & X-ray crystallography.	Using PPT &Whiteboard for detail discussion about CD & X ray crystallography	Ten-minute MCQ quiz after lecture about x ray crystallography

MIC 303. Recombinant DNA Technology (2015-2016)

Course Objectives:

The objective of this course is to make the student familiar with the currently used techniques to manipulate/ analyze DNA, RNA and proteins. The student will be made familiar with the methods used to clone genes, make and screen libraries, and the various applications of the polymerase chain reaction. The student will be taught about the methods currently used to carry out genome- wide analyses genome sequencing and global analyses of transcription and protein expression. The student will be made familiar with how recombinant DNA technology has been exploited in the study of biology as well as in the production of pharmaceutical products, transgenic plants & animals.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: will know about basic principle of RDT,different restriction & modifying enzymes,library construction and screening.

CO2: Will be familiar with the use of various cloning vectors, like plasmid ,cosmids and artificial chromosomal vectors.

CO3: Will be able to describe the various methods of gene transfer in both plant and animal.

CO4: Will be able to understand the gene library construction,use of reporter gene,Cre Lox system.

CO5: Will be aware of DNA is sequenced and will gain insights into how entire genomes of organisms are sequence, the many uses of the molecular markers, hybridization techniques like southern ,northern and western blotting.various applications of PCR, creation of plant and animal transgenics.

Course content

Unit 1: The recombinant DNA concept and principle of cloning, DNA manipulation enzymes,Vector constructions- ligation, transformation,selection,DNA libraries: genomic and cDNA libraries.

Unit 2: E. coli the Trojan horse of biotechnology,plasmids as vectors,derivatives of plasmids,cosmids,phasmids,phagemids,vectors for cloning of large inserts: YACs,BACs,MACs,PACs,Factors for selection of a vector.

Unit 3: Methods for introduction of recombinant DNA into host cells,Direct and indirect DNA transfer methods, Transformation ,transfection,transduction, specialized vectors for gene transfer to animals and plants cells, Agrobacterium and Ti plasmid,Binary vectors system,Animal cell transformation and Baculo virus vectors.

Unit 4: Construction of gene libraries and isolation of gene, comparative advantages of Cdna libraries over genomic libraries, the promoter,reporter,selectable and scorable marker gene, generation of marker free plants and animals,Cre Lox system.

Unit 5: Restriction enzymes and their uses,the blotting techniques, Southern,Northern and Western ,Polymerase chain reaction and its application ,RFLP, AFLP, STMS and their use in genetic mapping, DNA Sequencing methods and discovery of SNPs, Applications of Rdna technology in medicine ,environment and agriculture, potencial risks associared with r DNA technology.

Suggested Reading:

1. TA Brown. Gene cloning and DNA analysis. Blackwell Publ.
2. Old and Primrose. Principles of gene manipulation. An introduction to genetic engineering. Blackwell Scientific Publ.

Facilitating the achievement of Course Learning Outcomes

unit no.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	will know about basic principle of RDT,different restriction & modifying enzymes,library construction and screening	The students will be taught about the use of restriction enzymes and the use of linkers and adaptors in cloning. The step-wise construction of DNA libraries will be explained.	The student will be made to design a cloning strategy and detail the steps involved.
2.	Will be familiar with the use of various cloning vectors like plasmid ,cosmids and artificial chromosomal vectors.	Using whiteboard and PowerPoint slides the student will be given knowledge of the various vectors both cloning & expression	The student will be evaluated by a short class test.
3.	Will be able to describe the various methods of gene transfer in both plant and animal.	Using vedio lectures and PowerPoint slides the student will be given knowledge of the various methods of gene transfer in both plants & animals	The student will be evaluated by a short class test.
4.	Will be able to understand the gene library construction,use of reporter gene,Cre Lox system.	The student will learn about the library construction also discuss about different types of reporter gene.	Oral quiz & discussion
5.	Will be aware of DNA is sequenced and will gain insights into how entire genomes of organisms are sequence, the many uses of the molecular markers, hybridization techniques like southern ,northern and western blotting.various applications of PCR, creation of plant and animal transgenics. .	Using whiteboard and PowerPoint slides the student will be given knowledge of the various applications of polymerase chain reaction. The analysis of gene expression by real time PCR will be detailed. concepts of Shotgun sequencing methods for whole genome sequencing will be explained. The student will be initiated into the exciting and controversial area of transgenics and animal cloning with the help of examples of	Group discussion

		transgenics created and animals cloned.	

Fundamentals of Infection and Immunity

Unit 1. Principles of medical microbiology; classification of medically important microorganism, normal microflora of human body- origin of normal microflora, normal microflora and human host

Unit 2. Infection: Source of infection of man: vehicles of reservoir of infection. Exogenous infection 1. Patients 2. Carriers- healthy, convalescent, contact, paradoxical and chronic. Infected animals: zoonosis 4. Soil Endogenous infections

Mode of spread of infection:1. Respiratory 2. Skin. Wound and Burn Infections 4. Venereal Infection 5. Alimentary tract infection 6. Arthopos borne blood infections 7. Laboratory infections

Pathogenesis: Microbial pathogenicity, transmissibility, infectivity and virulence. Opportunistic pathogens, True pathogens, Toxigenicity, invasiveness

Unit 3. Immune system: organs and cells involved in the immune system and immune response. Natural or innate immune response. MHC I, MHC II, lymphocytes- properties and functions, Helper T cells, Antigen types, specify and haptens. Non specific immunity. Surface and physical barriers, Complement system, Lysozymes, interferons, Leukins, Phagocytins

Unit 4. The Immune response: active- passive, humoral- cellular, immune memory, antibody structure and production, antigen recognition, autoimmunity, cell mediated immunity, immunity- suppression, vaccines

References:

11. Cruse J and R. Lewis (2004) Atlas of Immunology 2nd Edn. CRC Press.
12. David Male, Jonathan Brostoff, David B Roth, Ivan Roitt.(2006).Immunology 7th edition.
13. Goldsdby R.A. Kindt T.S. and B.A. Osborne Kuby (2000) Immunology Fourth Edition W.H. Freeman & Co New York.
14. Reed R; Holmes D; Weyers J and A Jones (1998) Practical skills in Biomolecular SciencesAdison Wesley Longman Ltd.
15. Tizard; I.R. (1995) Immunology an Introduction 4th Edn. Saunders College Publishing.Harcourt Brace College Publishers.

MIC 403A: FOOD MICROBIOLOGY (ELECTIVE)

Course Objectives:

The course will enable students to understand the phenotypic and biochemical identification of food associated molds, yeasts, yeast-like fungi and bacteria. The course will teach the strategies to develop fermented and non-fermented milk products. The role of microbes in food spoilage, preservation and various food borne diseases will be discussed.

Course Learning Outcomes:

1: Knows traditional food preservation techniques including drying, salting, pickling, refrigeration, freezing, oxidation, vacuum packaging, canning/bottling, smoking, sugaring, chemical preservation and irradiation.

2: Gains knowledge about factors influencing microbial growth in food: extrinsic and intrinsic factors

3: Gathers information regarding microbes causing food intoxications and food-borne infections. Gains knowledge about conventional methods for food quality analysis and is able to use the most recent techniques of quantification and detection of food borne microbes and pathogens.

4: Gains knowledge about microbiology of milk and production and evaluation of the quality of starter cultures and fermented milk products such as yogurt cheese etc.

5: Knows about production of microbial biomass such as edible yeasts, mushrooms, single cell proteins.

Contents:

Unit 1: Microorganisms important in food microbiology: molds, yeasts, bacteria – General characteristics classification and importance. Principles of food preservation- Asepsis, Preservation by use of high temperature, drying and dessication, chemical preservatives and additives, preservation by radiation.

Unit 2: Factors influencing microbial growth in food: extrinsic and intrinsic factors, Microbial spoilage of food. Chemical changes caused by microorganisms during spoilage. Spoilage of fish, meat, poultry, eggs, fruits and vegetables and canned foods.

Unit 3: Classification of food borne diseases. Food borne infections- *Brucella, Bacillus,Clostridium perfringens, Escherichia, Salmonella, Shigella, Vibrio* and *Yersinia*. Food adulteration and prevailing food standards in India.

Unit 4: Microbiology of milk: Sources of microorganisms in milk and types of microorganisms in milk. Microbial contamination of milk (SPC, direct microscopic count, reductase and phosphatase test) Dehydration and Pasteurization of milk. Dairy products from microorganisms: butter, yoghurt and cheese.

Unit 5: Microorganisms as source of food: Single cell protein, Mushrooms and food value of mushrooms, Food conversions, Microbiological estimation of food: Samplecollection , preparation and analysis techniques.

Suggested readings:

1. Food Microbiology by W.C. Frazier, D.C. Westhoff , K.N. Vanitha. 5th edition. McGraw Hill Education. 2013.

2. Modern Food Microbiology by J.M. Jay, M.J. Loessner, D.A. Golden. 7th edition. Springer. 2006.

3. Fundamental Food Microbiology by B. Rayand A. Bhunia. 5th edition. CRC press. 2013.

4. Food Microbiology by M. R. Adams, M. O. Moss, P. McClure. 4th edition. Royal Society of Chemistry. 2015.

5. Food Microbiology: Fundamentals and Frontiers by M. P. Doyle, L. R. Beuchat. 3rd edition. ASM press. 2007.

6. Food Microbiology: An Introduction by T. Montville, K. Matthews, K.Kniel. 4th edition.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1	Knows traditional food preservation techniques including drying, salting, pickling, refrigeration, freezing, oxidation, vacuum packaging, canning/bottling, smoking, sugaring, chemical preservation and irradiation.	Detailed discussion on the use of classical methods of food preservation including drying, salting, pickling, refrigeration, freezing, oxidation, vacuum packaging, canning, bottling, smoking, sugaring, chemical preservation and irradiation.	Quiz on conventional food preservation method to be employed for specific food groups.
2	Gains knowledge about factors influencing microbial growth in food: extrinsic and intrinsic factors	Provide knowledge about intrinsic and extrinsic factors in detail.	Group discussion
3	Gathers information regarding microbes causing food intoxications and food-borne infections. Gains knowledge about conventional methods for food quality analysis and is able to use the most recent techniques of quantification and detection of food borne microbes and pathogens.	Provide knowledge about the microbes involved in food intoxications including Staphylococcus aureus, Clostridium botulinum and fungi producing mycotoxins. Familiarization of students with common food infections. Discussion about conventional methods for food quality analysis- culture dependent methods, colony count, immunological assays and PCR-based methods. Interactive lecture on recent advances in quantification	Short answer type test based on symptomatic identification of food intoxication/ food borne infection. Short student presentation on a new detection or quantification technique of food borne microbes and pathogens.

		and detection of food borne microbes.	
4	Gains knowledge about microbiology of milk and milk products	Making students aware of useful and pathogenic microorganisms of milk.	Group discussion
5	The student knows about production and evaluation of the quality of starter cultures and fermented milk products and oriental foods.	Use of videos and pictorial aids for familiarization of students with theproduction of starter cultures andfermented milk products and oriental foods.	Match the following type 5-minute test
6	Understands the relevance of microbial standards for food safety, quality assurance programs that revolutionize food safety and understands the use and production of probiotics, prebiotics.	Making students aware of the relevance of microbial standards for food safety. Discussion on probiotics, prebiotics.	Match the following type 5-minute test

MIC 403. BIOINFORMATICS (ELECTIVE 2)

Unit 1. Importance of Bioinformatics in genomics era, tools of Bioinformatics- database, analysis software.

Unit 2. The genome projects and impact of genomics, automated sequencing machines. The gene sequence databases- NCBI, GenBank, Sequence analysis software- pairwise and multiple sequence alignments, homology analysis

Unit 3. Structure and function prediction, *in silico* cloning, protein model and structural motif prediction

Unit4. The analysis softwares and programs LASERGENE, BLAST, Primer design- Primer 3, Prime Select, Mapping tools: Mapmaker and Map manager

MIC 403C. MICROBIAL GENOMICS AND PROTEOMICS (ELECTIVE 3)

Unit 1. The genomics era- functional and structural genomics, current status of microbial genomics project. Impact in agriculture, environment and medicine

Unit 2. The strategies- whole genome sequencing, shotgun and clone by clone approach, sequencing methods, large insert cloning vector, gene libraries

Unit 3. Sequence analysis, Swissprot and other protein analysis tools, BLAST and DNA analysis tools, microarray and design of chips.

Unit 4. The databases like EMBL gene bank, NCBI etc. Use of internet and networking, submission of data to gene banks, patents and copyrights.