

Semester-I

Undergraduate Certificate in Microbiology

GENERIC ELECTIVE (GE)- Microorganisms for Human Welfare

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Microorganisms for Human Welfare	4	4	0	0	Passed Class XII	Nil

UNDERGRADUATE CERTIFICATE IN BOTANY		
Programme : <i>Undergraduate Certificate in Microbiology</i>	Year: I	Semester: I
Subject: Microbiology		
Course: MIC GE 1	Microorganisms for Human Welfare	
Learning Outcomes: After the completion of the course the students will be able to: 1. Understand the microorganism used in daily life . 2. Understand the various microbial products and the diseases coursing microorganism		

Credits: 4	Generic Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: Asper Univ. rules

Unit – 1: Food and Fermentation Fermented Foods – Types, nutritional values and health benefits. Probiotics, prebiotics, synbiotics and nutraceuticals. Fermented Products – Alcoholic and non-alcoholic beverages, dairy

products Microorganisms as food (SCP fermented food products) and probiotics. Microorganisms in food spoilage and food borne infections

Unit – 2: Agriculture Bio-fertilizers and bio-pesticides - types and applications, beneficial microorganisms in agriculture, AM fungi, Mushroom cultivation, Biogas production.

Unit – 3: Pharmaceutical Industry Drugs – types, development and applications. Antibiotics – types, functions and antibiotic therapy. Vaccines – types, properties, functions and schedules.

Unit 4 Microbes in Human Health: List of important human diseases and their causative agents of various human systems. Definitions of immunity (active/passive), primary and secondary immune response, antigen, antibody and their types.

Unit 5 Industrial Microbiology Definition of fermentation, primary and secondary metabolites, types of fermentations and fermenters and microbes producing important industrial products through fermentation.

Suggesting Reading

1. Ananthnarayanan, R and Jeyaram Panicker, C. K. 2010. Textbooks of Microbiology, Orient Longman.
2. Dubey, R.C. and Maheshwari, D.K. 2013. A Textbook of Microbiology –2nd edition (S chand & Co. N. Delhi).
3. Michael, J. Pelczar, Jr. E.C.S., Chan, Noel R. 1998. Krieg Microbiology Tata McGraw- Hill Publisher.
4. Pelczar, M.J., Chan E.C.S. and Kreig, N.R. 1993. Microbiology 5th edition (Tata McGraw-Hill, New Delhi)
5. Prescott, L.M., Harley, J.P. and Klein, D.A., 2007. Microbiology –7th edition (Wm. C. Brown Publishers, USA) Elementary Microbiology – Modi, HA (vol. I), 1st edition (Ekta Pakashan, Nadiad).

Semester-II

Undergraduate Certificate in Microbiology

GENERIC ELECTIVE (GE)- MICROBIAL DIAGNOSIS IN HEALTH CLINICS

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
MICROBIAL DIAGNOSIS IN HEALTH CLINICS	4	4	0	0	Passed Class	Nil

UNDERGRADUATE CERTIFICATE IN BOTANY

Programme : *Undergraduate Certificate in Microbiology*

Year: I

Semester: II

Subject: Microbiology	
Course: MICGE 2	MICROBIAL DIAGNOSIS IN HEALTH CLINICS
Course Outcomes: After the completion of the course the students will be able to: 1. Understand the different types of microbial diseases 2. Understand the structure and shape of different pathogens 3. Understand the diagnosis of different diseases. 3. Understand rapid test of different clinical sample.	

Credits: 4	Generic Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: As per Univ. rules

Unit 1 Importance of Diagnosis of Diseases and Collection of Clinical Samples Bacterial, Viral, Fungal and Protozoan Diseases of various human body systems, Disease associated clinical samples for diagnosis. Collection of Clinical Samples: How to collect clinical samples (oral cavity, throat, skin, Blood, CSF, urine and faeces) and precautions required. Method of transport of clinical samples to laboratory and storage.

Unit 2 Direct Microscopic Examination Examination of sample by staining - Gram stain, Ziehl-Neelson staining for tuberculosis, Giemsa-stained thin blood film for malaria.

Unit 3 Culturing Pathogens Preparation and use of culture media - Blood agar, Chocolate agar, Lowenstein-Jensen medium, MacConkey agar, Distinct colony properties of various bacterial pathogens.

Unit 3 Serology, Molecular Methods and Kits for Rapid Detection of Pathogens

Serological Methods - Agglutination, ELISA, Nucleic acid based methods - PCR, Nucleic acid probes. Kits for Rapid Detection of Pathogens: Typhoid, Dengue and HIV, Swine flu.

Unit 4 Testing for Antibiotic Sensitivity in Bacteria Importance, Determination of resistance/sensitivity of bacteria using disc diffusion method, Determination of minimal inhibitory concentration (MIC) of an antibiotic by serial double dilution method

Suggested Readings

1. Ananthanarayan R and Paniker CKJ (2009) Textbook of Microbiology, 8th edition, Universities Press Private Ltd.
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Randhawa, VS, Mehta G and Sharma KB (2009) Practicals and Viva in Medical Microbiology 2nd edition, Elsevier India Pvt Ltd
4. Tille P (2013) Bailey's and Scott's Diagnostic Microbiology, 13th edition, Mosby
5. Collee JG, Fraser, AG, Marmion, BP, Simmons A (2007) Mackie and McCartney Practical Medical Microbiology, 14th edition, Elsevier.

Semester-III

Undergraduate Diploma in Microbiology

No. of Hours- 60

Generic Elective: MANAGEMENT OF HUMAN MICROBIAL DISEASES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
MANAGEMENT OF HUMAN MICROBIAL DISEASES	4	4	0	0	Passed Class	Nil

UNDERGRADUATE DIPLOMA IN MICROBIOLOGY		
Programme : <i>Undergraduate Diploma in Microbiology</i>	Year: II	Semester: III
Subject: Microbiology		
Course: MIC GE 3	MANAGEMENT OF HUMAN MICROBIAL DISEASES	
Course Outcomes: After the completion of the course the students will be able to <ol style="list-style-type: none">1. Understand the basic microbial diseases.2. Understand prevention and treatment of microbial diseases.3. Understand the concept of Antibiotics and antiviral drugs .		

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Credits: 4	Generic Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: As per Univ. rules

Unit 1 Introduction to Human Microbial Diseases Definition and concept of health, disease, Infection and Pathogen. Types of human microbial diseases and their transmission, causative agents and symptoms of human microbial diseases: Respiratory microbial diseases, gastrointestinal microbial diseases, , skin diseases, eye diseases, urinary tract diseases, sexually transmitted diseases, Microbial mediated cancers and Nosocomial infections.

Unit 2 Diagnosis of Human Microbial diseases Various serological and molecular methods for diagnosis of microbial diseases. Detection by diagnostic kits based on ELISA, Immunofluorescence, Agglutination tests,

Unit 3 Therapeutics of Microbial diseases Treatment using antibiotics: Mechanism of action of antibiotics belonging to different classes: beta lactam antibiotics (penicillin, cephalosporins), quinolones, polypeptides and aminoglycosides. Judicious use of antibiotics, importance of completing antibiotic regimen, Concept of DOTS, emergence of antibiotic resistance, current issues of MDR/XDR microbial strains.

Unit 4 Microbial Viral Diseases SARS/ Swine flu/Ebola causes, spread and control. Treatment using antiviral agents: Mechanism of action of Amantadine, Acyclovir,.

Unit 4 Prevention of Microbial Diseases

General preventive measures, Importance of personal hygiene, environmental sanitation and methods to prevent the spread of infectious agents transmitted by direct contact, food, water and insect vectors. Vaccines: Importance, types, vaccines available against microbial diseases, vaccination schedule (compulsory and preventive) in the Indian context.

Suggested Readings

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication.
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication.
3. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier.
4. Willey JM, Sherwood LM, and Woolverton CJ. (2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education.
5. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition.

Semester-IV

Undergraduate Diploma in Microbiology

Generic Elective: MICROBIAL BIOTECHNOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course	Eligibility	Pre-
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		Lecture	Tutorial	Practical/Practice	criteria	requisite of the course (if any)
MICROBIAL BIOTECHNOLOGY	4	4	0	0	Passed class	Nil

UNDERGRADUATE DIPLOMA IN MICROBIOLOGY		
Programme : <i>Undergraduate Diploma in Microbiology</i>	Year: II	Semester: IV
Subject: Microbiology		
Course: MIC GE 4	MICROBIAL BIOTECHNOLOGY	

Course Outcomes:
 After the completion of the course the students will be able to

1. Understand the concepts and biotechnological tools .
2. Understand the genetic modified organisms
3. Learn how different microbial products

Credits: 4	Generic Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: As per Univ. rules

Unit 1 Microbial Biotechnology and its Applications Microbial biotechnology: Scope and its applications in human therapeutics, agriculture (Biofertilizers, PGPR, Mycorrhizae), environmental, and food technology Use of prokaryotic and eukaryotic microorganisms in biotechnological applications Genetically engineered microbes for industrial application: Bacteria and yeast

Unit 2 Therapeutic and Industrial Biotechnology Recombinant microbial production processes in pharmaceutical industries - Streptokinase, recombinant vaccines (Hepatitis B vaccine) Microbial polysaccharides and polyesters, Microbial production of bio-pesticides, bioplastics Microbial biosensors

Unit 3 Applications of Microbes in Bio-catalytic processes and their industrial applications: Production of high fructose syrup and production of cocoa butter substitute

Unit 4 Microbial Products and their Recovery Microbial product purification: filtration, Immobilization methods and their application: Whole cell immobilization

Unit 5 Microbes for Bio-energy and Environment Bio-ethanol and bio-diesel production: commercial production from lignocellulosic waste and algal biomass, Biogas production: Methane and hydrogen production using microbial culture.

SUGGESTED READING

1. Ratledge, C and Kristiansen, B. (2001). Basic Biotechnology, 2nd Edition, Cambridge University Press.
2. Demain, A. L and Davies, J. E. (1999). Manual of Industrial Microbiology and Biotechnology, 2nd Edition, ASM Press.
3. Swartz, J. R. (2001). Advances in Escherichia coli production of therapeutic proteins. Current Opinion in Biotechnology, 12, 195-201.
4. Prescott, Harley and Klein's Microbiology by Willey JM, Sherwood LM, Woolverton CJ (2014), 9th edition, McGraw Hill Publishers.
5. Gupta PK (2009) Elements of Biotechnology 2nd edition, Rastogi Publications, 6. Glazer AN and Nikaido H (2007) Microbial Biotechnology, 2nd edition, Cambridge University Press
7. Glick BR, Pasternak JJ, and Patten CL (2010) Molecular Biotechnology 4th edition, ASM Press,
8. Stanbury PF, Whitaker A, Hall SJ (1995) Principles of Fermentation Technology 2nd edition., Elsevier Science
9. Crueger W, Crueger A (1990) Biotechnology: A text Book of Industrial Microbiology 2nd edition Sinauer associates, Inc.

Semester-V

Bachelor of Science in Microbiology

Generic Elective: INTRODUCTION AND SCOPE OF MICROBIOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
INTRODUCTION AND SCOPE OF MICROBIOLOGY	4	4	0	0	Passed Class	Nil

BACHELOR OF SCIENCE IN MICROBIOLOGY

Programme : <i>Bachelor of Science in Microbiology</i>			Year: III	Semester: V
Subject: Microbiology				
Course: MIC GE 5	INTRODUCTION AND SCOPE OF MICROBIOLOGY			

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Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the scope of microbiology
2. Understand the different techniques used in control of microorganisms
3. Understand the economic importance of microbes

Credits: 4	Generic Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: As per Univ. rules

Unit 1

Development of Microbiology Development of microbiology as a discipline and Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner.

Unit 2

Diversity of Microorganisms Systems of classification : Binomial nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility General characteristics of different groups: Acellular microorganisms and Cellular microorganisms giving definitions and citing examples.

Unit 3

Microscopy Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluorescence Microscope, Transmission Electron Microscope, Scanning Electron Microscope. **Sterilization** Moist Heat, Autoclave, Dry Heat, Hot Air Oven, Filtration.

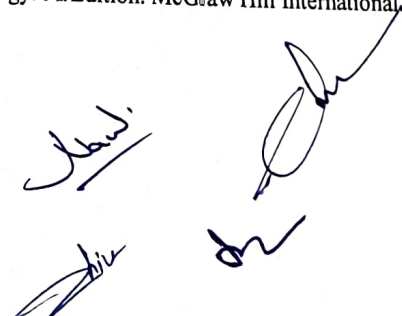
Unit 4 Industrial Microbiology Definition of fermentation, primary and secondary metabolites, types of fermentations and fermenters and microbes producing important industrial products through fermentation.

Unit 5

Food and Dairy Microbiology Microorganisms as food (SCP), microorganisms in food fermentations (dairy and non dairy based fermented food products) and probiotics. Microorganisms in food spoilage and food borne infections.

SUGGESTED READING

1. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition.
3. Cappuccino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited.
4. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.



Semester-VI

Bachelor of Science in Microbiology

GENERIC ELECTIVE (GE): INDUSTRIAL AND FOOD MICROBIOLOGY

No. OF Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course(if any)
		Lecture	Tutorial	Practical/Practice		
Industrial And Food Microbiology	4	4	0	0	Passed Class	Nil

BACHELOR OF SCIENCE IN MICROBIOLOGY

Programme : Bachelor of Science in Microbiology			Year: III	Semester: VI
Subject: Microbiology				
Course: MIC GE 6	INDUSTRIAL AND FOOD MICROBIOLOGY			
Course Outcomes:				
After the completion of the course the students will be able to:				
<ol style="list-style-type: none"> 1. Understand the industrially important microorganism and products . 2. Learn about the microorganisms used in food products and . 				

Credits: 4	Generic Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: Asper Univ. rules

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Unit 1

Introduction to Industrial microbiology Brief history and developments in industrial microbiology.

Types of fermentation processes - solid state, liquid state, batch, fed-batch and continuous. Types of fermenters - laboratory, pilot-scale and production fermenters. Components of a typical continuously stirred tank bioreactor.

Unit 2

Isolation of industrial strains and fermentation medium Primary and secondary screening. Preservation and maintenance of industrial strains. Ingredients used in fermentation medium - molasses, corn steep liquor, whey & yeast extract.

Unit 3

Microbial fermentation processes Downstream processing - filtration, centrifugation, cell disruption, solvent extraction.

Microbial production of industrial products - industrial production and uses of the enzymes

Unit 4

Food as a substrate for microbial growth Intrinsic and extrinsic parameters that affect microbial growth in food.

Microbial spoilage of food - milk, egg, bread and canned foods . **Principles and methods of food preservation and food sanitation** Physical methods - high temperature, low temperature, irradiation, aseptic packaging. Chemical methods -

salt, sugar, benzoates, citric acid, ethylene oxide, nitrate and nitrite. Food sanitation and control - HACCP.

Unit 5

Dairy products, probiotics and Food-borne Diseases Fermented dairy products - yogurt, acidophilus milk, kefir, dahi and cheese. Probiotics definition, examples and benefits. Food intoxication by *Clostridium botulinum* and *Staphylococcus aureus*. Food infection by *Salmonella* and *E.coli*.

Suggested Readings

1. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd Edition. Panima Publishing Company, New Delhi.

2. Patel AH. (1996). Industrial Microbiology .1st Edition. MacMillan India Limited Publishing Company Ltd. New Delhi, India.

Semester VII

GENERIC ELECTIVE (GE)- Biostatistics, Computer Applications and Bioinformatics

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Biostatistics, Computer Applications and Bioinformatics	4	4	0	0	Bachelor of Science in Microbiology	Nil

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BACHELOR IN MICROBIOLOGY WITH HONOURS		
Programme : <i>Master of Science in Microbiology</i>		Year: IV
Subject: Microbiology		Semester: VII
Course: MIC GE7	Course Title: Biostatistics, Computer Applications and Bioinformatics	
Course outcomes:		
Learning objectives:		
<ul style="list-style-type: none"> • To understand the statics role in biological and Research industry • To understand the basic concept biostatics and computer. • At the end of course students will be able to explain the role of computer and statics in Microbiology development and what is the scope of the various field of the subject and other beneficial roles. 		

Credits: 4	Generic Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: Asper Univ. rules

Unit I:

Presentation of data; Frequency distributions; Graphical representation of data by histogram, polygon, frequency curves and pie diagram. Measures of central tendency: Mean, median and mode; Measures of dispersion: Mean deviation, standard deviation, coefficient of variation;

Unit II:

Correlation : properties, nature, coefficient of correlation, , significance of correlation Probability: Basic concepts related to probability theory, classical probability. Probability Distributions

Unit III:

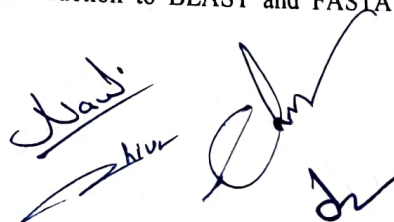
Testing of significance: Students t-test for the significance of population mean, Chi square test for population variance, F-test for the equality of two population variance; Analysis of variance- One-way

Unit IV:

Introduction to Computers: Definition, Components of computer, Basics for operating systems Introduction to MS Office (MS-Word, MS-Excel, MS-Power Point); Introduction to Networking Computer application in Microbiological ,fermentation and Pharmaceutical Industry

Unit V:

Introduction to Bioinformatics: Definition and scope; Search engines: tools for web search; Introduction to biological databases (NCBI, EBI, DDBJ, Gen Bank,),Introduction to BLAST and FASTA



studies.

Suggested Readings (Latest Editions):

1. Bailey, NT J (2000). Statistical Methods in Biology. English Univ. Press.
2. Campbell R.C (Latest Edition). Statistics for Biologist. Cambridge University Press, UK.
3. Sinha PK (Latest Edition). Fundamentals of computers. BPB Publication, New Delhi
4. Jonathan, P. 2008. Bioinformatics & Functional Genomics.
5. B.D.Singh(2015). Biotechnology, Kalyani Publication.
6. Sharma and Munjal(2015). A test book of Bioinformatics, Rastogi publication

Semester VII


GENERIC ELECTIVE (GE)- BACTERIOLOGY AND VIROLOGY

No. of Hours- 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
BACTERIOLOGY AND VIROLOGY	4	4	0	0	Bachelor of Science in Microbiology	Nil

BACHELOR IN MICROBIOLOGY WITH HONOURS		
Programme : Bachelor in Microbiology With Honours		Year: IV
Subject: Microbiology		Semester: VII
Course: MIC GE 8	Course BACTERIOLOGY AND VIROLOGY	



Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the structure, classification and functions of Bacteria .
2. Understand the structure of virus
3. Understand the role of bacteria and virus in human health .

Credits: 4	Generic Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: As per Univ. rules

Unit 1

Cell organization Cell size, shape and arrangements, capsule, flagella and pili, Composition and detailed structure of gram- positive and gram- negative cell wall and archaeal cell wall, Structure, chemical composition and functions of bacterial and archaeal cell membranes, Ribosomes, inclusions, nucleoid, plasmids, structure, formation and stages of sporulation.

Unit 2

Bacterial growth and control Culture media: Components of media, Synthetic or defined media, Complex media, enriched media, selective media, differential media, enrichment culture media. Pure culture isolation: Streaking, serial dilution and plating methods, cultivation, maintenance and stocking of pure cultures, cultivation of anaerobic bacteria. Growth: Binary fission, phases of growth.

Unit 3

Bacterial Systematics and Taxonomy Taxonomy, nomenclature, systematics, types of classifications. Morphology, ecological significance and economic importance of the following groups: Archaea: methanogens, thermophiles and halophiles. Eubacteria: Gram negative and Gram positive. Gram negative: Non-proteobacteria- *Deinococcus*, *Chlamydia*, Spirochetes. Alpha proteobacteria- *Rickettsia*, *Rhizobium*, *Agrobacterium*. Gamma proteobacteria - *Escherichia*, *Shigella*, *Pseudomonas*. Gram positive: Low G+C: *Mycoplasma*, *Bacillus*, *Clostridium*, *Staphylococcus* High G+C: *Streptomyces*, *Frankia*.

Unit 4

Introduction to Viruses Properties of viruses; general nature and important features. Subviral particles; viroids, prions and their importance. Isolation and cultivation of viruses. Viruses as pathogens: Role of viruses in causing diseases. Prevention and control of viruses:

Unit 5

Structure, and multiplication of viruses Morphological characters: Capsid symmetry and different shapes of viruses with examples. Viral multiplication in the Cell: Lytic and lysogenic cycle. Description of important viruses: salient features of the viruses infecting different hosts - Bacteriophages (T4 & Lambda); Plant (TMV & Cauliflower Mosaic Virus), Human (HIV & Hepatitis viruses).

SUGGESTED READING

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. W.M.T. Brown Publishers.
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP (2014). Brock Biology of Micro-organisms. 14th edition. Pearson Education, Inc.
3. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition. McMillan.
4. Carter J and Saunders V (2007). Virology; principles and Applications. John Wiley and Sons.

5. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR Skalka, AM (2004) Principles of Virology, Molecular Biology, Pathogenesis and Control. 2nd edition. ASM Press.
6. Shors Teri (2013) Understanding Viruses 2nd edition Jones and Bartlett Learning Burlington USA.
7. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition Tata McGraw Hill.

BSc 4th Year (Honors)

Semester VIII

GENERIC ELECTIVE (GE) – FOOD BORNE DISEASES AND FOOD PRESERVATION

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
FOOD BORNE DISEASES AND FOOD PRESERVATION	4	4	0	0	Bachelor of Science in Botany	Nil

BACHELOR IN MICROBIOLOGY WITH HONOURS

Programme : Bachelor in Microbiology with Honours		Year: IV	Semester: VIII
Subject: Microbiology			
Course: MIC GE 9	Course Title: FOOD BORNE DISEASES AND FOOD PRESERVATION		

Learning objectives:

- To understand the prevalence of bacteria in food commodities.
- To understand the occurrence of food-borne diseases.
- To know the different test for the detection of food-borne infection.

Learning outcomes:

At the end of course student will be able to

- Explain the role of microorganism in food commodities.
 - Explain the factor responsible for the growth of bacteria.
1. Perform the different microbiological test to determine the quality of food.

Credits: 4	Generic Elective
Max. Marks:	Min. Passing Marks: Asper Univ. rules

UNIT - I

Food spoilage: Microbes in food, factors affecting microbial growth in foods: Extrinsic and intrinsic, microbial spoilage of foods, microbial spoilage of food - milk and milk products, fruits and vegetables, meat products, canned foods.

UNIT - II

Food preservation methods: Aseptic handling, temperature treatment, dehydration, lyophilization, osmotic pressure, radiations canning, chemical preservatives (salt and sugars, organic acids, propylene oxide, wood smoke and antibiotics), mechanism of chemical preservatives.

UNIT - III

Food-borne diseases (Bacteria and Virus): Food poisoning (food intoxication and food infections); Bacterial food poisoning (*Clostridium*, *Bacillus cereus* and *Staphylococcus*); Viral infections: Rotavirus, Hepatitis A & C

UNIT - IV

Food-borne diseases (Fungus and protozoans): Fungal food poisoning (*Aspergillus* and *Penicillium*), health hazards of mycotoxins; Protozoal infections; *Entamoebahistoltyica*, *Teniasolium*, *Fasciola hepatica*

UNIT - V

Methods for microbiological examination of food and quality control: Indicator organisms for assuring the suitability of food products, methods of microbiological examination, direct culture technique, enumeration methods (plate count and MPN), alternative methods (dye reduction tests), electrical methods, quality criteria, sampling schemes.

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B.Sc 4th Year (Honors)

Semester VIII

GENERIC ELECTIVE (GE) – GENETIC ENGINEERING AND BIOTECHNOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GENETIC ENGINEERING AND BIOTECHNOLOGY	4	4	0	0	Bachelor of Science in Microbiology	Nil

BACHELOR IN MICROBIOLOGY WITH HONOURS		
Programme : <i>Bachelor in Microbiology with Honours</i>	Year: IV	Semester: VIII
Subject: Microbiology		
Course: MIC GE 10	Course Title: GENETIC ENGINEERING AND BIOTECHNOLOGY	
<p>Course outcomes: After the completion of the course the students will be able to:</p> <ol style="list-style-type: none"> 1. Understand the concept, scope and importance of traditional knowledge. 2. Study the Genetic Engineering and its role in Biotechnology . 3. Interpret the concepts of Intellectual property right . 		

Credits: 4	Generic Elective
Max. Marks:	Min. Passing Marks: As per Univ. rules

Unit 1

Introduction to genetic engineering Milestones in genetic engineering and biotechnology. Restriction modification systems: Mode of action, applications of Type II restriction enzymes in genetic engineering. DNA modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyl transferase kinases and phosphatases, and DNA

ligases. Cloning: Use of linkers and adaptors. Transformation of DNA: Chemical method, Methods of DNA, RNA and Protein analysis: Agarose gel electrophoresis, Southern - and Northern - blotting techniques

Unit 2

Vectors Cloning Vectors: Definition and Properties. Plasmid vectors: pBR and pUC series. Bacteriophage lambda and M13 based vectors. Cosmids, BACs, YACs. Expression vectors: *E.coli* lac and T7 promoter-based vectors, yeast YIp, YEp and YCp vectors, Baculovirus based vectors, mammalian SV40-based expression vectors.

Unit 3

DNA Amplification and DNA sequencing PCR: Basics of PCR, RT-PCR, Real-Time PCR. Genomic and cDNA libraries: Preparation and uses, Genome sequencing. Sanger's method of DNA Sequencing: traditional and automated sequencing.

Unit 4

Application of Genetic Engineering and Biotechnology Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral-mediated delivery, *Agrobacterium* - mediated delivery. Products of recombinant DNA technology: Products of human therapeutic interest – insulin . Bt transgenic - cotton, Gene therapy, recombinant vaccine.

Unit 5 Intellectual Property Rights Patents, Copyrights, Trademarks.

Master Of Science In Microbiology (5th year)

Semester IX

GENERIC ELECTIVE (GE) – APPLIED MICROBIOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
APPLIED MICROBIOLOGY	4	4	0	0	Honours Degree in Microbiology	Nil

MASTER OF SCIENCE IN MICROBIOLOGY		
Programme : <i>Master of Science in Microbiology</i>		Year: V Semester: IX
Subject: Microbiology		
Course: MIC GE 11	Course Title: Applied Microbiology	

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Learning objectives:

- Students will learn about the components of the Microbial products as well as their functions and response..
- To develop understanding of Process of their development
- To understand different Application of microbial Products .

Learning outcomes:

At the end of course student will be able to

- Explain the different components of Microbes involved in different product processing .
- Describe how these microbial products beneficial for welfare.

1.

Credits: 4	Generic Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: As per Univ. rules

Unit 1:

Applications and Function microbial Production of Nutraceuticals- Probiotics, Prebiotics, Synbiotics, SCP,.

Unit 2:

Biosensors: Definition, Components, Basic Characteristics, Principles, Applications. Bioplastics Definition, Properties, types and composition Environmental impact.

Unit 3:

Applications of Microbes in Biotransformation Definition, types of microbial transformations/bioconversions, biocatalysts,

Unit 4

Immobilisation methods and Applications Introduction, preparation of immobilised enzymes, RNAi Definition, RNA silencing and applications

Unit 5.

Nanotechnology Definition of nanoparticles, types, characterization and properties. Applications - drug delivery systems, antifouling, degradation of xenobiotics .

Suggested Readings

1. Harrigan WF (1998) Laboratory Methods in Food Microbiology, 3rd ed. Academic Press.
2. Garg N, Garg KL and Mukerji KG (2010) Laboratory Manual of Food Microbiology I K International Publishing House Pvt. Ltd.
3. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer.
4. Baird RM, Hodges NA and Denyer SP (2005) Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, Taylor and Francis Inc.

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Master Of Science (5th Year)

Semester IX

GENERIC ELECTIVE (GE) – MICROBIAL QUALITY CONTROL IN FOOD AND PHARMACEUTICAL INDUSTRIES

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Microbial Quality Control In Food And Pharmaceutical Industries	4	4	0	0	Honours Degree in Microbiology	Nil

MASTER OF SCIENCE IN MICROBIOLOGY

Programme : *Master of Science in Microbiology*

Year: V

Semester: IX

Subject: Microbiology

Course: MIC GE 12

Course Title: Microbial Quality Control In Food And Pharmaceutical Industries

Course outcomes: After the completion of the course the students will be able to

1. Understand the processing and importance of Herbarium.
2. Learn about the preparation of Flora.
3. Learn the basic techniques of classification.
4. Understand the collection and identification of plants.

Credits: 4	Generic Elective
Max. Marks: As per Univ. rules	Min. Passing Marks: As per Univ. rules

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Unit 1

Microbiological Laboratory and Safe Practices No. of Hours: 8

Good laboratory practices, Good microbiological practices. Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL-1, BSL-2, BSL-3. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration.

Unit 2

Determining Microbes in Food / Pharmaceutical Samples No. of Hours: 10

Culture and microscopic methods - Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical and immunological methods: Limulus lysate test for endotoxin, gel diffusion, sterility testing for pharmaceutical products. Molecular methods - Nucleic acid probes, PCR based detection, biosensors.

Unit 3

Pathogenic Microorganisms of importance in Food & Water No. of Hours: 8

Enrichment culture technique, Detection of specific microorganisms - on XLD agar, Salmonella Shigella Agar, Mannitol salt agar, EMB agar, McConkey Agar, Sabouraud Agar.
Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centres (COB, 10 min Resazurin assay).

Unit 4

HACCP for Food Safety and Microbial Standards No. of Hours: 4

Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations
Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water.

SUGGESTED READING

1. Harrigan WF (1998) Laboratory Methods in Food Microbiology, 3rd ed. Academic Press.
2. Garg N, Garg KL and Mukerji KG (2010) Laboratory Manual of Food Microbiology I K International Publishing House Pvt. Ltd.
3. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer.
4. Baird RM, Hodges NA and Denyer SP (2005) Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, Taylor and Francis Inc.

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Semester X

GENERIC ELECTIVE (GE): LICHENOLOGY

No. of Hours-60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
Lichenology	4	4	0	0	Botany in Honours Degree	Nil

MASTER OF SCIENCE IN BOTANY

Programme : *Master of Science in Botany*

Year: V Semester: X

Subject: Botany

Course: BOT
GE 13

Course Title: Lichenology

Course Outcomes:

After the completion of the course the students will be able to:

1. Understand the general characters, structure, types, reproduction and various habitats of lichens.
2. Develop conceptual skill about identifying fungi and lichens.
3. Understand the physiology and biochemistry of lichens.
4. Study the ecological and economic importance of lichens.
5. Gain knowledge about the major lichen families and their representative genera.

Credits: 4

Generic Elective

Max. Marks: As per Univ. rules

Min. Passing Marks: As per Univ. rules

Unit	Topic	No. of Hours (60)
1	Introduction, General characteristics of lichens, history of Lichenology, collection and preservation of lichens, habitat and growth form of lichens. Classification of lichens. Morphology and anatomy of lichens, Reproduction in lichens.	20
2	Physiology and chemistry of lichens, ecological and economic importance of lichens, Overview of some common lichens of Uttarakhand Himalaya.	15
3	Salient features of Parmeliaceae, Lecanoraceae, Teloschistaceae, Ramalinaceae, Physciaceae, Collemataceae, Candelariaceae, Peltigeraceae and Usneaceae.	15
4	Methods to identify different lichens. Demonstration of different lichen specimens	10

Suggested readings

- Arya, V., Kumar, B. and Arya, P. (2019). Lichen Wealth of Uttarakhand Himalaya. Lap Lambert Academic Publishing.
- Awasthi, D.D. (2000). Hand book of lichens, Bishen Singh Mahendrapal Singh: Dehradun India.
- Awasthi, D.D. (2007). A compendium of the macrolichens of India, Nepal and Sri Lanka. Dehradun Bishen Singh Mahendra pal Singh: Dehradun India.
- Sati, S.C. and Pant, P. (2023). A test Book on Lichens: The Endolichenic Fungi. Elite Publishing House, New Delhi.
- Webster, J. (1985). Introduction to Fungi. Cambridge University Press. New York.






UNIT-V Disinfection Chemical and Physical Disinfectant , UV IR Gama Radiation . Ionization and Non Ionizing

- Practical/Lab Course MIC SEC-MC-IP 1.** To determine the effect of temperature on microbial growth.
- To determine the effect of pH on microbial growth.
 - To determine the effect of oxygen on microbial growth
 - Fumigation
 - Efficacy of Disinfectant
 - Effect of uv in Microbial Growth
 - Isolation of Yeast
 - Sterilization Technique

Suggested Reading

- Dubey R.C. and Maheshwari, D.K. *A Textbook of Microbiology*. 3rd ed., S. Chand & Co, Ram Nagar, New Delhi, p. 1034. ISBN 81-219-2620-3
- Prescott's Microbiology, 10th Edition, McGraw Hill Publication
- Dubey, R.C. and Maheshwari, D.K. *Practical Microbiology*. 2nd ed., S. Chand & Co. P Ltd, New Delhi, p. 413. ISBN: 81:219-2559-2
- Dubey, R.C. *Advanced Biotechnology*. S. Chand & Co. P Ltd, New Delhi, p. 1161; ISBN: 81:219-4290-X.

Skill Enhancement Course: Food Fermentation Technology

No. of Hours-45

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Food Fermentation Technology	2	1	0	1		Nil

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Skill Enhancement Courses in Microbiology		
Programme : Skill Enhancement Courses in Microbiology	Year: I	Semester: II
Subject: Microbiology		
Course: MIC SEC 2	Food Fermentation Technology	
Learning Objective: The course aims to provide an advanced understanding of the core principles and topics of food fermentation techniques.		
Learning Outcome: <ul style="list-style-type: none"> • Understand the role of different microorganisms in Food industry • Learn different fermentation processes used in the food industry • Understand role of Probiotics in food 		

Skill Enhancement Course	
Credits: 2	Min. Passing Marks: As per Univ. rules
Max. Marks: As per Univ. rules	

- Unit 1 Fermented Foods** Definition, types, advantages and health benefits
- Unit 2 Milk Based Fermented Foods** Dahi, Yogurt, Buttermilk (Chach) and cheese: Preparation of inoculum, types of microorganisms and production process
- Unit 3 Grain Based Fermented Foods** Soy sauce, Bread, Idli and Dosa: Microorganisms and production process
- Unit 4 Vegetable and Non Vegetarian Based Fermented Foods** Pickels, Saeurkraut: Microorganisms and production process, **Fermented Meat and Fish** Types, microorganisms involved, fermentation process
- Unit 5 Probiotic and Prebiotics Foods** Definition, types, microorganisms and health benefits advantage for currant scenario .

Practical/Lab Course MIC SEC 2P

1. Preparation fermented foods
2. Isolation of curd bacteria
3. Isolation of Prebiotics
4. Preparation of Microbial products , Idli, bread, buttermilk dahi,

Skill Enhancement Course: Microbiological Analysis Of Air And Water

No. of Hours-45

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course	Eligibility	Pre-
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	Lecture	Tutorial	Practical/Practice	criteria	requisite of the Course (if any)
Microbiological Analysis Of Air And Water	2	0	1		Nil

Skill Enhancement Courses in Microbiology

Programme : Skill Enhancement Courses in Microbiology **Year: II** **Semester: III**

Subject: Microbiology

Course/MIC SEC 3 **Microbiological Analysis Of Air And Water**

Learning objectives:

- To understand how microorganisms adapt to different environments and their interaction with different habitat and also the spread of microorganism from the environment.
- To know different techniques of detection of microorganism from air, soil, and aquatic environment.
- To acquire knowledge of treating polluted water.

Learning outcomes:

At the end of course student will be able to

- Perform and demonstrate different methods used to determine the quality of water and air. Purify the household water through physical, chemical and biological method

Credits: 2

	Skill Enhancement Course
Max. Marks: As per Univ. rules	Min. Passing Marks: As per Univ. rules

UNIT – I Aeromicrobiology: Bioaerosols, Air borne microorganisms (bacteria, viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres, allergens.

UNIT – II Air Sample Collection and Analysis: Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, Identification characteristics.

UNIT – III Control Measures: Fat of bioaerosols, inactivation mechanisms – UV light, HEPA filters, desiccation, Incineration.

UNIT – IV Microbiological Analysis of Water: Sample Collection, Treatment and safety of drinking (potable) water, methods to detect portability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests.

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UNIT – V Control Measures: Precipitation, chemical disinfection, filtration, high temperature, UV light.

Practical/Lab Course MIC SEC 3P

1. Isolation of water micro flora by SPC
2. Check the water quality by Membrane filtration
3. Test of MPN
4. Isolation micro flora from fatty products
5. Complete test of fecal coli forms

Skill Enhancement Course: MICROBIAL QUALITY CONTROL IN FOOD AND

No. of Hours- 45

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Food Testing And Quality Control	2	1	0	1		Nil

Skill Enhancement Courses in Microbiology

Programme : Skill Enhancement Courses in Microbiology **Year: II** **Semester: IV**

Subject: Microbiology

Course: MIC SEC- 4 MICROBIAL QUALITY CONTROL IN FOOD AND PHARMACEUTICAL INDUSTRIES

Learning outcome : Understand the safety of microbiological lab
Understand the technique of isolation
Know about industrial lab and its standards

Credits: 2

Max. Marks: As per Univ. rules

Skill Enhancement Course

Min. Passing Marks: Asper Univ. rules

Unit I Microbiological Laboratory and Safe Practices

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Good laboratory practices - Good laboratory practices, Good microbiological practices: Biosafety cabinets - Working of biosafety cabinets, using protective clothing, specification for BSL-1, BSL-2, BSL-3. Discarding biohazardous waste - Methodology of Disinfection Autoclaving & Incineration

Unit 2 Determining Microbes in Food / Pharmaceutical Samples
Culture and microscopic methods - Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical and, sterility testing for pharmaceutical products;.

Unit 3 Pathogenic Microorganisms of Importance in Food & Water
Enrichment culture technique, Detection of specific microorganisms - on XLD agar, Salmonella Shigella Agar, Mannitol salt agar, EMB agar, McConkey Agar, Sabouraud Agar.

Unit 4 Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centres (COB, 10 min Resazurin assay)

Unit 5 HACCP for Food Safety and Microbial Standards
Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations. Microbial Standards for Different Foods and Water

Practical/Lab Course MIC-SEC 4P

1. Determine the pharmaceutical products micro flora
2. MLT
3. Sterility Testing
4. MBRT
5. Identified the selective microorganism

Skill Enhancement Course: Food Processing, Preservation and Packaging

No. of Hours- 45

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
Food Processing, Preservation and Packaging	2	1	0	1		Nil

Skill Enhancement Courses in Microbiology

Programme : Skill Enhancement Courses in Microbiology

Year: III

Semester: V

Subject: Microbiology

Course: MIC

SEC 5

Food Processing, Preservation and Packaging

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Course Outcomes:

The student at the completion will be able to –

- Adjust to protocols and guidelines relevant to the assistant role in Food Processing.
- Preservation and Packaging /Techniques
- Recognize the boundary of the Food Processing, Preservation and Packaging responsibility.
- Exhibit managing potential to the quality and safety.
- Be aware of relevant legislation, standard, policies and procedures followed in the lab Practical and internship on all units with skill partners

Credits: 2	Skill Enhancement Course
Max. Marks: As per Univ. rules	Min. Passing Marks: Asper Univ. rules

Unit 1 Introduction to food processing, food container manufacturing, food canning, food science and high processing techniques • Shelf life of processed food. • Food processing of cereals Legumes, oil seeds, fruits and vegetables Dairy products, dairy processing biotechnology, membrane technology in dairy products processing.

Unit 2 Introduction to preservation, types of preservation Natural and artificial preservative agent, class I, II and III preservative agents Methods of preservation, thermal process, Vacuum drying and dehydration, cooking and freezing Food preservation by chemicals, minimal processing of fresh foods.

Unit 3 Emerging techniques in food processing, Modified atmosphere packaging, genetic engineering

Unit 4 Emerging technologies for minimally processed fresh fruit juices, Pulse electric field, high hydrostatic pressure.

Unit 5 Environmental aspects of food processing technology, Food packaging wastes and its environmental aspects environmental impact on packaging, Food processing industry, safety in food processing

Practical/Lab Course MIC SEC 5P

1. Preservative efficacy test
2. Determination of shelf life
3. Process of canning
4. Role of environment in food process
5. Thermal Preservation technique
6. Pasteurization

Skill Enhancement Course: Biofertilizers And Biopesticides

No. of Hours-45

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		

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Biofertilizers And Biopesticides	2	1	0	1	NIH
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Skill Enhancement Courses in Microbiology

Programme : Skill Enhancement Courses in Microbiology **Year: III** **Semester: VI**

Subject: Microbiology

Course: MIC Biofertilizers And Biopesticides SEC 6

Learning Out come :

Understand the Biofertilizer and Biopesticides

Understand the impact of biofertilizer and biopesticides in nature

Credits: 2

Skill Enhancement Course

Unit 1 Biofertilizers General account of the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers. Symbiotic N₂ fixers: *Rhizobium* - Isolation, characteristics, types, inoculum production and field application, legume/pulses plants. Cyanobacteria, *Azolla* - Isolation, characterization, mass multiplication, Role in rice cultivation, Crop response, field application.

Unit 2 Non - Symbiotic N₂ fixers Free living *Azospirillum*, *Azotobacter* - free isolation, characteristics, mass inoculum production and field application.

Unit 3 Phosphate and silicate solubilizers Phosphate and silicate solubilizing microbes - Isolation, characterization, mass inoculum production, field application.

Unit 4 Mycorrhizal biofertilizers Importance of mycorrhizal inoculum, types of mycorrhizae and associated plants, Mass inoculum production of VAM, field applications of Ectomycorrhizae and VAM.

Unit 5 Bioinsecticides General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, *Bacillus thuringiensis*, production, Field applications, Viruses – cultivation and field applications. Introduction to mycoinsecticides.

Practical/Lab Course MIC SEC 6P



1. Isolation of Nitrogen fixing bacteria
2. Preparation of inoculum for large scale
3. Isolation of cyanobacteria in rice field
4. Isolation of biocides

Dr. P. S. Rao
Dr. P. S. Rao

Dr. P. S. Rao

Dr. P. S. Rao