CENTRE OF RESEARCH FOR DEVELOPMENT
P. G. CENTRE OF MICROBIOLOGY
UNIVERSITY OF KASHMIR
SRINAGAR-190006 J & K, INDIA

M.Sc. MICROBIOLOGY
CHOICE BASED CREDIT SYSTEM
COURSE STRUCTURE TO BE IMPLEMENTED
FROM ACADEMIC SESSION 2020-2021 ONWARDS

LEARNING OUTCOME

Microbiology is a fundamental and practical science. Microorganism are the first inhabitant of the planet and in fact have over the years made this planet habitable for other life forms. Research on microorganisms in the lab has contributed to the basic science of biology by illuminating some of the underlying mechanisms and processes. The purpose of this course curriculum is to provide high-quality instruction and training in both the fundamental and practical areas of microbiology. The applicability of the subject is countless and can be sketched by considering only a few points, viz., the human body contains 10 times more microbes than the number of cells.

This course content is designed in such a way so that students will acquire knowledge about different fields of microbiology as well as develop interest in exploring tremendous potential of microorganisms and hence the human resource created will be utilized for the welfare of humankind.

- **Fundamentals of Microbiology** - The students will understand the concepts of basic microbiology and will be able to perform various biochemical calculation, sterilization techniques and purification of microbial cultures.
- **Food & Dairy Microbiology** – Students will know the causes of food spoilage and mechanism of food preservation. They will learn about diseases caused by different types of microorganisms, fermented foods and different types of quality measurements along will entrepreneur skills.
- **Pharmaceutical Microbiology** – Students will get knowledge about different pharmaceutical products and their microbiological analysis. They will acquire knowledge of international standards used in pharmaceuticals.
- **Bacteriology, Mycology, Phycology, Virology -** Students will gain in-depth knowledge of characteristics and functions of bacteria, fungi, algae and viruses. Student will acquire knowledge about the applications and economic importance of theses microbial groups.
- **Environment & Agricultural Microbiology** - The economic backbone of India, “agriculture”, depends on both beneficial and pathogenic microbes. Students will get knowledge about microbial ecology and their utility in environment. They will acquire knowledge about the significance of microbial world in agriculture. They will get familiarized with application of microbes in waste management and remediation of environmental pollutants.
- **Immunology** – Students will be acquainted with the emergence of immunology and how the immune system protects us from infection through various lines of defense.
- **Medical Microbiology** - Students will be familiarized with the important bacterial, fungal, parasitic and viral human diseases and their pathogens. Students will acquire knowledge about different diseases their diagnostic methods and treatments.

- **Molecular Biology and Recombinant DNA Technology -** Students will get knowledge about eukaryotic and prokaryotic genome organization, mutations. They will acquire knowledge about the recombinant DNA technology and its significance
- **Fermentation and Industrial Microbiology** - Students will learn about the different types of fermentation processes, equipment's used and microbiological processes involved. Students will have gained in-depth knowledge of the principles of microbial production and recovery of industrial products at large scale.

A career in microbiology in India is a promising career choice and the job opportunities it provides are vast. Since India is a country with a large population, public health, cleanliness, study of food and waterborne disease and sanitation are of top priority. Microbiology is not confined to one area but it addresses all the corners of life especially its applications in different industries. Indeed, choosing a career in microbiology can be highly rewarding as it makes a difference to society, nation and the world around us. A microbiologist learns and explores the unseen world of microbes everyday much like an adventure and find answers to life's big questions. Perhaps, the only thing that is more contagious than a virus is hope and working in the field of Microbiology can bring that hope to the world. Pursuing Microbiology is truly an experience of a lifetime and it matters now more than ever.

INTRODUCTION AND BASIC STRUCTURE OF THE COURSE

Microbiology- the study of microorganisms, as a subject of study has immense importance as microorganism are the first inhabitant of the planet and in fact have over the years made this planet habitable for other life forms. Microorganisms are associated with our day to day life and affect us directly or indirectly in a number of ways. Microbiology as a subject has immense applications in the fields of public health, agriculture, environment, food and dairy industry as well as in biotechnology. This course content is designed in such a way as to impart quality education and training in both the basic and applied aspects of microbiology. Therefore, we intended to produce highly trained professionals who besides serving various public and private organizations in the area of public health, environment, agriculture, food and dairy industry and biotechnology will also become entrepreneurs, who can exploit the services of microorganisms for the benefit of mankind besides creating self-employability opportunities.

The revised syllabi and courses of study for Post-graduate programme in Microbiology will be based on 96 credits (average of 24 in each semester). All the 96 credits will spread over 5 different components *viz.* - (i) teaching, (ii) tutorial, (iii) seminar, (iv) three laboratory courses (one each in the first, second and third semester), and (v) project work /Internship in fourth semester. Each semester will consist of at least 24 credits including at least 12 core credits (compulsory), 12 discipline centric elective (maximum of 8 credits to be opted) and 2 generic and 2 open elective credits for the students of other departments of the university.

Course Structure: There will be 14 core courses (theory and laboratory) in all with each semester covering at least 2 core courses referred to as **MIC-CR**. Each core course will be worth 4 credits with theory covering at least 8 credits and practical component 4 credits. There will be Discipline Centric Elective (DCE) courses (mainly for Department's own students) worth 4 credits referred to as **MIC-DCE**. Students can opt for 2 courses to earn 8 credits or at least one course each to earn minimum of 4 credits. Further, in addition to **CR** and **DCE** courses there will be Generic Elective courses referred to as **MIC-GE** which will be open to the students of Biological sciences and Open Elective courses referred to as **MIC-OE** that will be open to students from all other faculties (Science, Social Science, Arts, Commerce etc) so that they may seek knowledge from unrelated subject which will nurture student's proficiency and /skill. The total course of M. Sc. Microbiology will comprises of **96 credits out of which 56 are core while other credit combinations would be as under**.

Credits	Core	DCE	GE	OE	Total
Minimum Credits	12	8	2-4	0-2	24
Average Credits	14	8	2	2	24

Each **CR** course will be worth of 100 marks and 4 credits comprising of **internal examination of 20 marks** and **external examination of 80 marks**. Internal assessment of theory papers will be based on quiz tests/assignments/seminars, etc. The practical component will also be of **internal examination** comprising 20 marks based on student's performance during practical periods and **external examination** of 80 marks through conduct of common test at the end of each semester to finalize awards for the same. The students will be required to submit their lab work records at the end of each semester examination for evaluation by the examiner/teacher(s) concerned.

MIC**-DCE** course is a choice based credit course where a student has to acquire 8 credits in total out of 10 DCE credits courses. One paper among **DCE course** will be worth of **4 credits carrying 100 marks** andcomprising of **continuous internal examination of 20 marks** and **external examination of 80 marks**. Two courses will be worth of 2 credits each carrying 50 marks,

Industrial/ Educational Tours: To make an on-field observation and impart on-site training in the subject, the students are required to go for tour organized during **2nd semester** (outside UT) carrying **2 credits** will form a component of **DCE**.

Each **GE and OE course** will be worth of **50 marks (2 credits).** MIC**-DCE, MIC-GE and MIC-OE** will be floated as semester courses wherein the selection will be based on the choice of the teacher concerned in terms of feasibility/availability as well as the number of vacancies available based on the choice of the concerned teacher. However, on the basis of the recommendations of Departmental Committee minimum number of seats under these courses should not be less than 4 for

DCE, GE and OE respectively in any such course.

P. G. 2020-onward batch shall be elegible to opt courses from **SWAYAM online platform** as per the schedule. The learners shall opt for relevant P. G. level credited courses from SWAYAM Platform by five National Coordinators, **i.e. UGC, AICTE, NPTEL, CEC** and **NITTTR.** The requirement of 08 credits to be obtained under OE/GE category can now be obtained from the SWAYAM Platform. These online courses only serve as an alternative corridor of courses for students and shall **not be mandatory**.

Project work/ Internship: Project work worth **22 credits** is compulsory for the students and will be assigned in **4th semester** based on choice of the student and space availability in relation to his/her choice. The students for project work will be evenly distributed among faculty members of the Department. The main emphasis will be on developing independent creative thinking and execution of scientific experiments, presentation and scientific writing.

The candidate has to submit dissertation in a bound form at the end of 4th semester. The final evaluation of the project work will be through a **Panel involving internal and external examiners**. Each student has to deliver the entire dissertation work through power point presentation in front of a panel of examiners.

In the Table below the terms refer to:

L - Lecture
T - Tutorial
P - Practical Work
CR - Core Course
DCE - Discipline Centric Elective
GE - Generic Elective
OE - Open Elective
MOOCs - Massive Open Online Courses

General course outline for 1st year program for two semesters
1st Semester

Course	Course Code	Course Name	Paper Category	Hours/Week			Credits
				L	T	P	
Core	MIC-20101CR	Fundamentals of Microbiology	Core	4	2		4
	MIC-20102CR	Bacteriology & Virology	Core	4	2		4
	MIC-20103CR	Laboratory Course	Core			8	4
DCE	MIC-20104DCE	Biotechniques	DCE	4	2		4
GE	MIC-20001 GE	*In vitro* Plant Morphogenesis & Regeneration	GE	2			2
	MIC-20002 GE	Toxicogenomics	GE	2			2

Note: Students can opt **SWAYM/ MOOCS for GE/OE Course** anytime within 02 years, whenever available online.

2nd Semester

Course	Course Code	Course Name	Paper Category	Hours/Week			Credits
				L	T	P	
Core	MIC-20201CR	Cell Biology & Enzymology	Core	4	2		4
	MIC-20202CR	Microbial Physiology & Metabolism	Core	4	2		4
	MIC-20203CR	Medical Microbiology	Core	4	2		4
	MIC-20204CR	Laboratory Course	Core			8	4
DCE	MIC-20205DCE	Molecular Biology and Microbial Genetics	DCE	4	2		4
	MIC-20206DCE	Environmental Microbiology	DCE				4
	MIC-20207DCE	Industrial Tour	DCE			2	2
GE	MIC-20003 GE	Analytical Instrumentation	GE	2			2
	MIC-20004 GE	Medical Virology	GE	2			2

Note: Students can opt **SWAYM/ MOOCS for GE/OE Course** anytime within 02 years, whenever available online.

General course outline for 2nd year program for two semesters

3rd Semester

Course	Course Code	Course Name	Paper Category	Hours/Week			Credits
				L	T	P	
Core	MIC-20301CR	Genetic Engineering & Genomics	Core	4	2		4
	MIC-20302CR	Immunology	Core	4	2		4
	MIC-20303CR	Industrial Microbiology	Core	2			2
	MIC-20304CR	Laboratory Course	Core			8	4
DCE	MIC-20305DCE	Biostatistics and Bioinformatics	DCE	4			4
	MIC-20306DCE	Food Microbiology	DCE	4	2		4
	MIC-20307DCE	Agricultural Microbiology	DCE	4	2		4
GE	MIC-20005 GE	Applied Food Microbiology	GE	2			2
	MIC-20006 GE	Clinical Microbiology	GE	2			2

Note: Students can opt **SWAYM/ MOOCS for GE/OE Course** anytime within 02 years, whenever available online. GE and OE of the 4th semester be opted in 3rd semester itself.

4th Semester

Course	Course Code	Course Name	Paper Category	Hours/Week			Credits
				L	T	P	
Core	MIC-20401CR	Research based project work, dissertation writing and submission in hard bound form	Core			12	12
	MIC-20402CR	Presentation and Viva-voce	Core				4
DCE	MIC-20403DCE	Special Paper*	DCE		4		4
	MIC-20404DCE	Designing and drafting a research proposal /Journal Club/Scientific paper writing	DCE				2
GE	MIC-20007 GE	Fermentation Technology	GE	2			2
GE	MIC-20008 GE	Applied Agricultural Microbiology	GE	2			2

***To be opted based on the area of dissertation**

Note: GE and OE of the 4th semester be opted in 3rd semester itself

Course Description 1st Semester

Core Courses

MIC-20101CR: FUNDAMENTALS OF MICROBIOLOGY (Credits 4)

Objectives: *This course has been designed to familiarize students with the basics of microbiology. The course will deal with the historical developments in microbiology, the biology of microorganism in relation to higher organisms, cultivation and control, and taxonomy of microorganisms. The course will lay a strong foundation for progressive advancement of knowledge for the students.*

Credit I

1.1 Historical perspective of microbiology with reference to Leeuwenhoeck, Robert Koch, Louis Pasteur, Edward Jenner, Joshep Lister and Alexander Flemming
1.2 Spontaneous and non-spontaneous generation, fields of microbiology
1.3 Microscopy, microbiology instrumentation and handling.
1.4 Staining methods: simple, differential, structural and special staining
1.5 Sterilization and methods of sterilization, biosafety and various biosafety levels in a microbiology laboratory

Credit II

2.1 Ultrastructure of prokaryotic cells: Bacteria; cell wall and cell membrane structure (L forms, spheroplast), mesosomes, flagella and motility, cytoplasm inclusions, pilli, fimbrae, capsule and slime layer
2.2 Endospore structure and sporulation process in bacteria
2.3 Differences between prokaryotic and eukaryotic cell
2.4 Ultrastructure and composition of fungi, algae and protozoa
2.5 Structure and composition of virus, viroids and prions

Credit III

3.1 Culture media: classification of media (simple, complex and special media with examples), specific media for the cultivation of bacteria, fungi, algae and protozoa
3.2 Culture techniques (pour plate, spread plate, streaking and swab culture), preservation and maintenance of microbial cultures
3.3 Growth: nutritional requirements, growth kinetics, generation time, growth curve, factors affecting growth.
3.4 Anaerobic culture, batch/continuous culture and their applications
3.5 Biofilm, Quorum sensing, composition, occurrence and its importance

Credit IV

4.1 Microbial taxonomy, nomenclature and classification of microorganisms, Haeckel's three kingdom classification, Whittaker's five kingdom approach
4.2 Woese domain system (Eukarya, Archae, Eubacteria)
4.3 Genetic and molecular taxonomy and its application in microbial diversity
4.4 General characteristics and classification of fungi.
4.5 General characteristics andclassification ofalgae and protozoa.

Learning outcome

- Students will gain in depth knowledge about historical developments in microbiology, basic techniques like preparation of media, sterilization, staining, and microscopy.
- Students will gain basic knowledge about different groups of microorganisms.
- Students will understand the taxonomy of microbial world.

Recommended Books

1. Prescott's Microbiology by Joanne Willey, Linda Sherwood and Christopher J. Woolverton, McGraw Hill Publisher Companies, Inc.
2. Microbiology by Michael J. Pelczaret. al., McGraw Hill Publisher Companies, Inc.
3. Brock Biology of Microorganisms by Madigan and Martinko, Pearson Education International.
4. General Microbiology by Roger Y Stanier, ML Wheelis and PR Painter, MacMillan Press Ltd.
5. Ananthanarayan&Paniker's text book of Microbiology by Reba Kanungo, Universities Press.

MIC-20102CR: BACTERIOLOGY AND VIROLOGY (Credits 4)

Objectives: *This course deals with the detailed classification of bacteria and viruses. Characteristic features of all important classes of bacteria and viruses with respect to their structure, function, replication and economic importance are useful to understand the microbial systematics.*

Credit I

1.1 Historical account of bacterial classification
1.2 Characteristics, classification and economic importance of Gram negative facultative anaerobic rods (Enterobacteriaceae and Vibrionaceae)
1.3 Characteristics, classification and economic importance of Gram negative aerobic rods and cocci (Pseudomonadaceae, Rhizobiaceae, Neisseriaceae)
1.4 Characteristics, classification and economic importance of Gram positive aerobic rods and cocci (Corynebacteriaceae, Mycobacteriaceae, Listeriaceae, Streptococcaceae, Staphylococcaceae)
1.5 Characteristics, classification and economic importance ofendospore forming Gram positive rods (Bacillaceae and Clostridiaceae)

Credit II

2.1 General characters, classification and economic importance of Cyanobacteria
2.2 General characters classification and economic importance of Mycoplasma
2.3 General characters, classification and economic importance of Rickettsiae
2.4 General characteristics, classification and economic importance of spirochaetes and actinomycetes
2.5 Domain Archea, morphology, genetics, ecology, economic importance and sub-types of archeabacteria

Credit III

3.1 Discovery, composition and structural features ofviruses
3.2 Lifecycle of viruses (lytic and lysogeniccycle)
3.3 General features and replication of T4, TMV, Influenza and HIVviruses
3.4 Taxonomy of viruses: classification and nomenclature as perICTV
3.5 Brief account on bacteriophages, mycophages, phycophages, cyanophages, protozoan viruses

Credit IV

4.1 Isolation and cultivation of plant, animal and bacterialviruses
4.2 Sub viral particles: Satellite viruses, viriods, DI particles andprions
4.3 Oncogenic virus (DNA and RNAviruses)
4.4 Introduction to virotherapy and its types (interferons & viralvaccines)
4.5 Antiviral agents and futureperspective

Learning outcome

- Students will understand history and composition of bacteria and viruses.
- Characteristic features of all important classes of bacteria and viruses with respect to their structure, function, replication and economic importance.

Recommended Books

1. Brock Biology of Microorganisms by Madigan and Martinko, Pearson Education International.
2. Prescott's Microbiology by Joanne Willey, Linda Sherwood and Christopher J. Woolverton, McGraw Hill Publisher Companies,Inc.
3. Ananthanarayan&Paniker's text book of Microbiology by Reba Kanungo, Universities Press.
4. Bergey's Manual of SystematicBacteriology.
5. Jawetz, Melnick&Adelbergs Medical Microbiology by Brooks et al., McGraw-Hill Medical.

MIC-20103CR: LABORATORY COURSE (Credits 4)

Objectives: *This course is framed to acquaint students with the practical aspects of basic microbiology. It shall enables students to learn lab practices and calculation needed for preparation of various reagents and buffers. The students shall learn the sterilization methods, isolation, enumeration of bacteria and fungi from environmental samples.*

1. Preparation of buffers and pH measurements
2. Understandings of biochemical calculations
3. To perform sterilization techniques
4. To study types of culture media and their preparations, colony characters of bacteria
5. Culture techniques
6. Isolation of bacteria from water samples
7. To study the growth curve of bacteria with reference to *E. coli*
8. To enumerate the CFU of bacteria (any) by serial dilution method
9. Staining techniques – simple, Gram, acid-fast, endospore staining
10. Confirmed test of coliform bacteria
11. To perform the motility test of bacteria
12. To perform antibiotic sensitivity and resistance assay
13. Screening of amylase and protease producers
14. Screening of lipase producers

Learning outcome

- The students will understand the practical aspects of basic microbiology.
- It shall enable students to learn lab practices and calculation needed for preparation of various reagents and buffers, sterilization methods, isolation, and enumeration of microorganisms.

Recommended Books

1. Microbiology: A Laboratory Manual by James G. Cappuccino and Natalie Sherman, Pearson Benjamin Cummings Publishers.
2. Practical Microbiology by D K Maheshwari & R C Dubey, S Chand & Company Publishers.
3. Alcamo's Laboratory Fundamentals of Microbiology by Pommerville J.C., Jones and Bartlett Publishers, Inc.

Discipline Centric Electives

MIC-20104DCE: BIOTECHNIQUES (Credits 4)

Objectives: *This aim of this course is to acquaint students with various techniques and instruments required to study and engineer microorganisms. Knowledge of techniques like centrifugation, chromatography, electrophoresis, blotting and crystallography shall help students understand the concepts of downstream processing and recombinant DNA technology in subsequent semesters.*

Credit I

1.1 Centrifugation techniques: basic principles of centrifugation and derivation of relation for coefficient and measurement of sedimentation co-efficient

1.2 Rotors and types of rotors

1.3 Differential and density gradient centrifugation

1.4 Analytical centrifugation and its applications

1.5 Viscosity and its measurement

Credit II

2.1 Basic principles of chromatography and its types

2.2 Ion exchange chromatography

2.3 Gel filtration chromatography

2.4 Affinity chromatography

2.5 GC-MS, HPLC

Credit III

3.1 Electrophoresis: basic principles and types

3.2 Polyacrylamide gel electrophoresis and agarose gel electrophoresis, SDS- PAGE

3.3 Two dimensional electrophoresis, immune electrophoresis & isoelectric focusing

3.4 Capillary electrophoresis, pulse-field electrophoresis

3.5 Blotting techniques -Southern, northern and western blotting

Credit IV

4.1 Radio isotopic techniques: principle and applications of tracer techniques in biology

4.2 Radioactive isotopes, radioactive decay; detection and measurement of radioactivity

4.3 Spectroscopic techniques- principle and working of theory of absorption of light by molecule

4.4 UV- visible spectrophotometer-principle and working

4.5 Fluorescence spectroscopic, MALDI-TOF**,** NMR and X ray crystallography

Learning outcome

- Students will understand the various techniques and instruments required to study and engineer microorganisms.
- The students will be familiarized with the techniques like centrifugation, chromatography, electrophoresis, GC-MS, HPLC , Blotting techniques, Radio isotopic techniques, spectroscopic techniques, NMR, MALDI-TOF and so on

Recommended Books

1. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker, Cambridge University Press.
2. Biochemistry Laboratory: Modern Theory and Techniques by Rodney F. Boyer, Pearson Prentice Hall.
3. Biophysical Chemistry Principles and Techniques by Upadhyay et al., Himalaya Publishing House.
4. Analytical Biochemistry by Ganai et al., Valley Publications.

Generic Electives

MIC-20001GE: *INVITRO* PLANT MORPHOGENESIS AND REGENERATION (Credits 2)

Objectives: *This course is designed to provide basic information on various methods of plant tissue culture and mass multiplication of plants in vitro.*

Credit I

1.1. Morphogenesis and cellular totipotency

1.2. Callus cultures: establishment of callus, callus growth and subculture

1.3. Cytodifferentiation: dedifferentiation and redifferentiation

1.4. Organogenesis: caulogenesis, rhizogenesis

1.5. Factors affecting cellular differentiation and organogenesis

Credit II

2.1 Somatic embryogenesis: initiation, basic requirements, embryo maturation and plantlet development

2.2 Micropropagation: definition, stages and techniques of micropropagation

2.3 Problems encountered in micropropagation

2.4 Applications of micropropagation

2.5 Synthetic seeds

Learning outcome

- Students will understand the basic information on various methods of plant tissue culture and mass multiplication of plants in vitro.

Recommended Books

1. An introduction to plant Tissue Culture by M.K. Razdan, Oxford & IBH publishing.
2. Plant cell tissue & organ culture- Fundamental methods by O. L. Gamborg, & G. C. Philips, Springer publications.
3. Plant Tissue Culture: An Introductory Text by Sant Saran Bhojwani and Prem Kumar Dantu, Springer Science & Business Media.
4. Biotechnology: Expanding Horizons by B.D. Singh, Kalyani Publishers.

MIC-20002GE: **TOXICOGENOMICS (Credits 2)**

Objectives: *This course has been developed to impart knowledge on environmental mutagens and mutagenesis. The basic and advanced methods used to evaluate the mutagenic potential of various pollutants and mutagens shall be taught.*

Credit I

1.1 . Ames test and micronucleus test

1.2 . Chromatid and chromosomal aberration

1.3 . FISH technique

1.4 . Use of Comet assay in environmental toxicology

1.5 . Screening, tier testing and test batteries for mutagenicity testing

Credit II

2.1 . Classification of carcinogens (physical, chemical and biological agent)

2.2 . Mechanism of chemical carcinogens (free radicals and alkylating agents)

2.3 . Somatic and genetic risk of environmental pollutants

2.4 . Necrosis, apoptosis and inflammation

2.5 . Cancer latency, threshold and non-threshold model of cancer

Learning outcome

- The students will understand environmental mutagens and mutagenesis.
- The students will understand the basic and advanced methods used to evaluate the mutagenic potential of various pollutants and mutagens.

Recommended Books

1. Genotoxicity and DNA Repair A Practical Approach by Sierra, L. María, Gaivão, Isabel (Eds.) Springer publications.
2. Genotoxicity Assessment Methods and Protocols by Dhawan, Alok, Bajpayee, Mahima (Eds.) Springer publications.
3. Genotoxicity: damage to DNA and its consequences by David H. PhillipsVolker M. Arlt Springer publications.

Course Description 2nd Semester
Core Course

MIC-20201CR: CELL BIOLOGY AND ENZYMOLOGY (Credits 4)

Objectives: *This course has been designed to help students understand the cellular organization of eukaryotes in comparison to prokaryotes including the membrane dynamics, cellular differentiation and communication, and cell cycle. Further the study of properties, classification and kinetics of enzymes shall help in understanding the pathways which are actually governed by enzymes.*

Credit I

1.1 Ultrastructure and organization of unicellular eukaryotic cell

1.2 Nucleus, mitochondria and chloroplasts and their genetic organization

1.3 Endoplasmic reticulum, golgi apparatus, protein trafficking

1.4 Flagella and mechanism of flagellar movements

1.5 Cell structural organization cytoskeleton (microtubules and microfilaments)

Credit II

2.1 Membrane structure and dynamics-diversity, structure and physiology of membrane pumps, carriers and channels

2.2 Signal transduction and its mechanism

2.3 Cell cycle -overview, phases of the cell cycle, cell growth and extracellular signals

2.4 Regulations of cell cycle progression (cyclins and cyclin dependent kinases), cell cycle- check points

2.5 Cell differentiation, apoptotic pathways and molecular mechanism of apoptosis

Credit III

3.1 Introduction to enzymology and characteristics of enzymes

3.2 Classification and nomenclature of enzymes (IUB nomenclature), concept of ribozymes and abzymes

3.3 Mechanism of enzyme action, theories of mechanism of enzyme action

3.4 Constitutive, inducible and marker enzymes

3.5 Enzyme activators, co-enzyme, prosthetic group and co-factors in enzymatic catalysis, concept of enzyme and substrate specificity, enzyme assay and its units

Credit IV

4.1 Enzyme kinetics, Michaelis-Menton equation and its derivation

4.2 Determination of V_{max}, K_m, K_{cat} and their significance, Lineweaver-Burk plots, Eadie-Hofstee and Hanes plots

4.3 Enzyme inhibition - competitive, uncompetitive, non-competitive, and irreversible

4.4 Isozymes and their metabolic significance, allosteric enzymes and co-operativity

4.5 Large scale enzyme extraction, enzyme purification, recovery and yield of enzymes

Learning outcome:

- Eukaryotic cell structure, cell cycle, cell cycle progression, and signal transduction will be understood
- Students will acquire knowledge about enzyme classification, nomenclature, enzyme kinetics and significance of various types of enzymes

Recommended Books

1. Molecular Cell Biology by Lodish et al., W.H Freeman and Company.

2. Molecular biology of the Cell by Alberts et al., Garland publishing Inc.
3. Lehninger Principles of Biochemistry by Lehninger by David L. Nelson and Michael M Cox, W.H Freeman and company.
4. Biochemistry by Stryer WH et al., W.H Freeman and company.
5. Understanding Enzymes by Trevor Palmer, Prentice Hall Publishers.

MIC-20202CR: MICROBIAL PHYSIOLOGY AND METABOLISM (Credits 4)

Objectives: *The metabolic diversity of microorganisms prompts one to know the reasons for adaptability of microorganisms to different nutrient conditions, this course shall help students understand how microorganism use different substrates as carbon and nitrogen sources. The study of different metabolic pathways like photosynthesis, anaerobic and aerobic respiration shall help in understanding the physiology and metabolism of microorganisms.*

Credit I

1.1 Nutritional diversity in microorganisms, bioluminescence and its mechanism in microorganisms
1.2 Essentiality of major and minor elements, mechanism of nutrient transport in microorganisms (ABC transporters, phosphotransferase, drug export systems and transport of amino acids)
1.3 Chemotrophs: acetogens, methylotrophs, methanogens and their importance
1.4 Methanotrophy: characteristics of methanotrophs, dissimilation of methane by methanotrophs and carbon assimilation by methylotrophs
1.5 Sulfidogenesis: biochemistry of sulfidogenesis, reduction of sulfate and sulfur, sulphur reducing bacteria

Credit II

2.1 Autotrophic nutrition in microorganisms: oxygenic vs anoxygenic photosynthesis
2.2 Photosynthetic pigments (chlorophyll, bacteriochlorophyll, rhodopsin, phycobiliproteins), basic photochemistry of PSI, PSII and light driven electron transport
2.3 Modes of CO_2 fixation (Calvin cycle, reverse TCA cycle, HP pathway)
2.4 Carbohydrate metabolism: classification, structure and functions of carbohydrates, stereoisomerism, aldoses and ketoses
2.5 Various pathways underlying the utilization of different sugars (EMP, ED, HMP) in microorganisms, gluconeogenesis and Pasteur effect

Credit III

3.1 Aerobic respiration: TCA cycle, glyoxylate cycle
3.2 Electron transport chain, substrate level and oxidative phosphorylation
3.3 Anaerobic respirations: sulphate, nitrate, carbonate respirations and their ecological significance
3.4 Fermentations: types of fermentations (homo, heterolactic and mixed fermentations)
3.5 Oxidation- reduction reactions, measurement of redox potentials, structure of ATP synthase complex; mechanism of ATP synthesis, inhibitors and uncouplers

Credit IV

4.1 Lipids: classification, structure and biosynthesis of glycerides, phospholipids and glycolipids, β-oxidation of saturated and unsaturated fatty acids
4.2 Amino acids: classification, structure and properties of amino acids, biosynthetic pathways of amino acids and their regulation with emphasis on tryptophan, tyrosine and histidine, transamination, deamination
4.3 Proteins: classification and structural organization of proteins (primary, secondary, tertiary and quaternary)
4.4 Nucleotide metabolism: biosynthesis of purine and pyrimidine nucleotides and their degradation
4.5 Vitamins as microbial growth factors

Learning outcome:

- Various types of nutrients utilized by microbes, their mechanism of transport and utilization of sugars via pathways will be learned
- Understanding about aerobic respiration, electron transport chain, fermentation, oxidation and reduction reactions will also be acquired

Recommended Books

1. Lehninger Principles of Biochemistry by Lehninger by David L. Nelson and Michael M Cox, W.H Freeman and company.
2. Biochemistry by Stryer WH et al., W.H Freeman and company.
3. Brock Biology of Microorganisms by Madigan and Martinko, Pearson Education International.
4. Prescott's Microbiology by Joanne Willey, Linda Sherwood and Christopher J. Woolverton, McGraw Hill Publisher Companies, Inc.
5. Physiology and Biochemistry of Prokaryotes by White David, Oxford University Press.

MIC-20203CR: MEDICAL MICROBIOLOGY (Credits 4)

Objectives: *This course describes the impact of microorganism on human health, the role of normal microbiota in human health. The etiology of various bacterial, viral, fungal and protozoan diseases, their lab diagnosis and prophylactic measures shall be taught in detail.*

Credit I

1.1 Normal microbial flora of human body and its importance
1.2 Mechanism of microbial pathogenesis: entry, colonization, growth, mechanism of damage host cell, host-pathogen interactions
1.3 Bacterial virulence factors, Infection Prevention control (IPC)
1.4 Epidemiology of infectious diseases and current pandemics
1.5 Pathogenicity vs virulence; quantitative measures of virulence: minimal lethal dose (MLD), LD_{50}, ID_{50}, $TCID_{50}$. Facultative / obligate intracellular pathogens, pathogenicity islands.

Credit II

2.1 Historical perspective of medical bacteriology
2.2 General characteristics, mode of transmission, pathogenesis and diagnosis of medically important bacterial diseases like Anthrax, Tuberculosis, Leprosy, Cholera, Typhoid, Gastric Ulcer, Tetanus, Pneumonia.
2.3 Etiology, pathogenesis and lab diagnosis of Diarrhea, Meningitis, Nosocomial infections and Zoonosis
2.4 General characteristics, mode of transmission, pathogenesis and diagnosis of diseases caused by *Staphylococcus, Streptococcus,Mycoplasma*, *Chlamydiae* and *Rickettesia*
2.5 Antibacterial drugs: Classification and mode of action.Emergence of bacterial drug resistant strains

Credit III

3.1 Introduction to medical virology
3.2 General characteristics, mode of transmission, pathogenesis and diagnosis of medically important viral pathogens: Chicken Pox, Hepatitis, Herpes, Human Papilloma virus (DNA viruses),
3.3 General characteristics, mode of transmission, pathogenesis and diagnosis of medically important viral pathogens: rabies, mumps, measles, AIDS, dengue (RNA viruses)
3.4 General characteristics, mode of transmission, pathogenesis and diagnosis of emergent viral diseases: Influenza (Swine flu), SARS - COVID-19, Chikungunya, Ebola, Hanta, Marburg, Zika and Rotavirus
3.5 Human prion diseases**,**novel approaches for viral detection; CRISPR, RT-PCR, immune-sensors, antiviral drugs, classification and mode of action

Credit IV

4.1 Introduction to medical mycology. Mycoses (superficial, subcutaneous, systemic and opportunistic)
4.2 Isolation, characterization and identification of medically important fungal pathogens. Antifungal drugs, classification and mode of action
4.3 General characteristics, mode of transmission, pathogenesis and diagnosis of protozoan pathogens: *Entamoeba*, *Plasomodium*, *Leishmania*, *Giardia, Toxoplasma* and *Trypanosoma*
4.4 General characteristics, mode of transmission, pathogenesis and diagnosis of platyhelminthes; *Taenia*, S*chistosoma* and Nemathelminthes; *Ascaris*,*Wuchereria*,.Antihelminthics drugs
4.5 Introduction to clinical microbiology (specimen collection. transport, handling, storage and laboratory analysis)

Learning outcome:

- Students will gain insight of human microflora, their significance, mechanism of pathogenesis of different pathogens, their characteristics and different types of diseases caused by bacterial pathogens
- Students will be introduced to viral pathogens, their characteristics, mode of transmission and different types of diseases caused by viral pathogens and how they are being controlled

Recommended Books

1. Ananthanarayan&Paniker's text book of Microbiology by Reba Kanungo, Universities Press.
2. Jawetz, Melnick&Adelbergs Medical Microbiology by Brooks et al., McGraw-Hill Medical.
3. Prescott's Microbiology by Joanne Willey, Linda Sherwood and Christopher J. Woolverton, McGraw Hill Publisher Companies, Inc.
4. Parasitology (Protozoology and Helminthology) by K.D.Chatterjee, CBS Publishers & Distributors.
5. Medical Parasitology by D. R. Arora and B. Arora, CBS Publishers & Distributors.

MIC-20204CR: LABORATORY COURSE (Credits 4)

Objectives: *This course is framed to acquaint students with the estimation and quantification of biological macromolecules like DNA, RNA, proteins and enzymes. Also the hands on experience on biochemical methods for identification and characterization of bacteria shall be carried out.*

1. Cell cycle: cell division of fungi and bacteria (with the help of slides/models/charts)
2. Differential isolation of chloroplast and mitochondria by differential centrifugation method
3. Estimation of carbohydrates
4. Estimation of lipids
5. Estimation of DNA
6. Estimation of RNA
7. Estimation of protein by Lowry's, and Bradford methods
8. Study of pH stress tolerance by microbes
9. Study of enzyme kinetics
10. Cultivation and enumeration of bacteriophages
11. To perform biochemical tests (Catalase, Urease test, Peroxidase)
12. IMVIC
13. Exploration of microbiota from soil sediments.

Learning outcome:

- Will have gained an in-depth knowledge of experiments such as types of cell cycles in bacteria and fungus, isolation of chloroplast and mitochondria by centrifugation
- Students can assay DNA, RNA, carbohydrates, lipids, proteins using standard methods. They can also know how to isolate microbes from various sources and their biochemical characterization

Recommended Books

1. Microbiology: A Laboratory Manual by James G. Cappuccino and Natalie Sherman, Pearson Benjamin Cummings Publishers

1. Practical Microbiology by D K Maheshwari & R C Dubey, S Chand & Company Publishers
2. Alcamo's Laboratory Fundamentals of Microbiology by Pommerville J.C., Jones and Bartlett Publishers, Inc.
3. Experimental Biochemistry by Ganai et al., Kumar Publications, Delhi

Discipline Centric Electives

MIC-20205DCE: MOLECULAR BIOLOGY AND MICROBIAL GENETICS (Credits 4)

Objectives: *This course is introduced with the aim of teaching the students the basics of genome organization, it will also explore and compare the central dogma i-e replication, transcription and translation in prokaryotes and eukaryotes. Further, the concept of horizontal gene transfer important for the genome evolution and the concept of operons in prokaryotes shall help students understand the basics of microbial genetics.*

Credit I

1.1 Historical perspective of DNA, structure and its forms
1.2 Genome organization in prokaryotes and eukaryotes, DNA supercoiling (Linking number, writhes and twists), gene concept and structure of gene
1.3 Prokaryotic and eukaryotic DNA replication
1.4 Experimental evidence for DNA replication in prokaryotes and eukaryotes, reverse transcription
1.5 DNA damage and repair mechanisms

Credit II

2.1 RNA and its types, concept of micro RNA, snRNAs, siRNA, scRNA, snoRNA, hnRNA, lncRNAand their functions. Structure of tRNA
2.2 Transcription: mechanism of transcription in prokaryotes and eukaryotes
2.3 Post-transcriptional modifications and regulation of transcription in eukaryotes
2.4 Genetic code, protein biosynthesis and its mechanism
2.5 Post translational modifications

Credit III

3.1 Gene families: split genes, pseudogenes, non-coding genes, overlapping genes and multi-gene families
3.2 Regulation of gene expression in prokaryotes-operon concept, regulatory elements of operon-inducers, apo-repressors and co–repressors. Positive and negative regulations
3.3 Catabolite repression. Detailed account of structure, function and regulation of *lac* operon, *trp*operon and lambdaoperon
3.4 Mutations: types of mutagens (physical, chemical), types of mutations site directed mutagenesis
3.5 Mutation screening in microorganisms: evaluation of mutagens using microbial systems- Ames test, detection of mutations

Credit IV

4.1 Gene transfer in bacteria: transformation, transduction, conjugation and sexduction
4.2 Molecular basis of recombination- models of homologus recombination, the Holliday model, double strand break repair model, site specific recombination
4.3 Gene mapping in prokaryotes: deletion mapping, complementation, DNA foot printing, chromosome walking and jumping
4.4 A general account of plasmids: Characteristics, functions, genes of plasmids, F plasmids, R-plasmids, Colicinogenic plasmids, Ti-plasmid, broad host range plasmids

4.5 Transposable elements: IS elements, bacterial transposons, mechanism and types of transposition. Genetic phenomena mediated by transposons, transposons as genetic tools.

Learning outcome:

- Genome organization, replication of DNA, DNA damage and their repair mechanism will be understood. Students will also learn about types of RNA and mechanism of transcription and translation
- Will gain an in-depth knowledge of types of gene families, regulation of gene expression, types of mutagens and different tests of mutagenicity. They will also how know gene is being transferred from one bacteria to another and also the general account of plasmids

Recommended Books

1. Molecular Biology of the Gene by Watson et. al., Benjamin Cummings.
2. Genomes 3 by T.A. Brown, Garland Science.
3. Microbial Genetics by Freifelder D, Narosa Publishing House.
4. Principal of Genetics by E.J Gardner, M.J.Simmons and DP Snustad, John Wiley and Sons
5. Biochemistry by Stryer WH et al., W.H Freeman and company.
6. Genetics: A Conceptual Approach by Benjamin A. Pierce, W.H Freeman and company

Discipline Centric Electives

MIC-20206DCE: ENVIRONMENTAL MICROBIOLOGY (Credits 4)

Objectives: *This course is designed with the aim to study the importance of microorganisms in the establishment of life on earth, distribution of microorganisms in different habitats like soil, water, air, extraterrestrial environments and methods to study them. It also deals with the ways such microorganisms can be motivated and manipulated for extraction of valuable substances, and conversion of waste to wealth.*

Credit I

1.1 Introduction to environmental microbiology. Brief account of microbial interaction, rumen microbiology, coral reefs, vibrio and squid relationships, Microbial mats.
1.2. Fresh water microbiology, trophic status of freshwater ecosystems
1.3. Waste water and drinking water treatment, treatment and applications of municipal solid waste. Composting and biogas production.
1.4 Microbiology of air: microorganisms in different atmospheric layers, air spora of indoor and outdoor environment, factors affecting air spora. Bio-aerosol and its control.
1.5 Space microbiology: historical development of space microbiology, evidence of metabolism (Gulliver experiment), survival of microorganisms in outer space

Credit II

2.1. Bioleaching and biomining (*ex situ* and *in situ* leaching), acid mine drainage
2.2. Microbiology of metal corrosion, biodeterioration of stone and concrete
2.3. Microbiological degradation of xenobiotics in the environment (bioremediation of organic pollutants like hydrocarbons, pesticides and plastics)
2.4. Bioremediation of heavy metals (mercury and arsenic), Bioremediation of polluted soils/sites employing genetically engineered microorganisms
2.5. Biomonitoring: bioindicators, biosensors and genosensors.

Credit III

3.1 Thermophiles: classification and ecological aspects
3.2 Adaptation mechanisms for tolerance to high temperature
3.3 Physical chemistry of thermozymes, commercial aspects of thermophiles and thermoenzymes.
3.4 Genetics of thermophiles.
3.5 Classification and distribution and applications: Acidophiles and alkaliphiles

Credit IV

4.1. Introduction to psychrophiles
4.2. Microbial diversity at cold ecosystem: snow and glaciers ice, sub-glacial environments and permafrost, glacier forefield.
4.3. Anaerobic bacteria, microalgae and cyanobacteria in cold ecosystem and piezopsychrophiles
4.4. Molecular adaptations to cold habitats: Membrane components, cold sensing, cold adapted enzymes, cryoprotectants and ice binding proteins, Role of exopolymers in microbial adaptations to sea ice.

4.5. Classification and distribution and applications: Halophiles and Barophiles

Learning outcome:

- Will learn how microbes interact with each other and different types of microbes present in aquatic system, air and atmosphere and different types of waste water treatment processes
- Thermophiles and psychrophiles: their classification, mode of adaptation to different habitats and their application will also be understood

Recommended Books

1. Microbial Ecology Fundamentals and Applications by Ronald M. Atlas and Richard Bartha, Pearson Education International.
2. Brock Biology of Microorganisms by Madigan and Martinko, Pearson Education International.
3. Environment and Pollution by R.S. Ambasht, CBS New Delhi.
4. Soil Microbiology, Ecology and Biochemistry by Paul E.A., Academic Press.
5. Wastewater Microbiology by Gabriel Bitton, A John Wiley & Sons, Inc, Publisher.
6. Physiology and Biochemistry of Extremophiles by Charles Gerday and Nicolas Glansdorff. ASM Press.

MIC-20207DCE: INDUSTRIAL TOUR (Credits 2)

Objectives: *This component is introduced with the aim to expose students to state of the art academic cum research facilities in reputed scientific organization outside the UT of Jammu and Kashmir so that they can be updated with the recent happening in the area of microbiology and related sciences.*

During 2nd semester, students are required to go for institutional visit to various academic and research institutions outside UT of Jammu & Kashmir carrying 02 credits and will form a component of DCE.

Learning outcome:

- Exposure to different industrial set ups and research institutes of India possessing different facilities will be acquired by the students

Generic Electives

MIC-20003GE: ANALYTICAL INSTRUMENTATION (Credits 2)

Objectives: *This aim of this course is to acquaint students with various techniques and instruments required to study and engineer living organisms including microorganisms. These techniques are also useful in evaluating the application of metabolites obtained from such organisms.*

Credit I

1.1 Principle and applications of microscopy

1.2 Fluorescent, confocal and electron microscopy

1.3 Principle of centrifugation and its applications

1.4 Ultracentrifugation and its applications

1.5 Chromotography-gel chromatography, GLC, HPLC

Credit II

2.1 Visible and UV spectroscopy

2.2 Spectro-flourimetry
2.3 Electrophoresis-PAGE, SDS-PAGE
2.4 PCR & agarose gel electrophoresis
2.5 BLOT techniques

Learning outcome:

- Knowledge of analytical techniques such as microscopy, centrifugation, chromatography, spectroscopy, electrophoresis, PCR and blotting will be acquired

Recommended Books

1. Analytical Biochemistry by Ganai et al., Valley Publications.
2. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker, Cambridge University Press.
3. Basic Techniques in Biochemistry and Molecular Biology by R K Sharma, S P S Sangha, I K International Publishing House.
4. Biochemistry Laboratory: Modern Theory and Techniques by Rodney F. Boyer, Pearson Prentice Hall.

MIC-20004GE: Medical Virology

(Credits 2)

Objectives: *This is a fundamental course designed to introduce the aims and scope of medical virology. This course describes the structural features of viruses. The*mode of transmission, pathogenesis and diagnosis*of various viraldiseases shall be taught in detail. The course shall impart knowledge and skill about the important viruses and their role in human health.*

Credit I

1.1 Introduction to Medical Virology; General Characteristics and Structural features of viruses
1.2 Life cycle of viruses (lytic and lysogenic cycle)
1.3 Sub viral particles: Satellite Viruses, Viroids, and Prions
1.4 Oncogenic viruses
1.5 Antiviral agents and future perspective

Credit II

2.1 General Characteristics, mode of transmission, pathogenesis and diagnosis of DNA Viruses:a)Herpes virus,b)Hepatitis Virus
2.2 General Characteristics, mode of transmission, pathogenesis and diagnosis of RNA Viruses:a)AIDS,b)Dengue
2.3 General characteristics, mode of transmission, pathogenesis and diagnosis of emergent Viruses:a)Influenza,b)SARS (COVID-19)
2.4 General characteristics, mode of transmission, pathogenesis and diagnosis of newly emergent Viruses: a) EBOLA,b) ZIKA
2.5 Novel approaches for viral detection

Learning outcome:

- Viral characteristics, their structure and various life cycle will be understood
- Characteristics, mode of transmission, pathogencity and diagnosis of DNA, RNA and newly emerging viruses will be known.

Recommended Books

6. Brock Biology of Microorganisms by Madigan and Martinko, Pearson Education International.
7. Jawetz, Melnick & Adelbergs Medical Microbiology by Brooks et al., McGraw-Hill Medical.
8. Prescott's Microbiology by Joanne Willey, Linda Sherwood and Christopher J. Woolverton, McGraw Hill Publisher Companies, Inc.
9. Jane Flint,VincentR. Racaniello, Glenn F. Rall,Theodora Hatziioannou, Anna Marie Skalka. Principles of Virology. Volume.1: Molecular Biology, 5th Edition.
10. Jane Flint,VincentR. Racaniello, Glenn F. Rall, and Anna Marie Skalkawith Lynn W. Enquist. Principles of Virology, 4th Edition, Volume II, Pathogenesis and Control.

Course Description 3rd Semester
Core Courses
MIC-20301CR: GENETIC ENGINEERING AND GENOMICS (Credits 4)

Objectives: *This course is designed to provide advancements in the area of recombinant DNA (rDNA) technology and genomics. The course deals with the methods involved in the development of recombinant vector(s), transformation, screening of recombinants and expression of proteins. The novel approaches in exploring microbiomes using omics technology and their applications in agriculture, environment and healthcare shall be described. The ethical and legal aspects associated with the release of genetically engineered organisms shall also be covered.*

Credit I

1.1 Essentials of recombinant DNA technology: cloning vectors-plasmids, cosmids, phagemids, BAC, YAC and expression vectors
1.2 Enzymes in recombinant DNA technology: DNA polymerase, reverse transcriptase, restriction endonucleases, polynucleotide kinase, terminal deoxynucleotidyltransferase, DNase, Methylase, phosphatases, ligases, RNase and their mode of action
1.3 Transformation and selection of recombinants: (Antibiotic, blue/white selection, colony PCR, restriction digestion and colony hybridization)
1.4 *Agrobacterium* based gene transfer in plants; Ti plasmid, structure and functions; chloroplast transformation
1.5 Promoters, reporters and markers used in genetic engineering

Credit II

2.1 Polymerase chain reaction (PCR) and its variants. Quantitative real time PCR (qRT-PCR) their applications
2.2 Construction and screening of genomic and cDNA libraries
2.3 Applications of rDNA technology in medicine (insulin, monoclonal antibodies, antibiotics, vaccine production) and agriculture (growth hormones,biotic and abiotic stress tolerant varieties)
2.4 Gene therapy: Inherited disorders, detection of gene defects, strategies for gene therapy-*in vivo* and *ex vivo* therapies, gene delivery strategies- viral vectors, liposomes their advantages and disadvantages; future prospects of gene therapy
2.5 Genetically engineered organisms (GEOs): microbes, plants, animals and their ethical issues

Credit III

3.1 History of genomics, introduction to model prokaryotic genomes (*Escherichia* and Lambda phage) in detail
3.2 Elementary idea of eukaryotic genomes (*Saccharomyces*, *Arabidopsis*, *Caenorhabditis*)
3.3 DNA sequencing, whole genome shotgun sequencing: next-generation sequencing and full genome sequencing platforms
3.4 Analysis of structural, functional and comparative genomics with reference to *E. coli*
3.5 From genomics to synthetic biology and bioengineering (*Mycoplasma laboratorium,* synthetic bacteriophage)

Credit IV

4.1 General idea of human microbiome project, Earth microbiome project, hologenome theory. Human genome project
4.2 Metagenomics: definition, principles, methods, library production, high throughput screening, metagenomics of archaeological samples; Sargasso sea project
4.3 Transcriptomics, proteomics, metabolomics, ionomics, culturomics and their applications (Brief account)
4.4 Genome editing and its application
4.5 Application of genomics in medicine, agriculture and environment

Learning outcome:

- Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering
- Studying the basics of genomics, synthesis, characterization and application in medicine, agriculture and environment

Recommended Books

1. Principles of Gene Manipulation and Genomics by Sandy B. Primrose and Richard Twyman, Blackwell Publishers.
2. Gene Cloning and DNA analysis by T.A Brown, Wiley-Blackwell.
3. Biotechnology: Expanding Horizons by B.D. Singh, Kalyani Publishers.
4. Molecular Cloning: A laboratory manual by Joseph Sambrook& David Russell CSHL press.
5. Molecular Biotechnology: Principles and Applications of Recombinant DNA by Glick B.R and Pasternak J.J, ASM Press.

Course outcome

- Will be able to understand the fundamental bases of immune system and immune response and also to understand the genetic organisation of the genes meant for expression of immune cell receptors and the bases of the generation of their diversity
- Will be able to apply the knowledge gained to understand the phenomena like host defense, hypersensitivity (allergy), organ transplantation and certain immunological diseases

MIC-20302CR: IMMUNOLOGY (Credits 4)

Objectives: *This course introduces the concept of host defense, the cells and organs involved in immune response, immunoglobulins their structure and interaction with antigens. It further explores the advances in immunological diagnostic of infections and the techniques involved therein.*

Credit I

1.1 General principles of immunology: history of immunology (contributions of Louis Pasteur, Edward Jenner, Karl Landsteiner, Paul Ehrlich, Elie Metchnikoff, MacFarlane Burnet, Rodney Porter)
1.2 Structure, composition and function of cells and organs involved in immune system
1.3 Mechanism of immune response
1.4 Antigens, nature and source of antigens, haptens, adjuvants, immunogenicity versus antigenicity
1.5 Antibody-structure and functions-subtypes; structural basis of antibody diversity; theories of antibody formation

Credit II

2.1 Antigen and antibody interactions: *In vitro* methods-agglutination, precipitation, complement fixation
2.2 Phagocytosis, opsonization, neutralization
2.3 Complement system: complement components and complement activation, pathways, regulation of complement system, biological consequences of complement activation, complement deficiencies
2.4 Structure, distribution of MHCs and its functions.
2.5 Herd immunity: Immune response during microbial infections.

Credit III

3.1 Gene regulation and immune response (IR) genes
3.2 HL-A and tissue transplantation-tissue typing, methods for organ and tissue transplantations in humans; graft versus host reaction and rejection
3.3 Tumor immunology**:** tumor antigens, host immune response to tumors
3.4 Tumor escape mechanisms, immuno diagnosis and therapy, Vaccines.

3.5 Hybridoma technology, myeloma cell lines used as fusion partner, fusion method, detection and application of monoclonal antibodies, recombinant antibodies.

Credit IV

4.1 Immunodeficiencies-animal models (Nude and SCID mice), SCID, DiGeorge syndrome, Chediak-Higashi syndrome, leukocyte adhesion deficiency, Chronic Granulomatous Disease (CGD); characteristics of tumor antigens
4.2 Hypersensitivity reactions: type I, II, III and IV the respective diseases, immunological methods of their diagnosis
4.3 Autoimmunity mechanism and diseases. General account of interferons, Lymphokines and cytokines
4.4 Immunotechniques: Immunodiffusion, Immunoelectrophoresis, RIA, ELISA, ELISPOT, Western blotting
4.5 Immunofluoresence, Flow cytometry, Immunoelectronmicroscopy, RIST, RAST and MLR

Learning outcome

- Will be able to understand the fundamental bases of immune system and immune response and also to understand the genetic organisation of the genes meant for expression of immune cell receptors and the bases of the generation of their diversity
- Will be able to apply the knowledge gained to understand the phenomena like host defense, hypersensitivity (allergy), organ transplantation and certain immunological diseases

Recommended Books

1. Kuby Immunology by Kindt T.J et al., W.H. Freeman and Company.
2. Immunology- A Short Course by Eli Benjamini, Richard Coico and G. Sunshine. Wiley's Publication.
3. Cellular and Molecular Immunology by Abbas AK, Lichtman AH and Pillai S: Saunders Elsevier.
4. Fundamental Immunology by William E. Paul, Lippincott Williams and Wilkins.
5. Roitt's Essential Immunology by Delves PJ et al., Blackwell Publishing/Oxford Univ. Press.
6. Immunology: An Introduction by Tizard IR, Saunders College Publishing.

MIC-20303CR: INDUSTRIAL MICROBIOLOGY (Credits 2)

Objectives: *This course is developed to impart knowledge about applications of microorganisms for the production of industrially important products. The basics of fermentation process and design of fermenters are described to understand the standardization process for the industrial production of foods, enzymes, beverages, therapeutics and other commercial products. The process of commercialization of microbial products and the intellectual property rights (IPR) associated with the technology transfer are included in this paper.*

Credit I

1.1 Upstream processes: source, isolation and screening of industrially important microorganisms, strain improvement through mutations and genetic engineering

1.2 General account on microbial fermentation, types of fermentation, carbon and nitrogen sources used for industrial fermentation

1.3 Bioreactors: features, design, types, operation and applications and concept of primary and secondary metabolites & their control

1.4 Downstream processes of fermentation products: Filtration, centrifugation, cell disruption, liquid-liquid extraction

1.5 Chromatography, membrane processes, drying (lyophilization and spray drying) and crystallization

Credit II

3.1 Industrial production of antibiotics (Penicillin, Streptomycin), Enzymes (Amylase), Aminoacids (Glutamic acid) and Vitamins (Riboflavin)

3.2 Production of Alcoholic beverages (Beer and Wine), Organic acids (Citric acid and Acetic acid)

3.3 Cell and enzyme immobilization, methods used for immobilization of enzymes

3.4 Concept of ISO-certification, Standard Operating Procedures (SOPs), Quality control

3.5 Intellectual Property Rights: Patents, Procedure involved in patent filing, Patenting microorganism

Learning outcome

- Will gain knowledge about industrially important microbes, recent developments in fermentation processes and various optimization strategies at fermenter level
- Understands the concept of sterilization methods and principles of batch and continuous processes and attains knowledge about designing of industrial strains and various media optimization strategies

Recommended Books

1. Principles of Fermentation Technology by P.F. Stanbury, W. Whitaker & S.J. Hall, Elsevier.
2. Biotechnology: A Text Book of Industrial Microbiology by W. Crueger& A. Crueger, Sinauer Associates Inc.
3. Biotechnology: Expanding Horizons by B.D. Singh, Kalyani Publishers.
4. Biotechnology by U. Satyanarayana, Books & Allied Ltd.

MIC-20304CR: LABORATORY COURSE (Credits 4)

Objectives: *This course shall deal with the practical aspects of detection of infection in clinical specimen, the microscopic examination of the pathogens and serological diagnosis. Isolation of microorganisms from agricultural soils and root nodule shall be carried out. Further, hands on training on basic molecular techniques like extraction of genomic and plasmid DNA, polymerase chain reaction, agarose gel electrophoresis and TA cloning shall be provided.*

1. Examination of urine samples for urinary tract infections
2. Isolation and microscopic examination of human fungal pathogen
3. Latex agglutination test (Widal slide test for typhoid fever)
4. Blood grouping and Rh Typing
5. Isolation of lactic acid bacteria from curd
6. Isolation of bacteria and fungi causing food spoilage
7. Isolation of bacteria and fungi from rhizosphere and non-rhizosphere soil samples
8. Isolation of bacteria from root nodule
9. Isolation of genomic DNA from *E. coli*
10. Agarose gel electrophoresis of isolated gDNA
11. Polymerase Chain Reaction (PCR) (amplification of 16S rRNA fragment using *E. coli*gDNA). Visualization of PCR products
12. Isolation of plasmid DNA from *E. coli*
13. T/A cloning (ligation, transformation, blue/white selection and restriction digestion)

Learning outcome

- Student is able to learn how to isolate bacteria and fungi from rhizosphere and non rhizosphere soil.
- Student Is able to isolate genomic DNA and Learns how to amplify DNA by PCR

Recommended Books

1. Microbiology: A Laboratory Manual by James G. Cappuccino and Natalie Sherman, Pearson Benjamin Cummings Publishers.
2. Practical Microbiology by D K Maheshwari & R C Dubey, S Chand & Company Publishers.
3. Alcamo's Laboratory Fundamentals of Microbiology by Pommerville J.C., Jones and Bartlett Publishers, Inc.
4. Gene Cloning and DNA analysis by T.A Brown, Wiley-Blackwell.
5. Molecular Cloning: A laboratory manual by Joseph Sambrook& David Russell CSHL press.

MIC-20305CR: BIOSTATISTICS AND BIOINFORMATICS (Credits 4)

Objectives: *The course **Biostatistics** is aimed at imparting the analytical and interpretative skills to the students so that they can analyze and interpret the data generated from the experiments in scientifically understandable form.*
*The course **Bioinformatics** shall deal with the analyses of gene and protein sequences to infer protein structure, function, evolutionary relationships and to study drug receptor interactions. Further, the students can make use of bioinformatics tools learnt for the project work and research career thereof.*

Credit I

1.1 A general account on biostatistics-samples and populations, types of variables, arithmetic mean, mode and median
1.2 Data interpretation: graphs, bar diagrams, average, range, standard deviation, standard error, coefficient of variation
1.3 General criteria for experimental design: latin square, block, completely randomized and split plot design
1.4 Regression and correlation analyses
1.5 Skewness and kurtosis and their measures, percentiles, quantiles, outliers

Credit II

1.1 Tests of statistical significance - t-test, z-test, F-test
1.2 Analysis of variance, ANOVA, One way Anova (concept and calculation), SPSS and its applications
1.3 Probability: definition, conditional probability, addition and multiplication rules, normal, binomial and poisson distribution
1.4 Non-parametric Mann-Whitney U test
1.5 Concept of isoclines, ecological diversity, incidences diversity (Simpson's index, ShannonWiener index

Credit III

1.1 History and scope of bioinformatics
1.2 Role of computers in bioinformatics: Operating systems (unix, linux), concept of networking
1.3 Biological database: literature (PubMed), nucleic acid (NCBI, EMBL) protein (NBRF, PIR, Swiss-Prot) and structural database (PDB)
1.4 Sequence analysis and comparison; Similarity and homology between sequences; sequence alignment–local and global alignment (BLAST, FASTA), Multiple sequence alignment (Clustal W)
1.5 Phylogenetic analysis: types of phylogenetic trees, approaches of constructing phylogenetic trees (UPGMA, maximum parsimony, maximum likelihood, neighbor joining), phylogenetic analysis by MEGA software

Credit IV

2.1 Bioinformatic tools in microbial research: ORF finder, primer design, restriction mapping (NEBcutter), removal of vector contamination (VecScreen), domain finder.
2.2 Promoter analysis databases. (BPROM, PlantPAN)
2.3 Prokayotic and eukaryotic genome analysis software and databases: Microbial genomic database (MBGD), Virus data bank (ICTVdb), Cell line database (ATCC), Ribosomal database project-RDP, Genomes online database-GOLD, The Arabidopsis Information Resource (TAIR), TIGR Rice Genome Annotation)
2.4 Structure prediction: secondary structure of RNA, secondary and tertiary structure of proteins, In silico isoelectric point and molecular weight of proteins using Compute PI/MW,
2.5 In silicosubcellular localization of prokaryotic and eukaryotic protein PSORTb, Cell-PLoc

Learning outcome

- Students learn as to why the students of biological sciences have to study and understand the subject statistics and make the students capable of designing their experiments, predict, interpret and conclude on the basis of statistical analysis.
- The students will get in-depth knowledge of various bioinformatics tools and techniques.

Recommended Books

1. Biostatistics: A Foundation for Analysis in the Health Sciences (Wiley Series in Probability and Statistics) by Daniel W Wayne, John Wiley & Sons Inc.
2. Fundamentals of Biostatistics by Khan and Khanum, Ukaaz Publications.
3. Biostatistics by P.N Arora and P.K. Malhan, Himalaya Publishing House.
4. Statistics for Biologists by Campbell, R.C., Cambridge University Press.
5. Bioinformatics and Functional Genomics by Jonathan Pevsner, Wiley-Blackwell.
6. Bioinformatics Sequence and Genome Analysis by Mount D.W., Cold Spring Harbor Laboratory Press.
7. Genome Analysis and Bioinformatics: A Practical Approach by T.R.Sharma, I K International Publishing House.

Discipline Centric Electives

MIC-20306DCE: FOOD MICROBIOLOGY (Credits 4)

Objectives: *This course shall impart knowledge and skill about the microbiological examination of food, production of food using microorganisms, food preservation methods and microbial spoilage of food. The detection and control of food borne pathogens and toxins using classical and advanced methods following national and international guidelines are also included.*

Credit I

1.1 History and development of food microbiology, sources and factors influencing microbial growth in foods: intrinsic factors or food environment and extrinsic factors
1.2 Biochemical changes caused by microorganisms in foods-degradation of carbohydrates, lipids, proteins and amino acids; putrefaction
1.3 Microbial spoilage of plant (Fruits, vegetables, cereals, oil seeds) and their products
1.4 Microbial spoilage of animal (milk, meat, egg) based foods
1.5 Spoilage of processed foods– canned products, causes of spoilage, appearance of spoiled cans

Credit II

2.1 Control of microorganisms in foods: asepsis, use of heat, low temperature, drying. Methods of food preservation (chemical preservatives, bio preservatives and irradiation)
2.2 Microbiology of fermented products: bread, wine, vinegar and fermented vegetables
2.3 Microbial examination of milk, meat, egg, fruits, vegetables and their products
2.4 Probiotics and prebiotics and their significance in human health.
2.5 Production of yoghurt, kefir and ice-cream and their health benefits

Credit III

3.1 Bacterial food borne pathogens (Staphylococcus, Clostridium sps, *Bacillus cereus, Salmonella, E.coli, Shiegella, Listeriara, Brucella*)
3.2 Fungal intoxications (mycotoxicosis- aflatoxins, ochratoxins and patulin)
3.3 Food borne viral pathogens: Norwalk virus, hepatitis A virus, hepatitis E virus, and rotavirus
3.4 Detection and enumeration of microorganisms and their products in food. Molecular detection: PCR, Q-PCR
3.5 Emergence and health risk of antibiotic resistance from processed foods and emerging foodborne pathogens

Credit IV

4.1 Safety aspects of food products with reference to Mycotoxins, Antibiotics, Pesticides, Weedicides and Heavy Metals
4.2 General principles of food safety risk management, Safe food alternatives (Organic foods)
4.3 Safety concerns of biofilm formation on equipment surfaces and their control measures, Quality control of food at all stages from production to packaging materials.
4.4 Good Agricultural Practices (GAP), HACCP,International and national food laws. USFDA, ISO-9000 and FSSAI
4.5 Biosafety ofgenetically modified foods: benefits and future challenges.

Learning outcome

- Will know about production and evaluation of the quality of starter cultures and fermented milk products and 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 and non-invasive techniques of quantification and detection of food borne microbes and pathogens and various new imaging techniques
- Understands the relevance of microbial standards for food safety, quality assurance programs that revolutionize food safety

Recommended Books

1. Food Microbiology by Frazier and Westhoff, TaTa McGraw Hill.
2. Food Microbiology: Fundamentals and Frontiers by Doyel et.al. ASM Press.
3. Basic Food Microbiology by Banwart G.J., CBS Publishers & Distributors.
4. Modern Food Microbiology by Jay et.al. Springer India Ltd.

MIC-20307DCE: AGRICULTURAL MICROBIOLOGY (Credits 4)

Objectives: *This course aims at imparting knowledge about the role of microorganism in agriculture. Importance of soil microbiota in relation to the formation of soil, biogeochemical cycling of important nutrients, as biofertilizers and biopesticides are also described. Further, major plant diseases caused by microorganisms and the importance of tissue culture in enhancing plant productivity are also covered.*

Credit I

1.1 Introduction and scope of agricultural microbiology.Contributions of M. Beijerinck, S. Winogradsky, B. Frank and S.Waksman
1.2 Soil as substrate for growth of microorganisms, soil microflora, culture dependent and independent methods of studying soil microflora
1.3 Rhizosphere, phyllosphere and endophytic microorganisms and their interactions with plants
1.4 Nitrogen cycle: ammonification, nitrification and denitrification. Biological nitrogen fixation (symbiotic and asymbiotic), biochemistry and molecular genetics of nitrogen fixation
1.5 Microbial transformations of phosphorus, potassium, sulphur and minor nutrients

Credit II

2.1 Mycorrhizae, Frankia, biology and their applications
2.2 Biofertilizers: production and application of *Rhizobium, Azospirillum, Azotobacter,* phosphobacteria and Cyanobacteria and their quality control
2.3 Concept of biopesticides: *Bacillus thuringiensis* (Bt), mode of action of Bt toxins and production of Btbiopesticides, Bttransgenics and their issues
2.4 Fungal and viral biopesticides: production and genetic improvement of Baculoviruses, advantages and disadvantages of fungal and viral biopesticides.
2.5 Role of beneficial microbes for combating abiotic stress in economically important crops

Credit III

3.1 Introduction to plant pathology: history, significance, symptoms and types of plant diseases
3.2 Defense mechanisms of plant disease: Pre-existing, structural and chemical defenses, induced defense mechanisms.
3.3 Bacterial diseases of economically important crops (canker, fire blight, angular leaf spot and wilt)
3.4 Fungal diseases of economically important crops (blast, rot, blight, smut rust and powdery mildew)
3.5 Viral diseases of economically important crops (mosaic diseases, tomato leaf curl, potato leaf roll)

Credit IV

4.1 Basic concepts of plant tissue culture, culture-media, plant hormones and growth parameters
4.2 Embryogenesis and organogenesis
4.3 Organ culture: meristematic and non-meristematic methods, somaclonal variations (brief account)
4.4 Micropropagation and its applications
4.5 Applications of plant tissue culture for plant improvement and germplasm conservation.

Learning outcome

- Understanding the properties of different types of soil and interaction of microbes with plants, insects and microbes.
- Insight knowledge on nitrogen fixing microorganisms, and other biofertilizers
- Learn the types of pathogen causing plant, bacterial and fungal.

Recommended Books

1. Soil microbiology and Biochemistry by EA Paul and F.E. Clark, Academic press.
2. Soil Microbiology by Subba Rao, Science Publishers.
3. Agricultural Microbiology by G.Rangaswamy and Bagyaraj, Prentice Hall India.
4. Soil Microorganisms and Plant Growth by N.S Subba Rao, Science Publishers.
5. Plant Pathology by P. D. Sharma Alpha Science International Publishers.
6. An introduction to plant Tissue Culture by M.K. Razdan, Oxford & IBH publishing.
7. Plant cell tissue & organ culture- Fundamental methods by O. L. Gamborg, & G. C. Philips, Springer publications.
8. Plant Tissue Culture: An Introductory Text by Sant Saran Bhojwani and Prem Kumar Dantu, Springer Science & Business Media.

Generic Electives

MIC-20005GE: APPLIED FOOD MICROBIOLOGY (Credits 2)

Objectives: *This course shall deal with the fundamental and applied aspects of food spoilage and food production by microorganisms. Further, foodborne infections/intoxications and methods to control them shall be taught in detail.*

Credit I

1.1 Historical developments in food microbiology
1.2 Factors influencing microbial growth in foods: intrinsic and extrinsic factors
1.3 Food spoilage, causes of spoilage and spoilage of canned foods
1.4 Food preservation
1.5 Microbial examination of milk, meat, egg, fruits and vegetables

Credit II

2.1 Microorganisms as single cell protein (SCP)
2.2 Probiotics and prebiotics, production of fermented milk (yoghurt, cheese and kefir)
2.3 Fermented vegetable (sauerkraut and kimchi) products
2.4 Foodborne intoxications: Staphylococcal intoxication, botulism, mycotoxicosis
2.5 Foodborne infections: Salmonellosis, Listeriosis, pathogenic *Escherichia coli*, gastroenteritis, shigellosis and brucellosis

Learning outcome

- Understanding the principles of microorganisms during various food processing and preservation steps
- Understanding the significance and activities of microorganisms in food

Recommended Books

1. Food Microbiology by Frazier and Westhoff, TaTa McGraw Hill.
2. Food Microbiology: Fundamentals and Frontiers by Doyel et.al. ASM Press.
3. Basic Food Microbiology by Banwart G.J., CBS Publishers & Distributors.
4. Modern Food Microbiology by Jay et.al. Springer India Ltd.

MIC-20006GE: CLINICAL MICROBIOLOGY (Credits 2)

Objectives: *This course deals with the basic biology, laboratory diagnosis and control measures of important human bacterial, fungal and viral pathogens.*

Credit I

1.1 Basic techniques in microbiology: Sterilization, preparation of media, culture techniques
1.2 Gram staining and acid fast staining
1.3 Collection, transportation and identification of specimen from blood and urine samples
2.3 Lab diagnosis of bacterial and fungal Infections using culture and non-culture methods
1.4 (Microscopy, PCR and serological tests)
1.5 Isolation and cultivation of viruses

Credit II

2.1 Introduction to clinical microbiology, types of infections
2.2 Brief description of medically important bacteria (*Mycobacterium tuberculosis*, *Vibrio cholerae*, *Salmonella typhi*, *Clostridium tetani*)
2.3 Introductions to medical virology; basic features of HIV, Influenza, Rabies, Hepatitis, Small pox
2.4 Introduction to medically important fungi (*Piedraia hortae, Trichophyton rubrum,Cryptococcus neoformans, Candida albicans*
2.5 Antibiotics and mode of action

Learning outcome

- The students will get in-depth knowledge of microbiological techniques

- The student will be familiarized with medically important pathogens

Recommended Books

1. Ananthanarayan&Paniker's text book of Microbiology by Reba Kanungo, Universities Press.
2. Jawetz, Melnick & Adelbergs Medical Microbiology by Brooks et al., McGraw-Hill Medical.
3. Prescott's Microbiology by Joanne Willey, Linda Sherwood and Christopher J. Woolverton, McGraw Hill Publisher Companies, Inc.

Course Description 4th Semester

MIC-20401CR: Research based project work, dissertation writing and submission in hard bound form (Credits 12)

Objectives: *This component shall inculcate in students the scientific temperament for finding solutions to the research problems. A student shall be required to select a research problem and perform experiments independently under the mentorship of a designated teacher. The methodology adopted and the findings of the study are to be compiled in a scientific manner and submitted to the department for evaluation in the form of a dissertation. A presentation of the methodology and finding should be made by the student in front of the scientific audience comprising of teachers, research scholars and the fellow students.*

Learning outcome

- Students will be familiarized with scientific temperament for finding solutions to the research problems.
- Students will perform experiments independently under the mentorship of a designated teacher.

MIC-20402CR: PRESENTATION AND VIVA-VOCE (Credits 4)

The students should make an open presentation defending their project work. The presentation will be open to all the students and teachers of the department.

Learning outcome

- The students will make research based power point presentation of their research project.
- The students will defend the research work in presence of all the students and faculty members including external examiner.

MIC-20403DCE: SPECIAL PAPER (Credits 4)

This paper will be separately designed for each student based on their area of interest to be decided in consultation with teachers. The study of the special paper shall lead to the advancement of knowledge of the students in at least one of the relevant areas of microbiology which in turn may decide their future study interests.

Learning outcome

- The study of the special paper shall lead to the advancement of knowledge in practical field.
- The students will be familiarized with the advanced techniques in microbiology.

MIC-20404 DCE: Designing and drafting a research proposal /Journal Club/Scientific paper writing (Credits 2)

A student will have to pick up a problem in biological sciences and develop a grant applicationon the theme under mentorship of allotted supervisor. Grant application will have following components:Introduction, National and international scenario, review of literature, objective, possible outcome, significance of the study, material and methods and summary
The recent and advanced scientific papers in high profile journals will be chosen by the students in consultation with mentor teachers and then presented by the student. The presenter is supposed to have all the relevant knowledge of the article.

Generic Electives

MIC-20007GE: FERMENTATION TECHNOLOGY (Credits 2)

Objectives: *This course shall impart knowledge about applications of microorganisms for the production of industrially important products. The basics of fermentation process and design of fermenters for the industrial production of antibiotics, enzymes, amino acids, vitamins and beverages shall be covered in this course.*

Credit I

1.1 Introduction to industrial microbiology
1.2 Fermentor and its types

1.3 Microbial fermentation and types of fermentation
1.4 Carbon and nitrogen sources used for microbial fermentation
1.5 Factors effecting microbial growth during fermentation

Credit II
1.2 Industrial production of antibiotics (penicillin, streptomycin)
1.3 Production of enzymes (protease, amylase and lipase)
1.3 Production of amino acids (lysine and tryptophan)
1.4 Production of vitamins (riboflavin and cyanocobalamin)
1.5 Production of alcohol and organic acids (beer, wine and citric acid)

Learning outcome
- The students will be familiarized with the design of fermenter and fermentation processes
- The students will get knowledge about microorganisms for the production of industrially important products.

Recommended Books

1. Principles of Fermentation Technology by P.F. Stanbury, W. Whitaker & S.J. Hall, Elsevier.
2. Biotechnology: A Text Book of Industrial Microbiology by W. Crueger& A. Crueger, Sinauer Associates Inc.
3. Biotechnology: Expanding Horizons by B.D. Singh, Kalyani Publishers.
4. Biotechnology by U. Satyanarayana, Books & Allied Ltd.

MIC-20008GE: APPLIED AGRICULTURAL MICROBIOLOGY (Credits 2)

Objectives: *This course is intended to deal with basics of agricultural microbiology, the plant microbe interactions, biological nitrogen fixation (BNF), use of microorganisms as biofertilizers and biopesticides shall be taught in detail.*

Credit I
1.1 Introduction to agricultural microbiology
1.2 Rhizosphere, phyllosphere and endophytic microorganisms and their interactions with plants
1.3 Biological nitrogen fixation (symbiotic and asymbiotic)
1.4 General account on plant-microbe interactions (beneficial and harmful)
1.5 Plant growth promoting bacteria and their uses

Credit II
2.1 Mycorrhizae and their applications
2.2 Biofertilizers, production and application of *Rhizobium* and *Azotobacter*
2.3 Cyanobacteria as biofuel and future prospectus
2.4 Biopesticides, production and uses
2.5 Bttransgenics their success and failures

Learning outcome
- Students will get knowledge about the basic agricultural microbiology.
- The students will get knowledge of biofertilizers and biopesticides.

Recommended Books

1. Agricultural Microbiology by G.Rangaswamy and Bagyaraj, Prentice Hall India.
2. Soil Microbiology by Subba Rao, Science Publishers.
3. Soil Microorganisms and Plant Growth by N.S Subba Rao, Science Publishers.
4. Plant Pathology by P. D. Sharma, Alpha Science International Publishers.