ANNEXURE - I

B.Sc., MICROBIOLOGY(HONORS)

(AS PER NEP - 2020)

SYLLABUS

(2024-2025 onwards)

Department of Biology
The Gandhigram Rural Institute- Deemed to be University
Gandhigram-624302,
Dindigul District
Tamil Nadu
India

B.Sc., MICROBIOLOGY HONORS - (AS PER NEP - 2020)

OBE ELEMENTS

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

PEO1: To gain technical aptitude and in-depth knowledge in the respective field
PEO2: To independently carry out practical, project and interpret the results scientifically
PEO3: To utilize the skills developed for gainful employment
PEO4: To update their knowledge periodically to match international standards.
PEO5: To enhance the intellectual foundation and prepare themselves for life in a, complex dynamic, and technological world.
PEO 6: To preserve, add to and transmit knowledge in the respective discipline.

PROGRAMME OUTCOME (PO)

PO1: Become knowledgeable in the respective discipline and apply the principles of the same to the needs of the subject of the Employer/Institution/Enterprise/Society.
PO2: Gain analytical skills in the respective discipline.
PO3: Be able to design/ conduct investigations and develop solutions to solve problems using appropriate tools.
PO4: Use knowledge gained from public health and safety, cultural, societal, and environmental needs which are friendly and sustainable.
PO5: Work individually/as group, have professional ethics, able to prepare & execute projects and use knowledge obtained/update it lifelong.

PROGRAMME SPECIFIC OUTCOME (PSO)

The students of B.Sc., Microbiology Honors should be able to:
PSO1: Apply their knowledge of Microbiology in the domain of agriculture, food, & medicine.
PSO2: Utilize techniques/ procedures relevant to Microbiological research work in laboratory or field settings and develop communication skills - written, oral and visual communication.
PSO3: Use mathematical, statistical tools and appropriate technologies in understanding microbiological data
PSO4: Extent knowledge and critically evaluate current views and theories in various areas of Microbiology
PSO5: Relate scientific knowledge to research on the topic, perform experimentation, collect, analyze and present data. Work effectively with others-to connect choices, actions and ethical decision making. Have a social responsibility.

B.Sc., MICROBIOLOGY HONORS PROGRAMME 2024-2027
(AS PER NEP - 2020)

Name of the Programme	**B.Sc., MICROBIOLOGY HONORS PROGRAMME**										
Year of Introduction	**2019**				**Year of Revision**				**2024**		
Semester-wise Courses and Credit distribution	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**Total**
No. of Courses	**9**	**10**	**9**	**8**	**8**	**8**	**6**	**4**	**--**	**--**	**62**
No. of Credits	**21**	**23**	**23**	**21**	**20**	**24**	**20**	**20**	**--**	**--**	**172**

Progressive Certificate, Diploma, Bachelor's Degree or Bachelor's Degree with Honors provided at the end of each year of exit of the four-years Undergraduate Programme.

S. No	**EXIT OPTIONS**	**CREDITS REQUIRED**
1.	**Certificate** upon the successful completion of the First Year (Two Semesters) of the multidisciplinary Four-years Undergraduate Programme.	**44**
2.	**Diploma** upon the successful completion of the Second Year (Four Semesters) of the multidisciplinary Four-years Undergraduate Programme.	**88**
3.	**Basic Bachelor's Degree** at the successful completion of the Third Year (Six Semesters) of the multidisciplinary Four-year Undergraduate Programme	**132**
4.	**Bachelor's Degree with Honors** in a Discipline at the Successful Completion of the Fourth Year (Eight Semesters) of the multidisciplinary four-years Undergraduate Programme	**172**

B.Sc., MICROBIOLOGY HONORS PROGRAMME
SCHEME OF EXAMINATION

Category	Course Code	Course Title	Number of Credits	Lecture Hours per week	Exam Duration (Hrs)	Max Marks		
						CFA	ESE	Total
Semester-I								
Core-Major-1	24MBUC1101	Fundamentals of Microbiology	3	3	3	40	60	100
	24MBUC1102	Practical I: Fundamentals of Microbiology	1	3	3	60	40	100
Core-Minor-1	24CHUB1101	Chemistry-I	3	3	3	40	60	100
	24CHUB1102	Chemistry Practical- I	1	3	3	60	40	100
Multidisciplinary-1	24MB111XX	Multidisciplinary-I	3	3	3	40	60	100
Ability Enhancement Course (AEC)	24ENUA1101	Essential English: Basic	3	3	3	40	60	100
Skill Enhancement Course	24TAUS1101/ 24MLUS1101/ 24HIUS1101	Indian language (Tamil/ Malayalam/ Hindi)-I	3	3	3	40	60	100
Value Added Course VAC-1	24FSUV1001	Environmental Science	2	2	-	50	-	50
Value Added Course VAC-2	24FAUV1001 24GTUV1002	Heritage and cultural history of India(Or) Shanthi Sena	2	2	-	50	-	50
	Total		**21**	**25**				

Category	Course Code	Course Title	Number of Credits	Lecture Hours per week	Exam Duration (Hrs)	Max Marks		
						CFA	ES E	Tota l
Semester-II								
Core-Major-2	24MBUC1203	Microbial Diversity	3	3	3	40	60	100
	24MBUC1204	Practical II: Microbial Diversity	1	3	3	60	40	100
Core-Minor-2	24CHUB1203	Chemistry- II	3	3	3	40	60	100
	24CHUB1204	Chemistry Practical -II	1	3	3	60	40	100
Multidisciplinary-2	--	Multidisciplinary-II: Computational Skills	3	3	3	40	60	100
Ability Enhancement Course (AEC)	24ENUA1202	Essential English: Intermediate	3	3	3	40	60	100
Skill Enhancement Course	24TAUS1202/ 24MLUS1202/ 24HIUS1202	Indian Language (Tamil/ Malayalam/ Hindi) -II	3	3	3	40	60	100
Value Added Course VAC-3	24PEUV1001	Yoga and fitness	2	2	-	50	-	50
Value Added Course VAC-4	24GTUV1001	Let us know Gandhi	2	2	-	50	-	50
Skill Enhancement Course	24TAUF0004/ 24MLUF0004/ 24HIU F0004	Functional Tamil/ Malayalam/ Hindi	2	2	-	50	-	50
	Total		**23**	**27**				

Category	Course Code	Course Title	Number of Credits	Lecture Hours per week	Exam Duration (Hrs)	Max Marks		
						CFA	ESE	Total
Semester-III								
Core-Major-3 Core-Major-4	24MBUC2105	Basic Biochemistry	3	3	3	40	60	100
	24MBUC2106	Cell and molecular biology	4	4	3	40	60	100
	24MBUC2107	Practical III: Basic Biochemistry, Cell & Molecular Biology	1	3	3	60	40	100
Core-Minor-3	24ARUB2105	Biostatistics- I	3	3	3	40	60	100
	24ARUB2106	Biostatistics Practical- I	1	3	3	60	40	100
Multidisciplinary-3	MOOC/NPTL	Multidisciplinary-III (Online Course)	3	3	3	40	60	100
Ability Enhancement Course (AEC)	24ENUA2103	Essential English: Advanced	3	3	3	40	60	100
Skill Enhancement Course	24TAUS2103/ 24HIUS2103/ 24MLUS2103	Indian Language (Tamil/ Hindi/Malayalam)-III	3	3	3	40	60	100
Extension	24EXUE2101	Village Placement Programme	2	2	-	50	-	50
	Total		**23**	**27**				

Category	Course Code	Course Title	Number of Credits	Lecture Hours per week	Exam Duration (Hrs)	Max Marks		
						CFA	ESE	Total
Semester-IV								
Core-Major-5 Core-Major-6 Core-Major-7	24MBUC2208	Microbial Physiology	4	4	3	40	60	100
	24MBUC2209	Basic Immunology and Virology	3	3	3	40	60	100
	24MBUC2210	Medical Microbiology	4	4	3	40	60	100
	24MBUC2211	Practical IV: Microbial Physiology, Immunology and, Virology and Medical Microbiology	1	3	3	60	40	100
Core-Minor-4	24ARUB2207	Biostatistics-II	3	3	3	40	60	100
	24ARUB2208	Biostatistics Practical- II	1	3	3	60	40	100
Ability Enhancement Course (AEC)	24MBUA220X	AEC (Core Elective)	3	3	3	40	60	100
Extension	24EXUE2201	Community Engagement	2	2	-	50	-	50
		Total	**21**	**25**				

Category	Course Code	Course Title	Number of Credits	Lecture Hours per week	Exam Duration (Hrs)	Max Marks		
						CFA	ESE	Total
Semester-V								
Core-Major-8 Core-Major-9 Core-Major-10	24MBUC3112	Food Microbiology	3	3	3	40	60	100
	24MBUC3113	Practical V: Food Microbiology	1	3	3	60	40	100
	24MBUC3114	Environmental Microbiology	3	3	3	40	60	100
	24MBUC3115	Agricultural Microbiology	4	4	3	40	60	100
	24MBUC3116	Practical VI: Environmental and Agricultural Microbiology	1	3	3	60	40	100
Core-Minor-5	24MBUB3109	Medical Parasitology and Entomology	4	4	3	40	60	100
Core-Major-11	24MBUC3117	Internship	2	-	-	50	-	50
Extension	24MBUE3101	Field Study / Visit	2	2	-	50	-	50
		Total	**20**	**22**				

Category	Course Code	Course Title	Number of Credits	Lecture Hours per week	Exam Duration (Hrs)	Max Marks		
						CFA	ESE	Total
Semester-VI								
Core-Major-12 Core-Major-13 Core-Major-14 Core-Major-15	24MBUC3218	Industrial Microbiology	3	3	3	40	60	100
	24MBUC3219	Microbial Technology	4	4	3	40	60	100
	24MBUC3220	Stem cell and Regenerative Biology	4	4	3	40	60	100
	24MBUC3221	Recombinant DNA Technology	4	4	3	40	60	100
	24MBUC3222	Practical VII: Industrial Microbiology and Microbial Technology	1	3	3	60	40	100
Core-Minor-6	24MBUB3210	Communicable diseases and Prevention	4	4	3	40	60	100
Core-Major-16	24MBUC3223	Pharmaceutical Microbiology	4	4	3	40	60	100
		Project*			-	40	40 +20	100
		Total	**24**	**26**		-	-	-

B.Sc., Microbiology (Honors) 4th year

***(Eligibility- Minimum 75% and above without arrears up to 6th semesters)**

Category	Course Code	Course Title	Number of Credits	Lecture Hours per week	Exam Duration (Hrs)	Max Marks		
						CFA	ESE	Total
Semester-VII								
Core-Major-17 Core-Major-18 Core-Major-19	24MBUC4124	Bacteriology	4	4	3	40	60	100
	24MBUC4125	Mycology	4	4	3	40	60	100
	24MBUC4126	Advanced Biochemistry	3	3	3	40	60	100
	24MBUC4127	Practical VIII: Bacteriology , Mycology and Advanced Biochemistry	1	3	3	60	40	100
Core-Minor-07	24MBUC4211	Plant and Animal Cell Culture techniques	4	4	3	40	60	100
Core-Minor-08	24MBUC4112	Clinical Lab Technology	4	4	3	40	60	100
		Total	**20**	**22**				

Category	Course Code	Course Title	Number of Credits	Lecture Hours per week	Exam Duration (Hrs)	Max Marks		
						CFA	ESE	Total
Semester-VIII								
Core-Major-20	24MBUC4228	Bioinstrumentation and Research Methods	4	4	3	40	60	100
Core-Major-21	24MBUC 4229	Advanced Bacterial Genetics and Molecular Biology	3	3	3	40	60	100
	24MBUC 4230	Bioinstrumentation and Advanced Bacterial Genetics and Molecular Biology	1	3	3	60	40	100
Core-Major-22	24MBUC4231	Project**	12	12	-	120	120+60	300
		Total	**20**	**22**				

*40 marks for Internal evaluation 40 marks for External evaluation and 20 for Joint viva- voce .

**120 marks for Internal evaluation 120 marks for External evaluation and 60 marks for Joint viva-voce.

LIST OF MULTIDISCIPLINARY COURSES

Course Code	Course Title	Credits
	First Semester	
24MBI1101	Basics of Life sciences	3
	Second Semester	
24CSUI1201	Computational Skills	3
	Third Semester	
24MBI2101	Multidisciplinary-III (Online Course)	3

LIST OF ABILITY ENHANCEMENT COURSES

Course Code	Course Title	Credits
	Fourth Semester	
24MBUA2201	Quality Control and Assurance Microbiology	3
24MBUA2202	Biology for Entrepreneurship	3

SEMESTER	FIRST	COURSE CODE	24MBUC1101
Course Title	FUNDAMENTALS OF MICROBIOLOGY		
No. of Credits	3	No. of contact hours per Week	3
New Course/ Revised Course	New Course	If revised, Percentage ofRevision effected	-
Category	Core Major		
Scope of the Course (may be more than one)	• Students will be able to develop their skills on fundamentals of Microbiology • Students will be able to develop Employability in various microbiological fields		
Cognitive Levels addressed by the Course	K-1: Remember Concept and scope of microbiology K-2: Understand Emerging viruses and challenges K-3: Apply to know microbial growth, microscopy, staining, and sterilization techniques K-4: Analyze microbial culture techniques K-5: Evaluate prokaryotic and eukaryotic cell structure K-6: Create knowledge on fundamentals of microbiology		
Course Objectives	The Course aims to: • Enhance the students' knowledge on the historical aspects and development of microbiology • Know about the scope of microbiology • Give an overview on microscopy and microbial growth • Make the students knowledgeable on the various microbial techniques involved. • Acquire an overall knowledge on the morphology and functions of the structures within the prokaryotes and eukaryotes.		

Unit	Content	No. Of hours
I	**History and Scope of Microbiology** Introduction- History of Microbiology- Theories of Spontaneous Generation, Biogenesis- Contribution of Anton Van Leevwenhoek, Louis Pasteur, Robert Koch and Edward Jenner - Scope and Applications of Microbiology in various fields- Industries, Food, Agriculture, Environment, Medical and Research.	10
II	**Organization of Prokaryotic and Eukaryotic Cells** Structure and Organization of Prokaryotic and Eukaryotic Cell-Size, Shape, Structure and organization of bacterial cell wall, Membrane, Ribosomes, Nucleoid, Slime layer, Capsule, Flagella, Spores, Cysts and Plasmids. Difference between Prokaryotic and Eukaryotic cells.	10
III	**Microscopy and Staining** Microscopy- Principles and applications of Simple, Compound, Phase contrast, Fluorescent, SEM and TEM- Specimen preparations for Electron Microscope. Principles and types of staining- Simple, Differential (Gram's, Spore and Capsule).	09
IV	**Sterilization Techniques** Sterilization, Principles types: Physical- Moist heat- Dry heat- Filtration (Membrane and HEPA), Radiations, Chemical agents- Mode of action.	09
V	**Microbial Growth and Culture Techniques** Microbial growth and nutritional requirements. Batch-Continuous-Synchronous culture- Growth curve. Culture and media preparation-Types of media – Liquid, semi-solid, Solid, Natural, Semi Synthetic, Synthetic, Enriched, Selective, Differential media. Isolation-Serial dilution techniques- -Pure culture techniques-Pour plate, Spread plate and Streak plate – Preservation.	10

References

Text Books:

1. Wiley, J.M., Sherwood, L.M. and Wodverton, C.J. 2019. Prescott's Principle of Microbiology, 9th Ed., Mc Graw Hill, New York.
2. Dubey, R.C and Maheswari, D.K 2013. A text book of Microbiology, Revised Edt., S.Chand Publishers, New Delhi.
3. Pelczar, Jr., Michael, Chan E. C. S. and Kreig Noel. 2010. Microbiology. 5th Ed. Tata McGraw Hill Book Company, New Delhi.

Reference Books:

1. Stanier, Y. Roger, John L. Ingrahm, Mark L. Wheelis and Page R. Painter. 2003. General Microbiology. V Ed. MacMillan Press Ltd. New Jersey. pp: 621-626; 655-670.
2. Sundararajan, S. 2003. Microorganisms. I Ed. Anmol Publications Pvt. Ltd. New Delhi..
3. Hans G. Schlegel. 2012(Reprint). General Microbiology. VIIEd.Cambridge University Press. UK..
4. Salle, A. J. 2001. Fundamental and Principles of Bacteriology. 7th Ed. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
5. John L. Ingrahm and Catherine Ingrahm.. 2000. Introduction to Microbiology. II Ed. Brooks/Cole, Thompson Learning division. USA.

	E-Resources: 1.http://www.bac.wise.edi/microtextbook/index.php 2.http://www.microbeworld.org.uk 3.http://www.microbiologyonline.org.uk/links.html
Course Outcomes	On completion of the course, students should be able to: CO 1: Discuss important historical aspect CO2: Describe principles and applications of microscopy and staining techniques CO3: Identify key structures and their functions in both eukaryotes and Prokaryotes CO4: Perform sterilization techniques for microbial control CO5: Assess the microbial growth and demonstrate the different cultural techniques in microbiology

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	1	1	3	3
CO2	3	3	1	3	3
CO3	3	2	1	3	3
CO4	3	3	1	3	3
CO5	3	3	3	3	3

SEMESTER	**FIRST**	**COURSE CODE**	**24MBUC1102**
Course Title	**PRACTICAL-I: FUNDAMENTALS OF MICROBIOLOGY**		
No. of Credits	1	No. of contact hours per Week	3
New Course/ Revised Course	New Course	If revised, Percentage ofRevision effected	-
Category	Core Major		
Scope of the Course (may be more than one)	• Students will be able to develop their skills on fundamentals of microbiology • Students will be able to develop Employability in various fields of microbiology		
Cognitive Levels addressed by the Course	K-1: Remember Concept basic microbiology K-2: Understand the isolation and handling of microorganisms and instruments K-3: Apply to know basic microbial techniques K-4: Analyze the principles of microscopes K-5: Evaluate the morphology and functions of the structures with the prokaryotes and eukaryotes K-6: Create knowledge on fundamentals of microbiology		
Course Objectives	The Course aims to: • Enhance the student's knowledgeable and impress upon them the important aspects of microorganisms • Understand the working procedure and principles of microscopes. • Provide practical knowledge and skill in the isolation and handling of microorganisms and instruments • Know pure culture techniques and methods of culturing of microorganisms • Acquire an overall knowledge on the morphology and functions of the structures with the prokaryotes and eukaryotes		

Unit	**Content**	**No. of Hours**
1.	Safety practices in microbiological laboratory	3
2.	Cleaning of glassware's and preparation of cleaning solutions	3
3.	Handling and maintenance of microscope	6
4.	Sterilization techniques - Handling of laboratory instruments and glass wares-Autoclave, Hot air oven, Laminar air flow pH meter, Petriplates.	6
5.	Media preparation Liquid media-Nutrient broth, Solid media-Nutrient agar, Semisolid media-Nutrient semisolid medium, Differential media-Mac Conkey agar, Selective medium-EMB	6
6.	Isolation and enumeration of bacteria by serial dilution and plating and Total count (Haemocytometer count)	6
7.	Pure culture techniques-Pour plate, Spread plate and Streak plate	6
8.	Staining techniques-Simple, Differential, Spore and Capsular staining	6
9.	Determination of motility of bacteria-Hanging drop method	3
10.	Measurement of size of the microorganisms-Micrometry	3
	Total hours	**48**

References	1. James. G. Cappucino. And Natabe Sherman, 2014. Microbiology – A Laboratory Manual, X Ed., Pearson Education (Singapore) Pvt. Ltd., India. 2. Dubey, R.C and Maheswari, D.K. 2012. Practical Microbiology, 5 Ed., Chand and Company Ltd., New Delhi. 3. Aneja. K.R, 2017. Experiments in Microbiology plant pathology tissue culture and mushroom production technology, 5 Ed. New Age International publishers (P) Ltd, New Delhi. 4. John G. Holt. 2000. Bergey's Manual of Determinative Bacteriology. 9 Ed. Lippincott Williams and Wilkins, USA. 5. Kannan N, 2003. Hand book of Laboratory culture media, Reagents and Buffers. Panama Publishing Corporation, New Delhi.
	E-Resources: 1. https://www.microbe.net/resources/microbiology/web-resources/ guides.emich/immunology 2. http://oew.mit.edu/courses/.../hst-176-cellular-and-molecular.immunology-fall-2005. 3. https://www.sciencedirect.com/journal/virology 4. https://www.news-medical.net/health/What-is-Virology.aspx
Course Outcomes	**On completion of the course, students should be able to do** CO 1: Demonstrate standard methods for the isolation, identification and culturing of microorganisms CO2: Explain the staining techniques CO3: Identify the different groups of microorganisms CO4: Asses the principles and applications of microscope CO5: Examine the pure culture techniques

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

SEMESTER	**SECOND**	**COURSE CODE**	**24MBUC1203**
Course Title	**MICROBIAL DIVERSITY**		
No. of Credits	3	No. of contact hours per Week	3
New Course / Revised Course	New Course	If revised, Percentage ofRevision effected	-
Category	Core Major		
Scope of the Course	• Students will be able to develop their skills on taxonomy and diversity of different microorganisms. • Students can execute Field Projects on the diversity of microorganisms		

Cognitive Levels addressed by the Course	K-1: Remember the concept of taxonomy and diversity of microorganisms K-2: Understand characteristics of different groups of microorganisms K-3: Apply in the field study K-4: Analyze methods of classification K-5: Evaluate the importance of microorganisms K-6: Create knowledge on Diversity of prokaryotic and eukaryotic microbes
Course Objectives	The Course aims to: • Highlight the different aspects of the classification of Prokaryotes and Eukaryotes. • Enhance the student's knowledge on the diversity of microbes. • Help students have an in-depth knowledge on the different groups and species of microbes • Make the students aware of the economical value of microorganisms • Sensitize the students on critical thinking of the ill effects caused by microbes.

UNIT	Content	No. of Hours
I	**Microbial Taxonomy** Introduction to microbial classification and Taxonomy-modern approaches-Numerical, molecular taxonomy and phylogeny. Hackel three kingdom and Whittaker's five kingdom concept.	10
II	**Bacterial Diversity** Bacteria-General characteristics and classification of Eubacteria and Archaebacteria. (Bergey's Manual). *E. coli, Rhizobium* sp., *Methanobacteria* sp., Economic importance of Bacteria.	10
III	**Fungal Diversity** Fungi- General characteristics and classification (Alexopoulous, Ainsworth and G.W.Martin) of fungi. *Rhizopus* sp., *Aspergillus* sp., Economic importance of Fungi.	10

IV	**Algal and protozoan Diversity** Algae- General characters, classification, mode of reproduction and economic importance of green algae , brown algae and pyrrophyta. Salient features of *Chlorella*. Protozoa - General characters, classification, and life cycle of *Plasmodium vivax***.** Importance of protozoa.	10
V	**Viral Diversity** Virus-morphology, general characters, classification (Baltimore classification). Life cycle and mode of reproduction of plant virus TMV, bacteriophage T4, and human virus HIV. Importance of Viruses.	8
References	**Text Books:** 1. Pelczar, Jr., Michael, Chan E. C. S. and Kreig Noel. 2010. Microbiology. 5th Ed. Tata McGraw Hill Book Company, New Delhi. 2.Prescott L M, JP Haley and D A Lein. 2005. Microbiology, sixth edition, International edition, McGraw Hill, NY. 3. Wiley, J.M., Sherwood, L.M. and Wodverton, C.J. 2019. Prescott's Principle of Microbiology, 9th Ed., Mc Graw Hill, New York. 4.Alexopoulos, CJ, and Mims, C.W. 2007. Introductory Mycology, John Wiley, New York	
	Reference Books: 1. Hans G. Schlegel. 2012. General Microbiology. VII Ed. Cambridge University Press. UK. 2. S. Biwasis and Amita Biswas. 2006. An Introduction to Viruses.4 Revised Ed. Vikaas Publishing House Pvt. Ltd., New Delhi. 3. John G. Holt. 2000. Bergey's Manual of Determinative Bacteriology. 9 Ed. Lippincott Williams and Wilkins, USA 4. Chatterjee, K. D. 2019. Parasitology Protozoology and Helminthology 13Ed CBS Publishers & Distributors, New Delhi.	
	E-Resources: 1.http://www.bac.wise.edi/microtextbook/index.php 2.http://www.microbeworld.org.uk 3.http://www.staff.ncl.ac.uk/n.y.morris/lectures/class2007.html	
Course Outcomes	On completion of the course, students should be able to: CO 1: Outline the classification of prokaryotes and eukaryotes CO2: Assess the basic principles and methods for the classification of Eubacteria and Archaebacteria . CO3: Explain the basic principles and methods of classification of fungi and algae CO4: Discuss the basic principles and methods of classification of protozoa's CO5: Evaluate the basic principles and methods used for the classification of viruses	

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	1	1	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

SEMESTER	**SECOND**	**COURSE CODE**	**24MBUC1204**
Course Title	**PRACTICAL -II: MICROBIAL DIVERSITY**		
No. of Credits	1	No. of contact hours per Week	3
New Course / Revised Course	New Course	If revised, Percentage ofRevision effected	-
Category	Core Major		
Scope of the Course	• Students will be able to develop their skills on diversity of microbes • Students can execute Field Projects on the diversity of microorganisms		
Cognitive Levels addressed by the Course	K-1: Remember characteristics of microorganisms K-2: Understand microscopic observation of different microbes K-3: Apply to know observation of microbes in the fields K-4: Analyze the methods of microbial observation K-5: Evaluate the importance of taxonomy and microbial diversity K-6: Create knowledge on Diversity of prokaryotic and eukaryotic microbes		

Course Objectives	The Course aims to: • Provide practical knowledge on the cultural characteristics of microorganisms • Make the modern technical capabilities to analyse the structures of Prokaryotes and eukaryotes • Encourage development of skills on observations of organisms • Extend knowledge on diversity of microorganisms • Give skills in the isolation various microorganisms

EXP. No.	EXPERIMENTS	No. of Hours
1.	Cultural characteristics of microorganisms, colony morphology, shape and margin	6
2.	Observation on a Gram-positive bacteria.	3
3.	Observation of a Gram-negative bacteria.	3
4.	Isolation and observation of an Archae bacteria.	6
5.	Microscopic observation of Algae - *Chlamydomonas, Nostoc* and *Anabaena*	6
6.	Microscopic observation of fungi and their spores – *Mucor, Rhizopus, Aspergillus* and *Penicillium,*	3
7.	Observation of Yeast morphology and budding	3
8.	Study of the following protozoans using permanent mounts/photographs: *Amoeba*, *Entamoeba*, *Paramecium* and *Plasmodium.*	3
9.	Winogradsky's Column Experiment	3
10.	Visit to microbial rich environments like lakes and demonstrate the presence of distinct and conspicuous microorganisms.	12
	Total hours	**48**

References	1. Dubey, R.C and Maheswari, D.K. 2012. Practical Microbiology, 5 Ed., Chand and Company Ltd., New Delhi. 2. Aneja. K.R, 2017. Experiments in Microbiology plant pathology tissue culture and mushroom production technology, 5 Ed. New Age International publishers (P) Ltd, New Delhi. 3. Kannan N, 2003. Hand book of Laboratory culture media, Reagents and Buffers. Panima Publishing Corporation, New Delhi. 4. Sundararaj T. 2005. Microbiology laboratory manual. Revised and published by Aswathy Sundararaj. No.5 First cross street, Thirumalai nagar, Perungudi, Chennai. 5. James. G. Cappucino. And Natabe Sherman, 2014. Microbiology – A Laboratory Manual, X Ed., Pearson Education (Singapore) Pvt. Ltd., India. 6. Harold J Benson, 2016. Microbiological Applications - Laboratory Manual in General Microbiology. 14 Ed., Me Grew-Hill, Boston.
	E-Resources: 1.https://www.google.com/search?q=cultural+characteristics+of+bacteria&client=firefox 2.https://www.google.com/search?q=isolation+of+archaebacteria&client=firefox
Course Outcomes	**On completion of the course, students should be able to:** CO1: Identify standard methods for the isolation and identification of microorganisms. CO2: Explain the application of microbes in various habitats. CO3: Evaluate the abundance of microbes. CO4: Create microbial practical skills on microbial isolation techniques. CO5: Demonstrate the presence of distinct and conspicuous microorganisms.

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	3	3	3
CO2	3	1	1	3	3
CO3	3	1	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

SEMESTER	THIRD	COURSE CODE	24MBUC2105
Course Title	**BASIC BIOCHEMISTRY**		
No. of credits	3	No. of contact hours per week	3
New Course / Revised Course	New Course	If revised, percentage of Revision effected	-
Category	Core Major		
Scope of the Course	❖ Basic understanding on the various biological molecules and their importance ❖ Skill development for analysis of biological macromolecules ❖ Creates employability scope in the biochemical laboratories / hospitals / industries		
Cognitive Levels addressed by the course	K-1 Ability to remember chemical nature of biomolecules K-2 Develop comprehensive knowledge on classification and properties of carbohydrates, proteins, lipids & nucleic acid K-3 Use biochemical tools for better understanding of structures of biomolecules and their functions K-4 Capacity to analyse the functions of carbohydrates, proteins, and lipids K-5 Make new techniques to study Biochemical importance and regulation K-6 Assessment of the role of vitamins in normal metabolism		
Course Objectives	**The course aims to:** • Understand the nature of various biological molecules and their importance • Highlight the salient feature on the classification and structural properties of carbohydrates • Create interest on the classification and properties of proteins • Impart knowledge on the structure and functions of lipids • Acquire overall knowledge on nucleic acids and vitamins		

UNIT	Content	No. of Hours
I	**Biochemistry in the Modern World** The origins of biochemistry, Biochemistry involves the study of very large biomolecules, from biology to biochemistry- brief history of biochemistry, the need of biochemical approach, current status and scopes of biochemistry. Chemical elements – Structure of atoms, molecules and chemical bonds, chemical reactions. Water – structure, physical and chemical properties. Applications of biochemistry in medicine, nutrition and agriculture.	
II	**Carbohydrates and glycobiology** Monosaccharide and disaccharides: aldose and ketoses, asymmetric centers, cyclic structures, hexose derivatives, Glycosidic bond in disaccharide. Polysaccharides: Homopolysaccharide, Heteropolysaccharide. Carbohydrates-Sources, significance, physical and chemical properties and classification of monosaccharides - glucose and fructose, disaccharides - sucrose and lactose and polysaccharides - starch and cellulose.	13
III	**Amino acids, Peptides and Proteins** Amino acids- residues of protein, Essential and non-Essential amino acids and their roles, peptides are chains of amino acid, Proteins- Sources, significance, structure (primary, secondary and tertiary), physical and chemical properties and classification of proteins and amino acids.	13
IV	**Lipids** Lipids-Sources, significance, structure, physical and chemical properties (saponification, rancidity, definition of acid number, saponification number and iodine number) and classification of lipids-Fatty acids – Simple lipids: tertiary compound lipids (phospholipid), derived lipids: steroids (cholesterol), saturated fatty acids (butyric acid), unsaturated fatty acid (linoleic acid).	13
IV	**Nucleotides, Nucleic acids and Vitamins** Nucleic acids-Sources, significance, structure and functions of DNA, Forms of DNA- A-form, B-form, and Z-form. Structure and functions of RNA (mRNA, tRNA and rRNA). Vitamins-Sources, significance-Water soluble vitamins (vitamin Riboflavin and vitamin Ascorbic acid), fat soluble vitamins (Vitamin A, D, E and K)-Functions and deficiency syndromes.	13
References	**Text Books:** 1. Albert L Lehninger, David L Nelson and Michael M Cox. Lehninger Principles of Biochemistry, 2nd edition, Wiley publisher. 2010. 2. Deb AC. Fundamentals of Biochemistry, 10th edition, New Central Book Agency (p)ltd, London. 2011. 3. Ambika Shanmugam. Fundamentals of Biochemistry for Medical students. Nagaraj and Company Pvt ltd, India. 1998. 4. Thomas M Devlin. Textbook of Biochemistry with Clinical Correlations, 7th edition, Wiley publisher. 2010. 5. J.L. Jain 2003 Fundamental of Biochemistry S. Chand of company Ltd, New Delhi.G.S. Sandhu 2002 Text	

	book of biochemistry 18th Edn. Campus books International, New Delhi. **Reference Books:** 1. Sathyanarayana U and Chakrapani U. Biochemistry, 4th edition, Elsevier 2. publishers. 2013. 3. Rafi MD. Textbook of Biochemistry for medical students, 2nd edition, UniversitiesPress, (India) Pvt. Ltd, Hyderabad, India. 2014. 4. Rajagopal G. Concise textbook of biochemistry, 2nd edition, Ahuja Publishing House. 2010. 5. Reginald H Garrett and Charles M Grisham, 5th edition. Biochemistry, Brooks Colepublishers. 2012. 6. Denise R Ferrier. Biochemistry, 6th edition, LWW publishers. 2013. **7.** David L. Nelson and Michael M. Cox (2017). Lehninger Principles of Biochemistry, 7th edition, W.H. Freeman and Company, New York **Web resources:** 1. Onlinelearning.hms.harvad.edu/biochemistry 2. Aldrin.tripod.com/biochemistry 3. https://study.com/biochemistry-class-online.html 4. Canterbury.libguides.com/bchm/websites
Course Outcomes	On completion of the course, students should be able to: CO1: Explain the chemical nature of biological macromolecules CO2: Discuss the classification and structural properties of carbohydrates CO3: Demonstrate the sources, significance and classification of protein CO4: Outline structure and the functions of lipids. CO5: Describe the structure and the biological activities of Nucleic acid and vitamins

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	3	3	3
CO2	3	1	1	3	3
CO3	3	1	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

SEMESTER	**THIRD**	**COURSE CODE**	**24MBUC2106**
Course Title	**CELL AND MOLECULAR BIOLOGY**		
No. of credits	4	No. of contact hours per week	4
New Course / Revised Course	New Course	If revised, percentage of Revision effected	-
Category	Core Major		
Scope of the Course	• Basic understanding on the molecules of life • Developing skills to for analysis mutagenesis • Creates employability scope in the molecular screening laboratories		
Cognitive Levels addressed by the course	**K-1** Ability to remember historical developments of cell biology. **K-2** Comprehensive knowledge on molecules of life **K-3** Capacity to understand molecular mechanism cell metabolism **K-4** Use molecular techniques for better understanding of structures of DNA, RNA and Proteins **K-5** Make new techniques to transcription **K-6** Assessment of functions of DNA, RNA and Proteins		
Course Objectives	**The course aims to** • Impart information on the historical developments of cell and molecular biology. • Make the student knowledgeable on concepts cell and molecular biology. • Give an in-depth knowledge on cell metabolism. • Enhance student's knowledge on nucleic acid structure. • Expose the students on mechanisms of transcription and translation process in prokaryotes and eukaryotes.		

UNIT	**Content**	**No. of Hours**
I	**Introduction to Cells and cell research** The Origin and Evolution of Cells-The evolution of metabolism, prokaryotes, eukaryotic cells, The origin of eukaryotes, the development of multicellular organisms-Experimental models in cell biology-*E. coli*, Yeasts, *Caenorhabditis elegans* and *Drosophila melanogaster, Arabidopsis thaliana*, vertebrates, animal cell culture.	13

II	**The chemical components of a cell and membranes** Water is held together by hydrogen bonds, four types of noncovalent attractions help bring molecules together in cells, some polar molecules form acids and bases in water a cell is formed from carbon compounds, cells contain four major families of small organic molecules, the chemistry of cells is dominated by macromolecules with remarkable properties noncovalent bonds specify both the precise shape of a macromolecule and its binding to other molecules-Biomembranes structure, the lipid bilayer composition and structural organization-Membrane proteins, structure and basic functions-phospholipids, sphingolipids, and cholesterol: synthesis and intracellular movement.	13
III	**Catalysis and the use of Energy by Cells** Cell metabolism is organized by enzymes, biological order is made possible by the release of heat energy from cells, cells obtain energy by the oxidation of organic molecules, oxidation and reduction involve electron transfers, ATP is the most widely used activated carrier molecule, energy stored in ATP is often harnessed to join two molecules together, NADH and NADPH are important electron carriers, there are many other activated carrier molecules in cells, The synthesis of biological polymers is driven by ATP hydrolysis.	13
IV	**Genetic Material** Early observation on the mechanism of heredity, DNA and RNA as genetic material, Properties of Genetic material. Structure of DNA -primary, secondary and different forms (A, B & Z). Prokaryotic and Eukaryotic Chromosome Organization-Genes – definition, types and functional organization. Fine structure of gene-Central dogma of Molecular biology.	13
V	**Gene structure and expression** Organization of genes in prokaryotes & Eukaryotes. Molecular mechanism and Enzymology of Transcription in prokaryotes and Eukaryotes, post transcriptional modifications, Genetic code, Molecular mechanism and Enzymology of Translation of proteins in prokaryotes and Eukaryotes, Post translational modifications. Regulation of gene expression in prokaryotes– Operon concept, lac & trp operon.	12

References

Text Books

1. Geoffrey M. Cooper - The Cell A Molecular Approach, 8th Edition, Oxford University Press (2019).
2. Bruce Alberts, Molecular Biology of Cell, 6th Edition,2015, Garland Science, Taylor & Francis Group, LLC
3. David Freifelder, 2020, Molecular Biology, 4th Reprint., Narosa Publishing House, New Delhi, India.
4. Lansing M. Prescott, John P. Harley and Donald A. Klein (2020). Microbiology (11thEd.). Mc Graw Hill companies.
5. E.J. Gardner, M.J. Simmons, D.P. Snustad, 2006. Principles of Genetics (8th Ed.) John Wiley & Sons, New York.

References

1. Lizabeth A. Allison., Fundamental Molecular Biology, 2nd Edition, 2012 John Wiley & Sons, Inc.
2. David P. Clark, Molecular Biology, 3 rd Edition, 2019 Elsevier Inc.
3. Robert F. Weaver, Molecular Biology, 5th Edition 2012 by The McGraw-Hill Companies, Inc.
4. Michael M. Cox, Molecular Biology Principles and Practice, 2012 by W. H. Freeman and Company.
5. James D. Watson, Molecular biology of the gene, 7th Edition,2014, Cold Spring Harbor Laboratory.

Web resources

1. www.cellbio.com/education.html
2. https://www.loc.gov/rr/scitech/selected- interval/molecular.html
3. global.oup.com/uk/orc/biosciences/molbio/
4. https://www.loc.gov/rr/scitech/selected-internet/molecular.html

Course Out comes

Upon completion of this course, students be able to:

CO1: Outline the fundamental concepts of life.
CO2: Discuss the various kinds of components of a cell and membranes
CO3: Explain the mechanisms of cell catabolism.
CO4: Describe the structure and composition on genetic material.
CO5: Compare the differences of transcription & translation process in prokaryotes with eukaryotes.

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	1	1	3	3
CO2	3	2	2	3	3
CO3	3	2	1	3	3
CO4	3	2	2	3	3
CO5	3	2	2	3	3

SEMESTER	THIRD	COURSE CODE	24MBUC2107
Course Title	**PRACTICAL III: BASIC BIOCHEMISTRY AND CELL & MOLECULAR BIOLOGY**		
No. of credits	1	No. of contact hours per week	3
New Course / Revised Course	New Course	If revised, percentage of Revision effected	-
Category	Core Major		
Scope of the Course	❖ Basic understanding on genetic marker ❖ Developing skills to for analysis mutagenesis ❖ Creates employability scope in the molecular screening laboratories		
Cognitive Levels addressed by the course	K-1 Ability to remember molecular techniques K-2 Comprehensive knowledge on mutants K-3 Use molecular techniques for better understanding of DNA K-4 Capacity to understand separation of DNA and protein K-5 Make new techniques to analyse mutagenesis K-6 Assessment of DNA amplification by PCR		
Course Objectives	**The course aims to:** • Impart a practical knowledge on how to measure isolate single colony and checking genetic marker • Demonstrate antibiotic resistance mechanism • Conduct genetic mapping studies • Determine transposon mediated mutagenesis • Perform mutagenesis and isolate chromosomal and plasmid DNA		

EXP. No.	EXPERIMENTS	No. of Hours
1.	Measurement: criteria of reliability, precision, accuracy, sensitivity, specificity	3
2	Preparation of buffer solutions	3
3	Estimation of carbohydrates - Anthrone method	3
4	Estimation of Proteins - Lowry's method	3
5	Estimation of lipids - Van Handel's method	3
6	Isolation of chromosomal DNA from *E. coli*	6
7	Estimation of DNA by spectrophotometry	3
8	Isolation of Plasmid DNA from *E. coli*	6
9	Separation of DNA by Agarose gel electrophoresis	3
10	Separation of protein by PAGE and determination of molecular weight	6
11.	Transformation in *E. coli*	6
12.	Demonstration of PCR	3
	Total Hours	48

References

1. Keith Wilson and John Walker. Principles and Techniques of Practical
2. Hands on Approach-A manual for the undergraduate laboratory, Thomson
3. Sambrook J and Russell DW (2001). Molecular cloning - A laboratory manual, Cold Spring Laboratory Press, New York, 3rd Edition. Vol. 1, 2, 3.
4. Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd Edition; ASM press; 2007.
5. Methods for General and Molecular Bacteriology. 1994. R.G.E. Murray, Willis A. Wood, Noel R. Krieg,ASM Press.
6. Experiments with Gene Fusions.1994. T.Silhavy. Cold Spring Har bour Lab.Press.
7. Dubey, R.C and Maheswari, D.K. 2012. Practical Microbiology, 3 Ed Revised., Chand and Company Ltd., India.
8. Short course in Bacterial Genetics. J.H. Miller. 1992.CSHLaboratories.
9. Surzyeki S (2000). Basic Techniques in Molecular Biology, Springer.

Course Outcomes

Upon completion of this practical course, students should be able to:

CO 1: Explain how to measure isolate single colony and checking genetic marker
CO 2: Demonstrate the antibiotic resistance mechanism
CO 3: Carry out mutagenesis and isolate chromosomal and plasmid DNA
CO 4: Determine molecular weight of protein using PAGE
CO5: Demonstrate PCR

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

SEMESTER	THIRD	COURSE CODE	24ARUB2105
Course Title	BIOSTATISTICS – I		
No. of Credits	3	No. of contact hours per week	3
New Course/ Revised Course	New Course	If revised, Percentage of revision effected	-
Category	Core Minor		
Scope of the Course (may be more than one)	1. It helps to research plan studies 2. Defines various types of data, variables and sources 3. Biostatistics guides researchers in selecting appropriate statistical methods based on the data type		
Cognitive Levels addressed by the Course	K1- Understanding the terminologies and basic concepts in Biostatistics K2- Developing Skills in computation of basic statistical measures in the biological data analysis and evaluation K3- Interpretation of results that are obtained after applying statistical methods		
Course Objectives	The Course aims • To understand fundamental principles and terminologies in biostatistics. • To apply fundamental descriptive techniques for classification, tabulation, and graphical display. • To solve the problems, use summary statistics and dispersion to address issues. • To understand the concept of data shape. • To explore variable relationships and predictions.		

Unit	Content	No. of Hours
I	**Introduction to Biostatistics** Introduction to Biostatistics – definition – Types of data – Collection of data – Sources of data in Biological Science – Limitation and uses of statistics.	8
II	**Presentation of data** Nature of data - Classification of data - Tabulation of data – Diagrammatic and Graphic representation of data and uses.	6
III	**Measures of Central Tendency:** Mean, Median, Mode – Definition – Simple problems of Individual series and Discrete series, Continuous series – Merits and Demerits.	8
IV	**Measures of Variation:** Range, Mean deviation, Quartile deviation, Standard deviation, Co-efficient of variation – Definition – Simple problems – Merits and Demerits. Measures of skewness & Kurtosis.	12
V	**Correlation and Regression Analysis:** Definition – Uses - Types of correlation – Methods of correlation (Simple (problems). Regression – Definition - Uses – Regression lines by method of least squares (Simple problems) – Properties of regression lines and coefficients.	12

References

Text Books

1. Daniel WW,(1987). Biostatistics, John Wiley and Sons, New York.
2. Gupta. S.C. and Kapoor. V.k, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, (12th Ed), 2020.
3. Sampath Kumar V.S; Bio-Statistics, Manomaniam Sundaranar University Publication, Tirunelveli, 1997.
4. Verma B.L, Shukla G.D and Srivastava.R.N, Biostatistics – Perspectives in Health Care; Research and Practice, New Delhi: CBS Publishers & Distributors, 1993.
5. Veer Bala Rastogi, Bio-statistics, Medtech publication, (3rd revised Edition), 2017.

Reference Books

1. Gupta. C.B, An Introduction to Statistical Methods, New Delhi: Vikas Publishers, 2004.
2. Gupta. S.P, Statistical Methods, New Delhi: Sultan Chand& Sons, 2014.
3. R.V. Hogg and A.T. Craig, Introduction to mathematical Statistics, (7thEd), 2012.
4. Rangaswamy, A Textbook of Agricultural Statistics, (3rd Ed), New Age International Publishers, New Delhi, 2020.
5. Rohatgi, V. K. and md.Ehsanes Saleh, A.K, An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Limited, New Delhi, (2nd Ed), 2009

E-Resources

1. https://www.biostat.washington.edu/about/biostatistics
2. http://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704_BiostatisticsBasics
3. https://www.edx.org/course/biostatistics-0
4. https://www.classcentral.com/subject/biostatistics
5. https://www.coursera.org/courses?query=biostatistics

Course Outcomes	**On completion of the course, students should be able to** CO1: Get acquainted with basic concepts of statistics and its relevance with the core subject. CO2: Visualization of biological data using diagrams, graphs. CO3: Analyze the different sample characteristics using descriptive statistics. CO4: Observe and interpret the relationship between various biological parameters. CO5: Calculate and interpret relationship and prediction estimates made on biological data.

Mapping of Cos with PSOs

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	2
CO2	3	2	3	2	3
CO3	3	3	2	3	3
CO4	3	3	3	3	3
CO5	3	3	3	2	3

SEMESTER	**THIRD**	**COURSE CODE**	**24ARUB2106**
Course Title	**PRACTICAL I : BIOSTATISTICS**		
No. of Credits	1	No. of contact hours per week	3
New Course/ Revised Course	New Course	If revised, Percentage of revision effected	-
Category	Core Minor		
Scope of the Course (may be more than one)	1. It helps to design studies 2. Creating graphical representations (histograms, scatter plots) to visualize data. 3. Biostatistics guides researchers in selecting appropriate statistical methods based on the data type		
Cognitive Levels addressed by the Course	K1- Understanding the fundamental concepts in practical oriented Biostatistics K2- Developing fundamental statistical skills for analyzing and evaluating biological data. K3- Interpretation of results that are obtained after applying statistical methods		
Course Objectives	The Course aims • To use a diagrammatic presentation for collected data. • To analyze the summarization of biological data • To analyze the dispersion of biological data • To apply the concept of data shape. • To analyze the concept of relationship, cause and effect between variables		

Unit	**Content**	**No. of Hours**
I	**Presentation of data:** Diagrams – One dimension – Two dimension. Graphs – Histogram - Frequency curves and polygons.	**6**
II	**Measures of Central Tendency:** Mean, Median, Mode – Individual series, Discrete series and Continious series	**6**
III	**Measures of Variation:** Mean deviation, Quartile deviation, Standard deviation, Co-efficient of variation – Individual series, Discrete series and Continious series	**7**
IV	Measures of skewness & Kurtosis: Skewness - Karl Pearson coefficient - Bowley's coefficient – Kelly's Coefficient methods. Kurtosis – based on moments method	**6**
V	**Correlation and Regression Analysis:** Simple linear correlation – Karl Pearson and Spearman's Rank method. Simple linear regression – Method of least square.	**7**
References	**Text Books** 1. Daniel WW,(1987). Biostatistics, John Wiley and Sons, New York. 2. Gupta. S.C. and Kapoor. V.k, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, (12th Ed), 2020. 3. Sampath Kumar V.S; Bio-Statistics, Manomaniam Sundaranar University Publication, Tirunelveli, 1997. 4. Verma B.L, Shukla G.D and Srivastava.R.N, Biostatistics – Perspectives in Health Care; Research and Practice, New Delhi: CBS Publishers & Distributors, 1993. 5. Veer Bala Rastogi, Bio-statistics, Medtech publication, (3rd revised Edition), 2017.	
	Reference Books 1. Gupta. C.B, An Introduction to Statistical Methods, New Delhi: Vikas Publishers, 2004.	

	2. Gupta. S.P, Statistical Methods, New Delhi: Sultan Chand& Sons, 2014. 3. R.V. Hogg and A.T. Craig, Introduction to mathematical Statistics, (7thEd), 2012. 4. Rangaswamy, A Textbook of Agricultural Statistics, (3rd Ed), New Age International Publishers, New Delhi, 2020. 5. Rohatgi, V. K. and md.Ehsanes Saleh, A.K, An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Limited, New Delhi, (2nd Ed), 2009
	E-Resources 1. https://www.biostat.washington.edu/about/biostatististics 2. http://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704_BiostatisticsBasics 3. https://www.edx.org/course/biostatistics-0 4. https://www.classcentral.com/subject/biostatistics 5. https://www.coursera.org/courses?query=biostatistics
Course Outcomes	**On completion of the course, students should be able to** CO1: Get acquainted with basic concepts of statistics and its relevance with the core subject. CO2: Analyze and interpret biological data using diagrams, graphs. CO3: Calculate and interpret the summary statistics. CO4: Observe and interpret the relationship between various biological parameters. CO5: Calculate and interpret relationship and prediction estimates made on biological data.

Mapping of Cos with PSOs

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	2
CO2	3	2	3	2	3
CO3	3	3	2	3	3
CO4	3	3	3	3	3
CO5	3	3	3	2	3

SEMESTER	FOURTH	COURSE CODE	24MBUC2208
Course Title	**MICROBIAL PHYSIOLOGY**		
No. of Credits	4	No. of contact hours per Week	4
New Course / Revised Course	New Course	If revised, Percentage of Revision effected	-
Category	Core Major		
Scope of the Course	• Students will be able to develop basic skills in microbial physiology • Students will be able to develop their skills on and microbial metabolism		
Cognitive Levels addressed by the Course	K-1: Remember bacterial morphology and ultra structure K-2: Understand mmotility and sporulation K-3: Apply to know microbial nutrition and growth K-4: Analyze newly emerging and life-threatening diseases and control measures K-5: Evaluate photosynthesis, carbon assimilation and bacterial metabolism K-6: Create knowledge on microbial physiology and metabolism		
Course Objectives	The Course aims to: • Make the students knowledgeable on bacterial morphology and cell wall composition • Give an outline on the processes involved in motility, sporulation and quorum sensing • Provide an in-depth knowledge on microbial nutrition and growth. • Highlight photosynthetic pathways in different bacterial groups. • Expose the students to the mechanisms of bacterial respiration and energy generation.		

UNIT	Content	No. of Hours
I	**Microbial nutrition and growth:** Nutritional types – autotrophs, heterotrophs, lithotrophs and organotrophs. Transport mechanisms –diffusion-active transport. Definition of growth, Growth curve, generation time and specific growth rate. Batch culture, Continuous culture– synchronous and asynchronous culture. Factors influencing microbial growth – pH, temperature, pressure, salinity, oxygen, etc.,	9
II	**Photosynthesis and Carbon assimilation:** Photosynthesis – Oxygenic and anoxygenic, photosynthetic and accessory pigments - chlorophyll - bacteriochlorophyll- rhodopsin- carotenoids- phycobiliproteins. Carbon dioxide fixation, Calvin cycle.	9
III	**Respiratory metabolism:** Embden Meyerhof pathway- Entner Doudroff pathway, alcoholic fermentation, TCA cycle, Gluconeogenesis - Pasteur effect, Glyoxalate cycle, Electron transport chain, Substrate level and Oxidative phosphorylation, Pentose phosphate pathway. Fermentation of Carbohydrates – homo and hetero-lactic fermentations	10

IV	**Bacterial cell structure formation and motility:** Composition and cell arrangement structure and biosynthesis of cell wall in Gram positive and Gram negative bacteria. Organs of locomotion- cilia, flagella, pili or fimbriae. Swarming motility, gliding motility and motility in spirochete – chemotaxis.	10
V	**Differentiation in bacterial cells and Quorum sensing:** Differentiation in bacterial cells- sporulation and morphogenesis- structure and properties of endospore - germination and outgrowth of bacterial endospores - Dormancy. Bacterial cell division, replication of bacterial chromosome, co-ordination of cell division with replication of chromosome, partitioning of chromosome into daughter cells. Microbial biofilms and quorum sensing.	10
References	**Text Books:** 1. Byung Hong Kim and Geoffrey Michael Gadd. 2008. Bacterial Physiology and Metabolism. Cambridge University Press, UK. 2. Albert G. Moat, John W. Foster and Michael P. Spector, 2002. Microbial Physiology, 4th Edn. Wiley Liss. 3. Salle, A.J, 2007. Fundamental Principles of Bacteriology, VII Ed., Tata McGraw Hill Book Company, New Delhi.	
	Reference Books: 1. Jeremy M Berg, John L Toymoczko and Lubert Stryer, 2012. Biochemistry VII Edition. W.H. Freeman and Company, NY 2. David L. Nelson and Michael M. Cox, 2017. Lehninger Principles of Biochemistry, 7th edition, W.H. Freeman and Company, New York 3. Pelczar, Jr., Michael, Chan E. C. S. and Kreig Noel. 2010. Microbiology. 5th Ed. Tata McGraw Hill Book Company, New Delhi. 4. Roger Y. Stanier., John L. Ingraham., Mark L.Wheelis., Page R.Painter., 2003. General Microbiology, V Ed., Macmillan Press Ltd., New Jersey. 5. Charu Gera and S. Srivastava, 2006. Quorum- sensing: The phenomenon of microbial communication, Current science. 90: 666-676. 6. Lansing M. Prescott, John P. Harley and Donald A. Klein, 2002 Microbiology. V Ed. WCB/McGraw Hill Company.	
	E-Resources: a. http://www.microbiologyonline.org.uk/links.html b. http://www.edu.pe.ca/southernkings/microbacteria.htm c. https://ocw.mit.edu/courses/biology/	
Course Outcomes	**On completion of the course, students should be able to:** CO1: Explain various microbial nutrition and growth curve. CO2: Delineate the principle and mechanisms of bacterial photosynthesis and carbon assimilation. CO3: Describe the pathways involved in bacterial respiration CO4: Discuss the bacterial cell wall composition, morphology and replication. CO5: Outline the principle mechanisms of motility and sporulation in microorganisms.	

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	3	3	3
CO2	3	2	2	3	3
CO3	3	2	2	3	3
CO4	3	1	1	3	3
CO5	3	1	2	3	3

SEMESTER	**FOURTH**	**COURSE CODE**	**24MBUC2209**
Course Title	**BASIC IMMUNOLOGY AND VIROLOGY**		
No. of Credits	3	No. of contact hours per Week	3
New Course / Revised Course	New Course	If revised, Percentage ofRevision effected	
Category	Core Major		
Scope of the Course	• Students will be able to develop their skills on immunology and virology • Students will be able to develop Employability in clinical field		
Cognitive Levels addressed by the Course	• K-1: Remember Concept and scope of immunology and virology • K-2: Understand cells and organs of immune system Emerging viruses • K-3: Apply to know immunological techniques and diagnosis of viruses • K-4: Analyze structural features, functions and responsiveness of immune system • K-5: Evaluate principles underlying the preparation of vaccines • K-6: Create knowledge on immunology and virology		

Course Objectives	The Course aims to: • Elaborate the structural features of the components of the immune system as well as their functions and responsiveness. • Introduce the basics of antigen and antibody • Impart basic knowledge hypersensitivity reactions and autoimmune diseases. • Gain an in-depth knowledge on bacteriophages, plant and animal viruses • Give an insight on vaccines and monoclonal antibody production

UNIT	Content	No. of Hours
I	**Introduction to Immunology:** Historical background, innate and acquired immunity, humoral and cell mediated immunity, organs and cells involved in immune response, identification and characterization of T and B cells, cell surface receptors, cellular cooperation, MHC restriction,	9
II	**Antigen and antibodies and Antigen – antibody reactions** Antigen characteristics, types of antigens, adjuvants, immunoglobulin structure properties, theories of antibody diversity, complement, complement Activation. *In-vitro* Methods - agglutination, precipitation, complement fixation, immunofluorescence, ELISA, Radio immunoassays; *In-vivo* Methods: skin tests and immune complex tissue demonstrations.	10
III	**Hypersensitivity reactions and autoimmune diseases:** Hypersensitivity reactions – Antibody mediated - Type I anaphylaxis – Type II Antibody dependent cell cytotoxicity – TypeIII Immune complex reactions - the respective disease and immune response - Lymphokines, cytokines - Type IV hypersensitivity reactions. Autoimmune diseases – Rheumatoid arthritis, Systemic lupus erythematosus, Multiple sclerosis. Types of grafts, graft rejection –properties and types of rejection; tissue typing, immunosuppressive therapy.	10
IV	**Virology: Bacteriophages and Plant Viruses:** Introduction to virology - Outline Classification and General characteristics. Bacteriophages – T4, λ phages, M 13 and ϕ x174. Plant viruses - TMV, sugar cane mosaic virus, peanut stunt virus, cauliflower mosaic virus.	9
V	**Animal viruses and Vaccines:** DNA containing animal viruses - Adeno viruses, Herpes viruses-type-I and type-II, Pox viruses – Variola virus. RNA containing animal viruses: Picorna virus, Rhabdo virus, Hepatitis viruses -A, B and C, Orthomyxo virus – Influenza H1N1, Paramyxovirus, Retroviruses – HIV, Rubella virus and Corona virus, Arbo virus – Dengue virus, Ebola virus, Prions. Principles underlying the preparation of live, attenuated vaccines and recombinant vaccine. Monoclonal antibody - production and application.	10

References

Text Books:

1. Judith A. Owen, Jenni Punt, Sharon A. Stanford, 2013. Kuby Immunology, 7th Edn. W. H. Freeman and Company, New York
2. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt, 2016. Essential Immunology, 13 Ed. Blackwell Scientific Publishers. USA.
3. Ananthanarayanan and Jayaram Panicker. 2016.Textbook of Microbiology, 7 Ed. Orient Blackswan, Hyderabad
4. Flint, S. J., Enquist, L. W., Racaniello, V. R., and Skalka, A. M. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses, 2nd ed. 944 pp. ASM Press, Washington, DC, 2004.

Reference Books:

1. Dimmock. N.J and Eatson, A.J., Leppard, K.N. (2016). Introduction to Modern Virology. VII edition. Blackwell Scientific Publications, Oxford.7th Edition.
2. Pelczar, Jr., Michael, Chan E. C. S. and Kreig Noel. 2010. Microbiology. 5th Ed. Tata McGraw Hill Book Company, New Delhi.
3. David Greenwood, Richard Slack and John Peutherer. (2000). Medical Microbiology.15th edition, Church Hill Living stone Publication.
4. Antibodies– A Laboratory Manual; E. D. Harlow, David Lane, 2nd Edn. CSHL Press (2014).
5. Understanding Immunology (Cell and Molecular Biology in Action). (2006), Peterwood, Pearson Education Ltd.

3.Bailey and Scott‟s Diagnostic Microbiology (2002). Betty A. Forbes, Daniel F. Sahm, Alice S. Weissefeld, Ernest A Trevino. Published by C.V. Mosby

4.Essentials of Diagnostic Microbiology – Lisa Anne Shimeld, Anne T. Rodgers,

E-Resources:

a) https://www.microbe.net/resources/microbiology/web-resources/
b) guides.emich/immunology http://oew.mit.edu/courses/.../hst-176-cellular-and molecular.Immunology -fall-2005
c) https://www.google.com/search?channel=nrow5&client=firefox-b-d&q=animal+viruses+and+diagnosis

Course Outcomes	On completion of the course, students should be able to: CO1: Discuss the structural features of the components of the immune system as well as their functions and responsiveness. CO2: Explain the basics of antigen and antibody CO3: Understand the processes in hypersensitivity reactions and autoimmune diseases. CO4: Describe the structure of different viruses infecting bacteria and plants CO5: Distinguish DNA and RNA based viruses

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	1	1	3	3
CO2	3	1	1	3	3
CO3	3	1	1	3	3
CO4	3	1	1	3	3
CO5	3	1	1	3	3

SEMESTER	FOURTH	COURSE CODE	24MBUC2210
Course Title	MEDICAL MICROBIOLOGY		
No. of Credits	4	No. of contact hours per Week	4
New Course / Revised Course	New Course	If revised, percentage ofRevision effected	-
Category	Core Major		
Scope of the Course	❖ students gain the knowledge of common medically important microorganism and the diseases ❖ Learn diagnostic approaches for microbial pathogens and various control measures		
Cognitive Levels addressed by the Course	K-1: Remember the basics of medical microbiology and Epidemiology K-2: Understand the mechanisms of pathogenesis K-3: Apply to know host parasite relationship and virulence factors associated with the pathogen. K-4: Analyze the diseases caused by bacterial and protozoa K-5: Evaluate on various viral and fungal diseases K-6: Create knowledge on the types and mode of action of various antimicrobial compounds and antimicrobial resistance		
Course Objectives	The Course aims to • Introduce the history and basic concepts of medical microbiology • Gain an in-depth knowledge on microbial pathogenesis • Impart basic knowledge on bacterial diseases, prevalence and virulence factors associated with the pathogen. • Give an insight on different viral and fungal diseases • Provide outline on prevention and control of microbial diseases		

UNIT	Content	No. of Hours
I	**Introduction to medical microbiology** Early discovery of pathogenic microorganisms; development of bacteriology as scientific discipline; contributions made by eminent scientists. Importance of Microbiology in Medicine. Epidemiology and Public Health: Classification of medically important microorganisms; Normal microbial flora of human body; role of the resident flora; normal flora and the human host	9
II	**Mechanisms of microbial pathogenesis:** Establishment, spreading, tissue damage and anti-phagocytic factors; mechanism of bacterial adhesion, colonization and invasion of mucous membranes of respiratory, enteric and urogenital tracts. Role of aggressins, depolymerising enzymes, organotropisms, variation and virulence. Organs and cells involved immune system and immune response.	10
III	**Bacterial diseases:** Classification of pathogenic bacteria - mode of transmission, pathogenesis, Symptoms, laboratory diagnosis, treatment and prevention of the bacterial diseases caused by *Staphylococcus, Streptococcus, Neisseria; Corynebacterium, Clostridium, Vibrio, Yersinia, Haemophilus, Mycobacterium*, Spirochetes, Bordetella, Rickettsiae, *Chlamydia*.	10
IV	**Viral and Fungal diseases:** General properties of pathogenic viruses - mode of transmission, pathogenesis, Symptoms, laboratory diagnosis, treatment and prevention of Pox viruses; Herpes virus, Hepatitis viruses, Human Immuno deficiency viruses (HIV), and Coronavirus. Fungal diseases of man, Epidemiology. Dermatophytes, dimorphic fungi. Superficial mycoses, Subcutaneous mycoses and Systemic mycoses. Opportunistic fungal pathogens.	13

V	**Prevention of microbial infection and control:** Antimicrobial therapy; various methods of drug susceptibility testing, antibiotic assay in body fluids. Brief account on available vaccines and schedules. Emergence of multi drug resistant bacterial, fungal pathogens, extremely drug resistant (XDR) pathogens and superbugs	**12**

References	**Text Books:** 1. Jawetz, Melnick and Adelberg's (2013) Medical Microbiology 22nd edition McGraw Hill Medical Publication division 2. David Greenwood, Richard Slack and John Peutherer. (2000). Medical Microbiology.15th edition, Church Hill Living stone Publication. 3. Ananthanarayanan and Jeyaram Paniker. 2016. Textbook of Microbiology, 7th Edition, Orient Publication, New Delhi
	Reference Books: 1. Michael. J. Pelczar, JR, E.C.S. Chan, Noel R. Krieg, 2010. Microbiology. TATA McGraw Hill, New Delhi. 2. Baron EJ, Peterson LR and Finegold SM Mosby, 2013. Bailey and Scott's Diagnostic Microbiology. 13 Ed. 3. Persing DH, Tenover FC, Versalovic J, Tang Y, Unger ER, Relman DA, White TJ eds. 2004. Molecular Microbiology: Diagnostic Principles and Practice. American Society for Microbiology Press 4. Hacker J and Dorbindt U. ed. 2006. Pathogenomics: Genome analysis of pathogenic microbes. Wiley-VCH. 5. Prescott, Harley and Klein. Microbiology; McGraw-Hill (2003). 6. Molecular Toxicology; Nick Plant, Garland Science (2003). 7. Stanier, Y. Roger, John L. Ingrahm, Mark L. Wheelis and Page R.Painter. 2003. General Microbiology. V Ed. MacMillan Press Ltd. New Jersey. pp: 585-620.
	E-Resources 1. . https://www.microbe.net/resources/microbiology/web-resources/ 2. https://www.omicsonline.org/medicalmicrobiology-diagnosis.php
Course Outcomes	**On completion of the course, students should be able to:** CO1: Understand the basic concepts of medical microbiology CO2: Explain the processes in microbial pathogenesis CO3: Familiar with bacterial diseases, epidemiology and virulence factors associated with the pathogen. CO4: Compare and contrast between different viral and fungal diseases CO5: Describe the measures in prevention and control of microbial diseases

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	3	3	3
CO2	3	1	1	3	3
CO3	3	1	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

SEMESTER	FOURTH	COURSE CODE	24MBUC2211
Course Title	**PRACTICAL-IV: MICROBIAL PHYSIOLOGY, IMMUNOLOGY, VIROLOGY AND MEDICAL MICROBIOLOGY**		
No. of Credits	1	No. of contact hours per Week	3
New Course / Revised Course	New Course	If revised, Percentage ofRevision effected	-
Category	Core Major		
Scope of the Course	• Students will be able to develop basic skills in microbial physiology, clinical microbiology, virology and immunology • Students will be able to develop their skills on medical microbiological techniques		
Cognitive Levels addressed by the Course	K-1: Ability to remember the basic concepts in microbial physiology, clinical microbiology, virology and immunology techniques K-2: Understand measurement of microbial growth and Physiological characterization of bacteria K-3: Comprehensive knowledge on biochemical test K-4: Capacity to analyse clinical samples to diagnose the disease condition K-5: Make new techniques to demonstrate ELISA K-6: Assessment of techniques in virology, immunology and medical microbiology		
Course Objectives	The Course aims to: • Impart a practical knowledge on how to measure bacterial growth curve and calculate generation time • Demonstrate through experiments, the effects of environmental factors on growth of bacteria • Identify unknown bacteria and fungi based on biochemical and culture characteristics • Enhance the student's knowledge and impress upon them on the important aspects of virology, immunology and medical microbiology • Provide practical knowledge and skills in diagnostic tests.		

EXP. No.	EXPERIMENTS	No. of Hours
1.	Measurement of microbial growth- cell count, turbidity method, standard plate count and cell biomass	3
2.	Effect of pH, temperature and salinity on bacterial growth.	3
3.	Morphology of microorganisms: Morphological variations in algae (Diatoms, Chlamydomonas, & Volvox). Morphological variations in Cyanobacteria (*Oscillatoria, Nostoc, & Anabaena*), Morphological variations in fungi (*Mucor, Aspergillus, & Penicillium).*	3
4.	Physiological characterization of bacteria: IMViC test, H_2S, Oxidase, catalase, urease test, gelatin liquefaction, casein, starch hydrolysis. Carbohydrate fermentation.	3
5.	Selection, collection, and transport of specimens, blood samples, sera for microbiological and immunological examinations	3
6.	Study of virus infected plant samples	3
7	Isolation and enumeration of Anaerobic bacteria from wound specimen.	3
8	Isolation and identification of Human pathogenic fungi and other opportunistic organisms.	3
9	Fixation of Smears for microscopy and different staining techniques a) Ziehl –Neelsen method for AFB b) Leishman's staining c) Albert's staining d) Giemsa's staining	3
10.	ABO Blood grouping and Rh typing	3
11.	Agglutination tests a) WIDAL b) VDRL Test (RPR). c) RA d) ASO (Anti streptolysin 'O' Test)	3
12.	Precipitation Tests a) Immunodiffusion test b) Immunoelectrophoresis	3
13.	Demonstration of ELISA (HIV & HBs Ag)	3
14.	Visit to Diagnostic Labs and Hospitals	6

References

1. Dubey, R.C and Maheswari, D.K. 2012. Practical Microbiology, 5 Ed., Chand and Company Ltd., New Delhi.
2. Aneja. K.R, 2017. Experiments in Microbiology plant pathology tissue culture and mushroom production technology, 5 Ed. New Age International publishers (P) Ltd, New Delhi.

	3. Kannan N, 2003. Hand book of Laboratory culture media, Reagents and Buffers. Panima Publishing Corporation, New Delhi. 4. Sundararaj T. 2005. Microbiology laboratory manual. Revised and published by Aswathy Sundararaj. No.5 First cross street, Thirumalai nagar, Perungudi, Chennai. 5. James. G. Cappucino. And Natabe Sherman, 2014. Microbiology – A Laboratory Manual, X Ed., Pearson Education (Singapore) Pvt. Ltd., India. 6. Harold J Benson, 2016. Microbiological Applications - Laboratory Manual in General Microbiology. 14 Ed., Me Grew-Hill, Boston. 7. Collee, J.C., Duguid, J.P., Fraser, A.C. and Marimon, B.P. (1996) Mackie and McCartney. Practical Medical Microbiology, 14th Edn. Churchill Livingstone, London. 8. Turgeon, M.L., 1990. Immunology and serology in laboratory medicine, St.Louis, C.V. Mosby Co. 9. E. D. Harlow, David Lane, 2014. Antibodies– A Laboratory Manual; 2nd Edn. CSHL Press
	E-Resources 1. https://currentprotocols.onlinelibrary.wiley.com/journal/1934368x 2. https://microbiologysociety.org/ https://www.abpischools.org.uk/topic/diseases/
Course Outcomes	**On completion of the course, students should be able to:** CO 1: Explain bacterial growth curve and generation time CO 2: Demonstrate the effects of environmental factors on growth of bacteria CO3: Identify unknown bacteria and fungi based on biochemical and culture characteristics CO 4: Enumerate and identify pathogenic bacteria and fungi from clinical samples CO5: Perform agglutination tests to diagnose diseases

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	1	2	3	3
CO4	3	3	2	3	3
CO5	3	3	2	3	3

SEMESTER	**FOURTH**	**COURSE CODE**	**24ARUB2207**
Course Title	**BIOSTATISTICS – II**		
No. of Credits	3	No. of contact hours per week	3
New Course/ Revised Course	New Course	If revised, Percentage of revision effected	-
Category	Core Minor		
Scope of the Course (may be more than one)	1. It helps researchers determine sample sizes and designing scientific experiments 2. Choose appropriate statistical methods based on the data type 3. Biostatistical techniques to draw conclusions about populations based on sample data		
Cognitive Levels addressed by the Course	K1- Understanding the terminologies and basic concepts in probability and sampling K2- Evaluating the fundamental concept of distributions K3- Applying hypothesis testing helps assess whether observed differences are statistically significant		
Course Objectives	The Course aims • To develop a basic understanding of probability theory • To recognize common sampling designs and understand when to use each design. • To learn about common Univariate probability distributions. • To learn the fundamental steps involved in hypothesis testing. • To learn about the problems solving procedures in hypothesis testing.		

Unit	**Content**	**No. of Hours**
I	**Probability:** Random Experiment - sample point - sample space. Events - Mutually exclusive and exhaustive events. Addition and Multiplication Theorems (without proof). Discrete and continuous random variables. probability density functions and distribution functions.	8
II	**Sampling Techniques:** Concepts of population and sample - Need for sampling - Census and sample surveys - Sampling and non-sampling errors - Sample size determination – Types of population. Probability sampling and non-probability sampling Techniques,	6

III	**Standard Univariate Distributions:** Discrete and continuous distributions – Uniform – Binomial – Poisson – Normal - Exponential (elementary properties and applications only)	8
IV	**Testing of hypothesis:** Basic concepts - Simple and composite hypotheses - Types of errors - Critical region - Significance level - Size and power of the test - p-value and its interpretation. Large sample test - Test of proportions and means. Small sample test - Test of significance for single sample test for mean - Difference between two samples.	12
V	**ANOVA and Chi-square test:** Basic Concepts- Assumptions - Testing procedures – One way Classification. Test of attributes – Chi-square test of goodness of fit – properties.	12
References	**Text Books** 1. Gupta. C.B, An Introduction to Statistical Methods, New Delhi: Vikas Publishers, (23rd Ed), 2004. 2. Gupta. S.P, Statistical Methods, New Delhi: Sultan Chand, 2017. 3. Goon, A.M., M. K. Gupta and B. Das Gupta, Fundamentals of Statistics- Vol. II., World Press, Ltd, Kolkata. 2016. 4. Hogg. R.T. and A.T. Craig. A.T, Introduction to mathematical Statistics, (7thEd), 2012. 5. Rangaswamy, A Textbook of Agricultural Statistics, (3rd Ed), New Age International Publishers, New Delhi, 2020.	
	Reference Books 1. Qazi Shoeb Ahmad, Viseme Ismail, Biostatistics, University Science press, new Delhi, (1st Edition), 2008. 2. Rohatgi, V. K. and Md. Ehsanes Saleh. A.K, An Introduction to Probability Theory and Mathematical Statistics, 2nd Edition, Wiley Eastern Limited, New Delhi, 2009. 3. Siegel, Sideny, Non-Parametric Statistics for Behavioral Sciences, New Delhi: MCGraw Hill, 2006. 4. Verma B.L, Shukla G.D and Srivastava.R.N, Biostatistics – Perspectives in Health Care; Research and Practice, New Delhi: CBS Publishers & Distributors, 1993. 5. Veer Bala Rastogi, Biostatistics, Medtech publication, (3rd revised Edition), 2017.	
	E-Resources 1. https://www.biostat.washington.edu/about/biostatististics 2. http://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704_BiostatisticsBasics 3. https://www.edx.org/course/biostatistics-0 4. https://www.agrimoon.com/wp-content/uploads/Statistics.pdf 5. https://www.coursera.org/courses?query=biostatistics	
Course Outcomes	**On completion of the course, students should be able to** On completion of the course, students will be able to do the following: CO1: Compared and evaluate different probability approaches domain subject. CO2: Known about the various sampling techniques to real-world scenarios.. CO3: Recognize and understand discrete and continuous probability distributions and properties CO4: Interpret from the various estimation and parametric hypothesis testing procedures covered. CO5: Suitable scenarios chose to data there or more groups and categorical data.	

Mapping of Cos with PSOs

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	2
CO2	3	2	3	2	2
CO3	2	3	2	3	3
CO4	3	3	3	3	3
CO5	3	3	3	2	3

SEMESTER	FOURTH	COURSE CODE	24ARUB2208
Course Title	PRACTICAL II: ALLIED BIOSTATISTICS		
No. of Credits	1	No. of contact hours per week	3
New Course/ Revised Course	New Course	If revised, Percentage of revision effected	-
Category	Core Minor		
Scope of the Course (may be more than one)	1. It helps to find the practical knowledge 2. We use inferential statistics to test hypotheses about populations and samples. 3. Can explore relationships and draw meaningful conclusions.		
Cognitive Levels addressed by the Course	K1- Understanding the principles of hypothesis testing, including the formulation of null and alternative hypotheses. K2- Explore various parametric tests and their applications. K3- Learn about the association between variables		
Course Objectives	The Course aims • To learn about the probabilistic concepts. • To learn about the fitting of distributions. • To learn about z-tests for means and proportions • To learn about t-tests for independent and paired means. • To explore variation between group means between categorical variables.		

Unit	Content	No. of Hours
I	**Probability:** Problems based on permutation and combinations - Problems based on Additive and multiplication theorem.	6
II	**Fitting of distributions:** Normal – Binomial - Poisson	6
III	**Large sample test: (Parametric test)** Test of Significance for Proportion – Test of significance for sample means	7
IV	**Small Sample test: (Parametric test)** Test of Significance for population mean – Difference between two means	6
V	**ANOVA and Chi - square test:** One-Way ANOVA - One independent variable and compares means across three or more groups. Chi – Square test for goodness of fit	7

References

Text Books

1. Gupta. C.B, An Introduction to Statistical Methods, New Delhi: Vikas Publishers, (23rd Ed), 2004.
2. Gupta. S.P, Statistical Methods, New Delhi: Sultan Chand, 2017.
3. Goon, A.M., M. K. Gupta and B. Das Gupta, Fundamentals of Statistics- Vol. II., World Press, Ltd, Kolkata. 2016.
4. Hogg. R.T. and A.T. Craig. A.T, Introduction to mathematical Statistics, (7thEd), 2012.
5. Rangaswamy, A Textbook of Agricultural Statistics, (3rd Ed), New Age International Publishers, New Delhi, 2020.

Reference Books

1. Qazi Shoeb Ahmad, Viseme Ismail, Biostatistics, University Science press, new Delhi, (1st Edition), 2008.
2. Rohatgi, V. K. and Md. Ehsanes Saleh. A.K, An Introduction to Probability Theory and Mathematical Statistics, 2nd Edition, Wiley Eastern Limited, New Delhi, 2009.
3. Siegel, Sideny, Non-Parametric Statistics for Behavioral Sciences, New Delhi: MCGraw Hill, 2006.
4. Verma B.L, Shukla G.D and Srivastava.R.N, Biostatistics – Perspectives in Health Care; Research and Practice, New Delhi: CBS Publishers & Distributors, 1993.
5. Veer Bala Rastogi, Biostatistics, Medtech publication, (3rd revised Edition), 2017.

E-Resources

1. https://www.biostat.washington.edu/about/biostatististics
2. http://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704_BiostatisticsBasics
3. https://www.edx.org/course/biostatistics-0
4. https://www.agrimoon.com/wp-content/uploads/Statistics.pdf
5. https://www.coursera.org/courses?query=biostatistics

Course Outcomes

On completion of the course, students should be able to

CO1: Acquire knowledge on uncertainty of an event
CO2: Understand the fitting of theoretical distributions
CO3: Evaluate the large samples size related problems
CO4: Known about the small samples size related problems
CO5: Explore scenarios of treatment effects and group differences good fit.

Mapping of Cos with PSOs

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	3
CO2	3	2	3	2	3
CO3	3	3	2	3	3
CO4	2	3	3	3	3
CO5	3	3	3	2	2

SEMESTER	**FIFTH**	**COURSE CODE**	**24MBUC3112**
Course Title	**FOOD MICROBIOLOGY**		
No. of Credits	3	No. of contact hours per week	3
New Course/ Revised Course	New Course	If revised, Percentage of Revision effected	--
Category	Core Major		
Scope of the Course (may be more than one)	• Students will be able to develop their skill on food microbiology and know the microbial quality analysis of food products • Students can execute science projects on the food microbiology		
Cognitive Levels addressed by the Course	K-1 Ability to remember basic concepts in food and dairy microbiology K-2 Comprehensive knowledge on fermentation technologies in the food processing industry K-3 Use techniques for food and dairy products quality analysis K-4 Capacity to analyze the role of government organizations involved in food quality control K-5 Make new techniques to study food spoilage organisms and Food borne diseases K-6 Assessment of quality and safety assurance in the food and dairy industries		
Course Objectives (Maximum:5)	• Introduce the scope and development of food microbiology • Highlight fermentation technologies in the dairy and food processing industry. • Create awareness among the students about the dairy and food quality analysis and the role of government organizations involved in food quality control. • Give an overview on food spoilage organisms- Food borne diseases- to understand infection process and food borne outbreaks. • Impart knowledge on quality and safety assurance in the food and dairy industry		

UNIT	**Content**	**No. of Hours**
I	**Microbiology of Foods** Introduction - History and important food microorganism. Microorganisms in the atmosphere: airborne bacteria, airborne fungi, microorganism of soil, water, plants, microorganisms of animal origene: the skin, nose and throat. Factors affecting the microbial growth of a food- Intrinsic factor & Extrinsic factors - pH, moisture, water activity, oxidation-reduction potential, nutrient contents.	13
II	**Food spoilage and food preservation** Microbial Food Spoilage: Important Factors in Microbial Food Spoilage, Spoilage of Specific Food Groups, Food Spoilage by Microbial Enzymes, Indicators of Microbial Food Spoilage. Microbial Foodborne Diseases: Important Facts in Foodborne Diseases, Foodborne Intoxications, Foodborne Infections, Foodborne Toxic infections, New and Emerging Foodborne Pathogens. Methods of food physical preservations – drying, heat processing, chilling, and freezing, radiation - chemical methods – Nitrates, Nitrites.	13
III	**Dairy Microbiology** Introduction - Physical and chemical properties of milk. Processing of milk - homogenization, storage, and transportation. Judging and grading of milk and its products. Pasteurization and its types, Microbiological analysis of milk- DMC, SPC, MBRT, Resazurin test, Alkaline phosphatase test. Microbial contamination in milk-milk borne diseases.	13
IV	**Dairy and fermented Products** Fluid milk products and dried milk Products. Skimmed milk powder, other dairy products: Ice Cream, Butter, Whey. Milk Fermentation – Yoghurt, butter milk and Kefir.	13
V	**Food sanitation, control, and Inspection** Microbiology in food sanitation: bacteriology of water supplies, sewage and waste water supplies, microbiology of food product.Food control agencies and their regulations - Food standards - GMP, HACCP, FSO, FSSAI, FDA, BIS Systems for food safety	12
References	**Text books:** 1. Carl, A.B and Tortorello, M.L. 2014. Microbiology, 2nd Ed.Academic Press, London. 2. Sivasankar, B. 2010. Food processing and preservation, PHLLearning Pvt. Ltd., New Delhi. 3. Tucker, G.S.2008. Food Biodeterioration and Preservation. BlackwellPublishers, UK.	

	4. Jay, J.M.2000 Modern Food Microbiology 6th Ed. AspenPublication, USA.
	Reference Books 1. Jay, J.M.2000 Modern Food Microbiology 6th Ed. Aspen Publication, USA. 2. Joshi V. K and Ashok Pandey. 1999. Biotechnology: Food Fermentation Microbiology, Biochemistry and Technology. (VOL II). 3. M. R. Adams, M. O. Moss, 2007. Food Microbiology. New Age International. 4. Bibek Ray, 2004, Fundamental Food Microbiology, CRC PRESS 5. William C. Frazier and Dennis C. Westhoff. 2014.Food microbiology; Edition: 4th ed, McGraw Hill publication
	Web resources: 1. http://www.microbes.info 2. http://www.fsis.usda.gov/ 3. http://www.cdc.gov. 4. http://www.microbes.info/ resource/food microbiology 5. http://www.binewsonline.com/1/what is food microbiology.html
Course Outcomes	**On completion of the course, students should be able to:** CO1: Explain the role of microorganisms in food and factors influencing their growth. CO2: Discuss and demonstrate an overview on food spoilage organisms- Food borne diseases. CO3: Assess the techniques/processes used in microbial products using fermentation technology. CO4: Delineate the processes of sanitation in dairy industries CO5: Describe the aspects of quality assurance of milk especially HACCP and FDA

Mapping of Cos with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	2	3	3	2
CO3	3	3	3	3	3
CO4	3	2	3	3	3
CO5	2	3	3	3	2

SEMESTER	**FIFTH**	**COURSE CODE**	**24MBUC3113**
Course Title	**PRACTICAL-V: FOOD MICROBIOLOGY**		
No. of Credits	1	No. of contact hours per Week	3
New Course / Revised Course	New Course	If revised, Percentage ofRevision effected (Minimum 20%)	-
Category	Core Major		
Scope of the Course	• Students will be able to develop their practical skills on to isolate food pathogenic microorganisms from contaminated food. • Students can execute fermentation process to make various fermented products.		
Cognitive Levels addressed by the Course	K-1 Ability to remember basic concepts in food, dairy and industrial microbiology K-2 Comprehensive knowledge on microbial quality of food products K-3 Use techniques for microbial food analysis K-4 Capacity to analyze traditional fermented products to industrial fermentation K-5 Make newer approaches to develop genetically engineered microbes K-6 Assessment of on biosafety, bioethics, hazards of environmental engineering		
Course Objectives	The Course aims to: • Provide practical knowledge and skills in production as well as evaluate microbial quality of food products. • Make the modern technical capabilities to analyse food for specific microorganisms • Encourage development of skills in co-operative learning in small groups to design methods for microbial food analysis as a team and communicate the decisions of the design to peers • Extend knowledge on traditional fermented products to industrial fermentation products in the applied areas of food microbiology • Give skills in immobilization of microorganisms		
EXP. No.	**EXPERIMENTS**		**No. of Hours**
1	Food microorganisms- direct cell count and direct plate cell count from food sample		3
2	Enumeration of anaerobic bacteria from food samples		3

3	Observation of food samples to study *Lactobacillus* and *Saccharomyes*	3
4	Isolation and identification of microorganisms from canned foods	3
5	Assessment of milk quality by methylene blue reduction test	3
6	Assessment of milk quality by phosphatase test for pasteurized milk.	3
7	Isolation of lactic acid bacteria from milk sample	3
8	Wine production from grapes - analysis of physiochemical parameters	3
9	Immobilization of yeast cell using sodium alginate	3
10	Isolation of salmonella from poultry	3
11	Starch (Amylase) and casein (Protease) hydrolyses tests	3
12	Visit to Food, dairy, and Fermentation Industries	12
	Total Hours	**48 hrs**

References

1. Spencer, JFT and De spencer, ALR. 2001. Food Microbiology protocols, Humama press, Totowa, New Jersey.
2. Dubey, R.C and Maheswari, D.K. 2002. Practical Microbiology, 1st Ed., Chand and Company Ltd., India.
3. Precott, H. 2002. Laboratory excercises in Microbiology. 5th Edition. The Mac Graw – Hill Companies.
4. 4. K. R. Aneja. 1993. Experiments in Microbiology, Plant Pathology and Tissue Culture. Wishwa Prakashan. New Delhi. India.
5. Kannan N, 2003.Handbook of laboratory culture media, Reagents, Stains and buffers. Panimalar Publishing Corporation, New Delhi.

Course Outcomes

On completion of the course, students should be able to:

CO1: Identify standard methods for the isolation and identification of microorganisms in food sample.
CO2: Explain the application of rapid microbial analysis of food.
CO3: Evaluate the data obtained and report accurately on the findings.
CO4: Create microbial practical skills for the production of fermented foods.
CO5: Demonstrate practical skills in immobilization of microorganisms.

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

SEMESTER	**FIFTH**	**COURSE CODE**	**24MBUC3114**
Course Title	**ENVIRONMENTAL MICROBIOLOGY**		
No. of Credits	3	No. of contact hours per Week	3
New Course / Revised Course	New Course	If revised, Percentage ofRevision effected	-
Category	Core Major		
Scope of the Course	• Students will be able to develop their skills on environmental microbiology Students can execute Field Projects on the environmental pollution		
Cognitive Levels addressed by the Course	K-1: Remember Concept of soil and microbial interactions K-2: Understand Microbial analysis of drinking water, Aero and Aquatic microbiology K-3: Apply to know Waste management K-4: Analyze Bioremediation and Geomicrobiology K-5: Evaluate Environmental monitoring K-6: Create knowledge on Applied Environmental Microbiology		
Course Objectives	The Course aims to: • Understand the current views of microbial association in various environments; • Know an idea on Aero and Aquatic microbiology • Critically think the role of microbes in treatment of wastes/sewage • Impart information on microbial bioremediation • Study the concepts of bio-safety and environmental monitoring		

Unit	Content	No. of Hours
I	**Soil and soil microbial interactions:** Characteristics and classification of soil. Interactions between microorganisms: Mutualism, commensalism, ammensalism synergism, parasitism, predation, competition.	13
II	**Microbial analysis of drinking water, Aero and Aquatic microbiology** Microbial analysis of drinking water: Tests for coli forms - presumptive test confirmed test and completed tests. Aeromicrobiology - Phylloplane microflora – Aquatic microbiology.	13

III	**Waste management & Sewage Treatment** : Types of wastes characterization of solid and liquid wastes. Solid waste treatment–Nature of sewage and its composition. Sewage Treatment: Treatment methods primary and secondary(anaerobic–methanogenesis) treatments	13
IV	**Bioremediation and Geomicrobiology:** Microbial degradation of pesticides, Xenobiotics, degradation of lignin, cellulose and pectin. Geomicrobiology: Microbes in metal extraction, mineral leaching and mining, copper extraction by leaching and microbes in petroleum product formation. Global Environmental Problems: Global Warming, Acid rain, Ozone depletion. Bio deterioration of wood and metals.	13
V	**Environmental monitoring:** Environmental regulations - Biohazards - Types of hazardous emission – Bio safety measures - Environmental Impact Assessment.	12

References

Text Books:

1. Raina M. Maier, Ian L. Pepper and Charles P. Gerba. 2008. Environmental Microbiology. Academic Press. New York.
2. Atlas, R.M. and Bartha, R. 2002. Microbial Ecology: Fundamentals and Applications. 4 Ed., Benjamin Cummings, Redwood City.CA.
3. Subba Rao, N. S. 1995. Soil Microbiology. IV Ed. Oxford & IBH Publishing Co. Pvt. Ltd.New Delhi.
4. Salle, A.J. 2007. Fundamental Principles of Bacteriology, VII Ed., McGraw Hill Publishing Co. Ltd., New York.

Reference Books:

1. Mara. D and Horan. N 2003. The Handbook of Water and Waste Water Microbiology. Academic. Press, California.
2. Clescri, L.S., Greenberk, A.E. and Eaton, A.D.1998. Standard Methods for Examination of Water and Waste Water, 20th Edition, American Public Health Association.
3. Subba Rao, N.S. 1995. Biofertilizers in Agriculture and Forestory.3rd Ed., Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi.
4. Kumar, H.D. 1991. Biotechnology, II Ed., East – West Press Private Ltd., New Delhi.
5. Pelczar.M.J. and Reid 1986 "Microbiology". V Ed., Tata McGraw Hill Co., New Delhi.pp:593-617.

E-Resources:

1. https://www.microbe.net/resources/microbiology-web-resources
2. https;//www.microbes.info/resources/3/environmental-microbiology
3. https://blogs.ntu.edu.sg/library-resources/resource-guide-formicrobiology
4. https://www.asm.org/division/w/web-sites.htm

Course Outcomes

On completion of the course, students should be able to:

CO 1: Discuss on the soil characteristics and biogeochemical cycling
CO2: Predict the importance of microbial analysis of drinking water and Aero and aquatic microbiology
CO3: Explain the different aspects of waste management and sewage treatment systems
CO4: Elaborate on bioremediation
CO5: Evaluate the environmental monitoring regulations

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	1	1	3	3
CO2	3	3	3	3	3
CO3	3	3	1	3	3
CO4	3	3	1	3	3
CO5	3	3	1	3	3

SEMESTER	FIFTH	COURSE CODE	24MBUC3115
Course Title	AGRICULTURAL MICROBIOLOGY		
No. of Credits	4	No. of contact hours per Week	4
New Course / Revised Course	New Course	If revised, Percentage ofRevision effected	-
Category	Core Major		
Scope of the Course	• Students will be able to develop their skills on agricultural microbiology • Students will be able to develop Employability in agriculture		
Cognitive Levels addressed by the Course	K-1: Remember Concept of soil and microbes involved in agriculture K-2: Understand the importance of nitrogen fixation K-3: Apply to know the role of microbes in biogeochemical cycle K-4: Analyze the production of biofertilizers K-5: Evaluate the types and role of biopesticides K-6: Create knowledge on microbes in agriculture		
Course Objectives	The Course aims to: • Impart in-depth information on soil and agriculture • Make the students understand the role of microbes in agriculture • Give an overview on plant microbe interaction. • Make the students to know about various techniques involved in biofertilizers production • Introduce the importance of biofertilizers and biopesticides		

UNIT	Content	No. of Hours
I	**Soil Microbiology:** Soil- formation, soil structure, soil types. Physical and chemical properties of soil. Microbes in soil – types, abundance, distribution, factors influencing microbial activity in soil.	13hrs
II	**Microbial transformations of minerals:** Biogeochemical cycles-Carbon, Nitrogen, Phosphorous and Sulphur cycles. Organic matter decomposition, humus formation and C:N ratio.	13hrs
III	**Biological Nitrogen fixation:** Microorganisms in the Rhizosphere, Rhizoplane and Phylloplane-Biological nitrogen fixation, symbiotic and free living nitrogen fixation, nitrogenase- structure and function - Genetics of N_2 fixation- importance of nitrogen fixation.	13hrs
IV	**Types and production of Biofertilizers:** Biofertilizers – Importance and various types of Biofertilizer *Rhizobium, Azotobacter, Azospirillum, Cyanobacteria, Azolla*, Phosphate solubilizing microorganism-Mycorrhizal biofertilizers, PGPR - *Pseudomonas* Sp. Biofertilizers production, quality control and BIS specification.	13hrs
V	**Plant pathogenic microorganisms and Biopesticides:** Characters of plant pathogens, symptoms and control measures of bacterial, fungal and viral diseases. Microbial pesticides-classification, mode of action of bacterial pesticides (*Bacillus thuringiensis*), fungal (*Trichoderma viride*) and viral pesticides (NPV).	12hrs

References

Text Books:

1. Subba Rao, N. S., 2019. Biofertilizers in Agriculture and Forestry, 4 Ed., Cbs Publ & Dist Pvt Ltd, New Delhi.
2. Subba Rao, N. S. 1995. Soil microorganisms and plant growth. Oxford & IBH Publishing Co.Pvt.Ltd. New Delhi.
3. Martin Alexander, 1983. Introduction to Soil Microbiology, Wiley eastern Ltd., NewDelhi.

Reference Books:

1. Gupta, S.K., 2014 Approaches and trends in plant disease management. Scientific publishers, Jodhpur, India.
2. Jamaluddin *et al.*, 2013 Microbes and sustainable plant productivity. Scintific Publishers Jodhpur, India.
3. Gaur, A.C., 1999. Microbial technology for Composting of Agricultural Residues by Improved Methods, 1st print, ICAR, New Delhi.
4. Glick, B.R. AND Pasternak, J.J, 1994. Molecular Biotechnology, ASM Press, Washington DC.
5. Purohit, S. S., Kothari, P. R. and Mathur, 1993. Basic and Agricultural Biotechnology, Agrobotanical Publishers (India). Bikaner.

E-Resources:

1.https://microbewiki.kenyon.edu/index.php
2.https://www.elsevier.com/books/advances-in-agricultural-microbiology/subba-rao/
3.https://en.wikipedia.org/wiki/Agricultural_microbiology

Course Outcomes	On completion of the course, students should be able to do: CO1: Outline the physico- chemical aspects of the soil and its microbial diversity CO2: Evaluate the role of microbes in the different biogeochemical cycles and in agriculture CO3: Discuss biological nitrogen fixation in symbiotic and non symbiotic associations with plants. CO4: Explain the value, production, application and crop response of biofertilizers CO5: Apply the knowledge on biopesticides and their role in pest control.

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	1	1	3	3
CO2	3	3	3	3	3
CO3	3	1	1	3	3
CO4	3	2	2	3	3
CO5	3	3	1	3	3

SEMESTER	FIFTH	COURSE CODE	24MBUC3116
Course Title	PRACTICAL-VI: ENVIRONMENTAL AND AGRICULTURAL MICROBIOLOGY		
No. of Credits	1	No. of contact hours per Week	3
New Course/ Revised Course	New Course	If revised, Percentage of Revision effected	--
Category	Core Major		
Scope of the Course (may be more than one)	• Students will be able to develop their skills on environmental and agricultural microbiology • Students can execute Field Projects on the environmental pollution and agriculture		
Cognitive Levels addressed by the Course	K-1: Remember isolation and characterization of microbes important in environment and agriculture K-2: Understand the environmental pollution and plant-pathogen interaction K-3:(Apply potential biofertilizers in agricultural field K-4:(Analyze microbes present in different environment) K-5:(Evaluate the role of microbes in environmental pollution management and agriculture) K-6:(Create knowledge on environmental and agricultural microbiology)		
Course Objectives (Maximum:5)	The Course aims • To understand the microbes, present in different environment • To understand the role of microbes in environmental pollution management • To provide practical knowledge in the isolation and characterization of microbes important in agriculture. • To understand the plant-pathogen interaction • To be able to isolate organisms that have potential as biofertilizers		

S. No.	Content	No.of Hours
1.	Isolation and identification of micro flora of sewage and air	3
2.	Microbial assessment of water MPN test.	6
3.	Determination of BOD of polluted water	3
4.	Determination of COD of polluted water	3
5.	Demonstration of Winogradsky column	6
6.	Isolation of antagonistic microorganisms from soil	3
7.	Isolation and authentication of *Rhizobium* from legume root nodules	3
8.	Isolation of *Azotobacter* from soil	3
9.	Isolation of *Azospirillum* from roots	6
10.	Examination of Mycorrhizae-AM	3
11.	Isolation of Phosphate solubilizing bacteria from soil	3
12.	Isolation and identification of cyanobacteria	6
	Total Hours	**48 hrs**

References

Text Books:

1. Dubey,R.Cand Maheswari, D.K.2002. Practical Microbiology,1st Ed., Chandand Company Ltd., India.
2. K.R. Aneja. 1993.Experiments in Microbiology, Plant Pathology and Tissue Culture. Wishwa Prakashan. New Delhi. India.
3. Sadasivam, S and Manikam, A.1992. Biochemical methods for agricultural sciences. Wiley Eastern Ltd., New Delhi.
4. Aaronson S. (1970). Experimental Microbial Ecology, Academic Press, New York.
5. Darsha Dharajiya, Hitesh Jasani, (2015). Environmental Microbiology and Biotechnology - A

	Practical Manual
	Reference Books: 1. Collins CH, Lyne PM. (1985). Microbiological methods. Butter worths, London. 2. Clesceri LS, Greenberg AE, Eaton AD. (1998). Standard methods for examination of water & waste water. American Public Health Association.
	E-Resources: 1.https://www.google.com/search?client=firefox-b-d&q=1.+Demonstration+of+Winogardsky+coloumn. 2.https://www.google.com/searchIsolation+of+biofertilizers+from+soil
Course Outcomes	On completion of the course, students should be able to do CO1: Be able to know the different environmental pollutions CO2: Methods to determine the environmental pollution CO3: Be able to understand the importance of microbes in agriculture CO4: Be able to know the methods of isolation, identification and mass production of ioinoculants CO5: Be able to know the methods to identify plant pathogens

Mapping of Cos with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

SEMESTER	FIFTH	COURSE CODE	24MBUC3109
Course Title	MEDICAL PARASITOLOGY AND ENTOMOLOGY		
No. of Credits	4	No. of contact hours per week	4
New Course/ Revised Course	New Course	If revised, Percentage of revision effected	-
Category	Core Minor		
Scope of the Course	1. Understand the concept of entomology and parasitology 2. Know the different types of parasites 3. Learn the laboratory skills for examination of parasitic infection		
Cognitive Levels addressed by the Course	K1- Analyze the mechanism of disease transmission K2- Assess the various vector control measures K3- Identify the different types of parasites K4- Examine the blood smear preparation for parasitic infection K5- Understand the parasitic infection in immuno-compromised patients		
Course Objectives	The Course aims to: • Inculcate the vector borne diseases in humans • Explain the life cycle of human parasites • Know the life cycle of helminth parasites • Understand the cultivation of protozoan parasites • Remember the parasitic infections in immune-compromised hosts		

Unit	Content	No. of Hours
I	**Entomology and disease transmission** Modern concepts and scope of entomology. Biology and lifecycle of arthropod vectors- ticks, mites, fleas, mosquitoes and flies Mechanism of vector borne disease transmission in India. Vector control measures. Role of ICMR and VCRC in vector control in India.	13
II	**Parasitology:** Definition-types of parasites-host-parasite relationships, disease transmission and life-cycle of protozoan parasites- *Entamoeba, Plasmodium, Leishmania, Trypanosoma, Giardia, Trichomonas, Balantidium, Toxoplasma, Cryptosporidium*. Preventive and control measures of protozoan parasites.	13
III	**Helminthology:** Life cycle and diseases of Cestodes- *Taenia solium, T. saginata, T. echinococcus,* Trematodes- *Fasciola hepatica, Fasciolopsis buski, Paragonimus westermanii, Schistosomes*. Nematodes - *Ascaris, Ancylostoma, Trichuris, Trichinella, Enterobius, Strongyloides* and *Wuchereria*. Preventive and control measures of helminth parasites.	13
IV	**Laboratory techniques in parasitology:** Examination of faeces for ova and cysts - worm burden, concentration methods, floatation and sedimentation techniques staining by Iron haemotoxylin method, blood smear examinations-thick/thin smears- cultivation of protozoan parasites.	13
V	**Parasitic infections in Immuno-compromised patients:** Parasitic infections in immune-compromised hosts and AIDS patients, *Cryptosporidial* diarrhoea, *Giardiasis, Strongyloides,* infection and *Toxoplasmosis* - diagnosis and treatment.	12

References

Text Books

1. Chatterjee, K. D. 2019. Parasitology (Protozoology & Helminthology). 13 Ed. CBS Publishers & Distributors, New Delhi.
2. Jayaram Panicker, CK (2017). Text Book of Parasitology. 6 Ed, Jaypee Brothers Medical Publishers, New Delhi.
3. Parija, SC (2013). Text book of Medical Parasitology. 4 Ed. Orient longmans.
4. Arora, D.R. and Arora, B.(2002). Medical Parasitology, 1st Edn. CBS Publishers & Distributors, New Delhi.

Reference Books

1. Schmidt, G.D. john janovy, jr.and Roberts, L.S. (2009) Foundations of Parasitology, 9 Edn, McGraw-Hill, New york.
2. Levanthal, R. and Cheadle, R.S. (2020). Medical Parasitology. F.A. Davies Co., Philadelphia.
3. Robert Desowitz (1980). Ova and Parasites. Harper and Row Publishers, New York.
4. Eldridge, B.F., Edman, John. 2004. Medical Entomology, 2 Ed. Kluwer Academic Publisher

E-Resources

1. https://www.who.int/malaria/publications/atoz /9241544104_part1/en/
2. http://www.microbiologyonline.org.uk/links.html
3. http://www.microbeworld.org.uk
4. https://www.omicsonline.org/medicalmicrobiology-diagnosis.php

Course Outcomes	**On completion of the course, students should be able to:** CO1: Analyze the medical importance of vector borne diseases. CO2: Understand the life cycle and disease transmission of protozoan parasites CO3: Learn the life cycle and diseases of cestodes and nematodes parasites CO4: Remember the laboratory techniques of examining parasitic infections CO5: Realize the parasitic infection in AIDS patients.

Mapping of Cos with PSOs

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

SEMESTER	**SIXTH**	**COURSE CODE**	**24MBUC3218**
Course Title	**INDUSTRIAL MICROBIOLOGY**		
No.of Credits	3	No.of contact hours per Week	3
New Course / Revised Course	New Course	If revised, Percentage of Revision effected	-
Category	Core Major		
Scope of the Course	• Students will be able to develop their skills on industrially important microbes and knowtheir uses in biotech industries • Students can execute field Projects on the microbial fermentations		
Cognitive Levels addressedby the Course	K-1 Ability to remember basic concepts in Industrial microbiology K-2 Comprehensive knowledge on fermentation technologies K-3 Use techniques for production of various industrial microbial products. K-4 Capacity to analyze industries involving microbial technology K-5 Make newer approaches to Industrial waste and sewage treatment and disposal K-6 Assessment of on Institutional Biosafety		
Course Objectives	The Course aims to: • Understand industries involving microbial technology • Make knowledge on production of various industrial microbialproducts. • Know the various techniques used in industries. • Impart the functioning of bioreactors • Create a comprehensive knowledge on upstream and downstreamprocessing		

UNIT	**Content**	**No.of Hours**
I	**Introduction to industrial microbiology** History and concept of industrial microbiology – principle, construction and design of fermenter, types - aseptic containment, control and monitoring variables - Agitator, Aerator, Pressure Gauge, pH, DO probe.	13
II	**Screening methods for Industrially important microbes** Isolation of industrially important microbes and Screening methods - Strain selection and improvement - mutation and recombinant DNA technology.	13
III	**Fermentation process** Fermentation - batch, fed batch and continuous. Upstream fermentation process- Principles of media formulations - Media formulation strategies - carbon, nitrogen, vitamin, mineral sources, and anti-foaming agent. Industrial sterilization methods - Concepts of inoculum development. Down-stream processing – recovery and purification of fermented products – cell disruption, solvent extraction, chromatography and drying.	13
IV	**Large scale cultivation of microbes and Industrial production** Large scale cultivation of industrially important microbes. Industrial products derived from microbes- intracellular and extra cellular -fermented products- production of beverages (wine & beer) - organic acids (vinegar, & lactic acid) - enzymes (amylase, & protease), antibiotics (penicillin & streptomycin) - Importance and production of Single cell protein (SCP).	13
V	**Industrial waste disposal and its regulation** Novel approaches to industrial effluent treatment and disposal – EPA's Guide for Industrial Waste Management - Institutional Bio-safety committee.	12

References	**Text Books:** 1. Casida, L.E. 2015. Industrial Microbiology, New Age International Pvt, New Delhi 2. Stanbury, P.F., Whittaker, A. and Hali, S.J. 2017. Principles of FermentationTechnology, III Ed., Butterworth-Heinemann, Elsevier, UK 3. Srivastva, M.L. 2008. Fermentation Technology, Narosa Publ. House, NewDelhi.
	References: 1.V. K. Joshi and Ashok Pandey. 2009. Biotechnology: Food Fermentation-Microbiology, Biochemistry and Technology, Vol -2. Educational Publishers & Distributors, Kochi, India. 2.Prescott and Dunn's. 2005. Industrial Microbiology. CBS publishers andDistributors. New Delhi 3.Patel A.H. 2011. Industrial Microbiology, Laxmi Publications, New Delhi 4.Wulf Crueger and Anneliese Crueger. 2000. A textbook of Industrial Microbiology II Ed. Panima Publishing Corporation, New Delhi.
	E-Resources: 1. www.rmit.edu.au/courses/034150 2. microbiologyonline.org 3. https://www.omicsonlineorg/.../industrial-microbiology-journals-articles- ppt-list.php 4. www.nature.com/nrmicro/series/applied and industrial
Course Outcomes	**On completion of the course, students should be able to:** CO1: Discuss historical aspects of industrial microbiology and fermentationtechniques CO2: Compare screening methods for Industrial microbes CO3: Explain the biology of Industrial Microorganisms CO4: Evaluate the Industrial production of various products CO5: Apply the rules and regulation of industrial microbiology

Mapping of Cos with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	1	3	3
CO2	3	3	3	3	3
CO3	3	2	3	3	3
CO4	3	3	3	3	3
CO5	3	1	1	3	3

SEMESTER	SIXTH	COURSE CODE	24MBUC3219
Course Title	**MICROBIAL TECHNOLOGY**		
No. of Credits	**4**	No. of contact hours per Week	**4**
New Course / Revised Course	New Course	If revised, Percentage ofRevision effected	-
Category	Core Major		
Scope of the Course	❖ Basic understanding on basic concepts in microbial technology ❖ Skill development for biotransformation and production of useful compounds ❖ Creates employability scope in the biotechnology industries		
Cognitive Levels addressed by the Course	K-1 Ability to remember basic concepts in microbial technology K-2 Comprehensive knowledge on fermentation K-3 Use techniques for biotransformation and production of useful compounds K-4 Capacity to analyze pharmaceutical compounds. K-5 Make newer approaches to bio-mining and bioremediation K-6 Assessment of on biosafety, bioethics, hazards of environmental engineering		
Course Objectives	**The course aims to:** • Introduce the basic concepts of microbial biotechnology and fermentation process • Gain an in-depth knowledge on microbial productions of Energy and pharmaceutical products • Impart basic knowledge on Bio-pesticides and Biofertilizers Microbial production. • Give an insight on Bio-mining, and bioremediation • Provide outline on biosafety, bioethics, hazards of environmental engineering		

UNIT	Content	No. of Hours
I	**Introduction to Microbial technology** Definition- scope, historical development in Microbial technology – Isolation, screening, selection and strain development strategies for industrially important microorganism. Mode of culturing- Batch, Continuous and Fed-batch culture methods. Microbial growth kinetics – Formulation of fermentation media - Defined and undefined media -Factors affecting fermentation. Immobilization of microbial cells / enzymes. Biosensors – definition, types and applications.	13

II	**Microbial productions** Production of biofuel from biomass - methane, alcohol and bio-hydrogen. Production of pharmaceutical compounds through microbes – TPA, Insulin, Recombinant Vaccines – production of antibodies. Steroids. Production of antibiotics	13
III	**Bio-pesticides and Biofertilizers production** Microbial production of bio-pesticides (*Bacillus thuriengiensis*). Microbial production of biofertilizers – *(Rhizobia, Azospirillum* and AM). Single cell protein (algae and yeast)	13
IV	**Bio-mining, and bioremediation** Extraction of Cu, Au, U and rare-earth elements from ore by microbes; -recovery of petroleum by microbes - Treatment of tannery effluents by microbes. Sewage Treatment. Microorganisms in bioremediation: Degradation of xenobiotics.	13
V	**Regulation in microbial technology** Rules and regulation in microbial technology - biosafety, bioethics, hazards of environmental engineering and intellectual property rights (IPR) and protection (IIP).	12
References	**Text Books** 1. Dubey R.C., 2014. Advanced Biotechnology 1st Edition. S. Chand & Company Ltd., New Delhi. 2. Chhatoval G.R., 1995. Text book of Biotechnology, 1st Ed, Anmol Publications Pvt. Ltd., New Delhi. 3. Trevan, M.D, Boffey, S., Goulding, K.H. and Stanbury, P. 1990. Biotechnology- The basic Principles. Tata McGraw Hill, New Delhi. 4. Subba Rao, N. S., 2019. Biofertilizers in Agriculture and Forestry, 4 Ed., Cbs Publ & Dist Pvt Ltd, New Delhi. **Reference Books** 1. Dubey R.C., 2001. A text book of Biotechnology 1st Edition. S. Chand & Company Ltd., New Delhi. 2. Kumar, H.D. 1991 Biotechnology, 2nd Ed., East – West Press Private Ltd., New Delhi. 3. Demain, A.L., Solomon, N.A. 1986." Manual of Industrial Microbiology and Biotechnology", ASM Press, Washington. 4. Gupta, S.K., 2014 Approaches and trends in plant disease management. Scientific publishers, Jodhpur, India. **Web resources** 1.https://www.edx.org/learn/biotechnology 2. http://bmc biotechnol.biomedcentral.com 3. http://www.microbiologyonline.org.uk/links.html	
Course Outcomes	**Upon completion of this course, students should be able to:** CO1: Understand basic concepts of microbial technology and fermentation process CO2: Explain the process of microbial productions CO3: Familiar with production of Bio-pesticides and Biofertilizers CO4: Delineate the processes in bio-mining, and bioremediation CO5: Analyse and biosafety, bioethics, hazards of environmental engineering	

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	2	3	3
CO2	3	2	2	3	3
CO3	3	3	2	3	3
CO4	3	3	2	3	3
CO5	3	3	2	3	3

SEMESTER	SIXTH	COURSE CODE	24MBUC3220
Course Title	**STEM CELL BIOLOGY AND REGENERATIVE BIOLOGY**		
No. of Credits	4	No. of contact hours per week	4
New Course/ Revised Course	New Course	If revised, Percentage of Revision effected	--
Category	Core Major		
Scope of the Course (may be more than one)	Students will be able to develop their skills on stem cell techniques. Students will be able to develop employability skills.		
Cognitive Levels addressed by the Course	**K-1**: Remember concept and scope of stem cells. **K-2**: Understands concept on induced pluripotent stem cell technology. **K-3**: Apply various conditions for culture animal cells. **K-4**: Evaluate various methods for the characterization of the cultured cells. **K-5**: Create knowledge on therapeutic application.		
Course Objectives (Maximum:5)	**The Course aims** • The students will learn about basics of stem cells. • The student will able to learn fundamental scientific principles on stem cells. • The students will learn about development of mesenchymal stem cell. • The student will able generation and manipulation of human embryonic stem cells • The student will able to learn stem cell applications.		

UNIT	Content	No. of Hours
I	**Introduction to Stem cells** Stem cell, embryonic stem cells, embryonic germ cell, Bone marrow stem cells, adult stem cell, Differentiation. Introduction to concepts in stem cell biology (renewal, potency, etc.). Stem cell characterizations: isolation & characterizations, markers & their identification, growth factor requirements and their maintenance in culture. Pluripotency and Reprogramming.	**12**
II	**Stem Cell Development** Hematopoietic stem cell. Induced pluripotent stem (Ips) cell technology. Epigenetic memory in iPS cells. Epigenetic controls of stem cells. Early embryonic development. Lymphoid cell differentiation and maturation. Cell cycle regulators in stem cells. Molecular mechanisms of self-renewal, pluri/multipotency and lineage differentiation. Molecular basis of pluripotency and stem cell niche.	**12**
III	**The Human Umbilical Cord** A source of stem cells. Isolation of mesenchymal stem cell (MSCs) from the umbilical cord. In vitro-differentiation potential of Umbilical cord mesenchymal stem cell. In vivo applications of UCSC. Cord blood stem cells transplantation: Advantages and disadvantages. Cord blood banking.	**12**
IV	**Embryonic Stem Cell** Utilization Generation and Manipulation of Mouse Embryonic Stem Cells. Generation and Manipulation of Human Embryonic Stem Cells. Animal Models of Regeneration (Hydra, Planaria, Earthworm, Zebra fish, etc).	**12**
V	**Cancer Stem Cell** The origin of cancer stem cells, the impact of cancer stem cell concept on cancer therapy. Epigenetics and Reprogramming in Stem Cell Biology. Stem Cell Gene Therapy. Stem cell therapy for neurodegenerative diseases. Stem cell therapy for cardiac regeneration. Clinical cell transplantation for leukemia. Ethical issues associated with stem cell biology.	**12**

References

Text books:

5. Ian Freshney, R. 2010. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 6th Edition, John Wiley & Sons, Inc.
6. John M. Davis. 2011. Animal cell culture essential methods, John Wiley & Sons, Inc.
7. Regenerative Medicine and Cell Therapy (Hossein Baharvand, Nasser Aghdami. 2012).
8. Principles of Regenerative Medicine 2nd Edition (Anthony Atala, Robert Lanza, James A. Thomson &Robert Nerem. 2010).
9. Stem Cells (Anna Wobus & Kenneth Boheler. 2008).

Reference Books

1. Essentials of Stem Cell Biology 2nd Edition (Robert Lanza, 2009).
2. Kursad Turksen, Adult and Embryonic Stem Cells, Humana Press.
3. Carlson, B. M. (2007). Principles of Regenerative Biology. Elsevier Inc.. pp. 400. ISBN 978- 0-12-369439-3.
4. Reddien, P. W.; Alvarado, A. S. (2004). "Fundamentals of planarian regenerations". Annual Review of Cell and Developmental Biology 20: 7250757.
5. Reya, T; Morrison, SJ; Clarke, MF; Weissman, IL (2001 Nov 1). "Stem cells, cancer and cancer stem cells." Nature 414 (6859): 105-11.

	6. Heppner, GH; Miller, BE (1983). "Tumor heterogeneity: biological implications and therapeutic consequences". Cancer metastasis reviews 2 (1): 5-23.
	E-Resources: **1.** https://stemcellforum.org/about_stem_cell_research/useful_links.cfm
Course Outcomes	On completion of the course, students should be able to do **CO1**: To understand the basic principles and methodologies in stem cell development. **CO2**: To understand the different lineage specific stem cells. **CO3**: Understands the use of mesenchymal stem cell from the umbilical cord **CO4**: Evaluate the differences in regeneration among model organisms. **CO5**: Understands the therapeutic application of stem cells.

Mapping of Cos with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	2	3	3	2
CO3	3	3	3	3	3
CO4	3	2	3	3	3
CO5	2	3	3	3	2

SEMESTER	**SIXTH**	**COURSE CODE**	**24MBUC3221**
Course Title	**RECOMBINANT DNA TECHNOLOGY**		
No. of Credits	**4**	No. of contact hours per Week	**4**
New Course / Revised Course	**New Course**	If revised, Percentage ofRevision effected	
Category	Core Major		
Scope of the Course	❖ Basic understanding on basic concepts in genetic engineering ❖ Skill development on rDNA technology ❖ Creates employability scope in the forensic labs		
Cognitive Levels addressed by the Course	K-1 Ability to remember basic concepts in genetic engineering K-2 Comprehensive knowledge on microbial biotechnology K-3 Use techniques for detection of right clones K-4 Capacity to analyze the importance of gene transfer mechanisms K-5 Make newer approaches to gene therapy K-6 Assessment of molecular cloning		
Course Objectives	**The course aims to:** • Make the students knowledgeable on various techniques and enzymes used in recombinant DNA construction. • Give an outline on Cloning vectors and Gene libraries • Provide an in-depth knowledge on Gene transfer techniques. • Highlight the processes involved in expression of rDNA. • Expose the students on the methods to analyse the Rdna		

UNIT	Content	No. of Hours
I	**Construction of recombinant DNA** Isolation of DNA and recombinant DNA construction. Core techniques used in rDNA technology – Restriction digestion, ligation and transformation. Enzymes used- Restriction enzymes, DNA ligases, reverse transcriptase, klenow fragment, Alkaline phosphatase, Polynucleotide kinase, terminal transferase, Dnase and Rnase.	7
II	**Cloning vectors and Gene libraries** Cloning vectors - plasmids, phages and cosmids. Cloning strategies. Cloning and selection of individual genes, Gene libraries: cDNA and genomic libraries.	6
III	**Gene transfer techniques** Specialised cloning strategies. Expression vectors, Promoter probe vectors, vectors for library construction - artificial chromosomes. Gene transfer techniques – Transformation, transduction, electroporation, microinjection, Gene gun. Agrobacterium mediated gene transfer.	6
IV	**Expression of rDNA** Rationale for the design of vectors for the over expression of recombinant proteins: selection of suitable promoter sequences, ribosome binding sites, transcription terminator, fusion protein tags, purification tags, protease cleavage sites and enzymes, plasmid copy number, inducible expression systems.	6

V	**Analysis of recombinant DNA** PCR methods and application.DNA sequencing Methods; dideoxy and chemical method. Nucleic acid hybridization methods. Microarray technique.	7
References	**Text Books:** 1. Principles of gene manipulation. 1994. Old & Primrose. Blackwell Scientific Publications. 2. Molecular cloning. 3 volumes. Sambrose and Russell. 2000. CSH press. 3. Winnacker, E.L. (1987). From genes to Clones: Introduction to Gene technology. VCH Publications, Federal Republic of Germany 4. Glover, D.M. (1984) Gene Cloning:. The Mechanism of DNA Manipulation. Chapman and Hall, London. **5.** Brown, T.A. (1995) Gene Cloning. Chapman and Hall, London. **Reference Books:** 1. Albert G. Moat, John W. Foster and Michael P. Spector (2002) Microbial Physiology, 4th Edn. Wiley Liss. 2. . Glick, B.R. and Pasternak, J.J. (1994). Molecular Biotechnology, ASM Press. 3. Watson JD, Hopkins NH, Roberts JW, Steitz JA, Weiner AM. (1998). Molecular biology of the gene, 4th edition, Benjamin/Cummings publishing company **Web resources:** a. https://www.toppr.com/guides/biology/biotechnology-principles-and-process/processes-of-recombinant-dna-technology/ b. https://www.rpi.edu/dept/chem-eng/Biotech-environ/Projects00/rdna/rdna.html c. http://www.whatisbiotechnology.org/index.php/science/summary/rdna d. https://www2.le.ac.uk/projects/vgec/highereducation/topics/recombinanttechniques e. http://biology.kenyon.edu/courses/biol114/Chap08/Chapter_08a.html	
Course Outcomes	**Upon completion of this course, students should be able to:** CO1: Discuss the various techniques and enzymes used in recombinant DNA construction. CO2: Outline the Cloning vectors and Gene libraries. CO3: Explain Gene transfer techniques. CO4: Delineate processes involved in expression of rDNA. CO5: Describe the various methods to analyse the rDNA.	

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	2	3	3
CO2	3	3	2	3	3
CO3	3	3	2	3	3
CO4	3	3	2	3	3
CO5	3	3	2	3	3

SEMESTER	SIXTH	COURSE CODE	24MBUC3222
Course Title	**PRACTICAL VII: INDUSTRIAL MICROBIOLOGY AND MICROBIAL TECHNOLOGY**		
No. of Credits	**1**	No. of contact hours per Week	**3**
New Course / Revised Course	New Course	If revised, Percentage ofRevision effected	-
Category	Core Major		
Scope of the Course	❖ Skill development for microbial production of useful compounds ❖ Creates employability scope in the bio-based industries		
Cognitive Levels addressed by the Course	K-1 Ability to remember basic concepts in Industrial microbiology K-2 Comprehensive knowledge on fermentation technologies K-3 Use techniques for production of various industrial microbial products. K-4 Use techniques for biotransformation and production of useful compounds K-5 Make newer approaches to Industrial waste and sewage treatment and disposal K-6 Capacity to analyze pharmaceutical compounds.		
Course Objectives	**The course aims to:** • Understand the current views of microbial products. • Know an idea on microbial fermentation • Impart basic knowledge on Bio-pesticides and Biofertilizers Microbial production. • Give an insight on Bio-mining, and bioremediation • Provide outline on biosafety, bioethics, hazards of environmental engineering		

EXP. No.	EXPERIMENTS	No. of Hours
1	Study of different parts of fermenter	3
2	Production of citric acid by Aspergillus	6
3	Production of cellulase by solid state fermentation	6
4	Production of protease by submerged fermentation	6
5	Starch (Amylase) and lipid (lipase) hydrolysis test	6
6	Microbial production of bioethanol	3
7	Estimation of ethanol	3
8	Amylase production from *Bacillus* sp.	3
9	Immobilization of bacterial cell using sodium alginate	3
10	Lab scale production of *Rhizobium* biofertilizer	3
11	Screening of microbes for production of secondary metabolites	6
12	Industrial visit and observation of industrial fermenter and downstream process	6
	Total hours	**48 hrs**

References

1. James. G. Cappucino. And Natabe Sherman, 2014. Microbiology – A Laboratory Manual, X Ed., Pearson Education (Singapore) Pvt. Ltd., India.
2. Rajan.S and Selvi Christy R. Experimental Procedures in Life Sciences. Anajanaa Book House, Chennai
3. S. Palanichamy and M. Shunmugavelu 2009. Research methods in Biological Sciences. Palani paramount publications, Palani
4. Rodney Boyer 2001 Modern Experimental Biochemistry. III Ed. Addison Wesley Longman Pvt. Ltd, Indian Branch, Delhi, India.

Web resources:

1. https://www.microbe.net/resources/microbiology-web-resources
2. https;//www.microbes.info/resources/3/environmental-microbiology
3. https://blogs.ntu.edu.sg/library-resources/resource-guide-formicrobiology
4. https://www.asm.org/division/w/web-sites.htm

Course outcomes

Upon completion of this course, students should be able to:

CO 1: Develop skills on the aspects of industrial microbiology and fermentation techniques
CO 2: Evaluate the Industrial production of various products
CO 3: Develop practical skill molecular and biotechnological techniques
CO 4: Produce microbial products in lab scale
CO5: Capacity to analyze pharmaceutical compounds.

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	3	2	2
CO2	3	3	3	2	2
CO3	3	3	3	2	2
CO4	3	3	3	3	2
CO5	3	3	3	2	2

SEMESTER	SIXTH	COURSE CODE	24MBUB3210
Course Title	COMMUNICABLE DISEASE AND PREVENTION		
No. of Credits	4	No. of contact hours per Week	4
New Course / Revised Course	New Course	If revised, Percentage ofRevision effected	--
Category	Core Minor		
Scope of the Course	❖ students gain the knowledge of common pathogenic microorganism and the diseases ❖ Learn diagnostic approaches for microbial pathogens and various control measures		
Cognitive Levels addressed by the Course	K-1: Remember the basics concepts in infection and Epidemiology K-2: Understand pathogen, host, and environment characteristic interactions and how they create disease patterns in the population K-3: Apply to know the diseases transmitted through faecal-oral route K-4: Analyze diseases transmitted through vectors K-5: Evaluate on sexually transmitted diseases and preventive measures K-6: Create knowledge on the communicable diseases of respiratory tract		
Course Objectives	The: Course aims to • Make the students knowledgeable on the concepts of infection and epidemiology • Give an outline on the diseases transmitted through Faecal-oral route • Give an in-depth knowledge on diseases of respiratory tract. • Highlight causative agents, symptoms, treatment, and prevention of sexually transmitted diseases. • Expose the students on the vector borne diseases.		

UNIT	Content	No. of Hours
I	**Basic concepts of infection and epidemiology** Infection, Infectious Process, Host – Pathogen Interactions. Infectious Disease – definitions, incubation periods, clinical forms. Factors influencing disease transmission. Epidemiology of communicable diseases –host, reservoir, carrier, vector. Emerging and re-emerging infectious diseases. Control measures of communicable disease – Control of sources, blocking the channels of transmission, protecting the susceptible host.	9
II	**Diseases transmitted through Faecal-oral route** Prevalence, causes, symptoms, treatment and prevention of faecal-oral transmitted diseases: Cholera, Shigellosis, typhoid, viral diarrhoea, Amoebiasis, Giardiasis and Ascariasis	10
III	**Diseases of respiratory tract:** Prevalence, causative agents, symptoms, treatment, prevention and control measures of diseases of upper and lower respiratory tract: Pneumonia, Tuberculosis, Pertussis, Diphtheria, common cold, Influenza, Swine Flu, Avian Flu, Enterovirus, SARS, MERS, COVID	10
IV	**Sexually transmitted diseases:** Prevalence, causative agents, symptoms, treatment, and prevention of STDs: Chlamydia, Chancroid, Syphilis, Gonorrhoea, Genital herpes, Hepatitis B, HIV, HPV, Trichomoniasis	10
V	**Vector borne diseases** Diseases transmitted through vectors; Chikungunya, Dengue fever, Zika, Japanese encephalitis, Lymphatic filariasis, Malaria and Leishmaniasis – prevalence, symptoms, causes, treatment and control measures	9

References

Text Books:

1. Ananthanarayanan. R. and C.K. Jayaram Panicker.1997. Textbook of Microbiology Orient Longman.
2. Broude A. I. (1981): Medical "Microbiology": and Infectious Diseases W.B. Saunders & Co., Philadelphia
3. Mackie and McCartney Medical Microbiology Vol.1: Microbial Infection. Vol.2: Practical Medical Microbiology Churchill Livingstone, 1996.

Reference Books:

1. Michael. J. Pelczar, JR, E.C.S. Chan, Noel R. Krieg. 2000. Microbiology. TATA McGraw Hill. pp: 673-763.
2. Prescott, Harley and Klein, 2003. Microbiology; McGraw-Hill .
3. Stanier, Y. Roger, John L. Ingrahm, Mark L. Wheelis and Page R. Painter. 2003. General Microbiology. V Ed. MacMillan Press Ltd. New Jersey. pp: 585-620.
4. Greenwood D, Richard C.B. and PeuthererS.J.. 2000. Medical Microbiology. Churchill Livingstone.
5. D.C. Shanson, Wright PSG, 1982Microbiology in Clinical Practice. .
6. Baron EJ, Peterson LR and Finegold SM Mosby. 1990. Bailey and Scott's Diagnostic Microbiology.

E-Resources

1. . https://www.microbe.net/resources/microbiology/web-resources/
2. https://www.omicsonline.org/medicalmicrobiology-diagnosis.php

Course Outcomes	**On completion of the course, students should be able to:** CO1: Discuss the concepts of infection and epidemiology of communicable diseases. CO2: Outline the diseases transmitted through Faecal-oral route. CO3: Explain various diseases of respiratory tract. CO4: Discuss the causative agents, symptoms, treatment, and prevention of sexually transmitted diseases. CO5: Describe the causes, symptoms, treatment and control of vector borne diseases.

Mapping of Cos with PSOs

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

SEMESTER	**SIXTH**	**COURSE CODE**	**24MBUC3223**
Course Title	**PHARMACEUTICAL MICROBIOLOGY**		
No. of credits	4	No. of contact hours per week	4
New Course / Revised Course	New Course	If revised, the percentage of Revision effected	
Category	Core Major		
Scope of the Course	❖ Basic understanding of the Drugs and their production ❖ Developing skills to for analysis the action mode of action ❖ Creates employability scope in the pharmaceutical industries		
Cognitive Levels addressed by the course	K-1 Ability to remember historical developments of biologics and biopharmaceuticals K-2 Comprehensive knowledge of drug development K-3 For a better understanding of drug manufacturing practices K-4 Capacity to understand the upstreaming and down streaming processes involved in production. K-5 Assess the role of various agencies in the regulatory aspect		
Course Objectives	**The course aims to:** • Impart information on the historical developments of pharmaceutics in Microbiology • Make the student knowledgeable on drug development in industries • Expose the students to the production of drugs in the pharma industry • Give in-depth knowledge of sources and stages in production • Enhance student's interest in agencies of regulatory aspects.		

UNIT	**Content**	**No. of Hours**
I	**Introduction to Pharmaceutical Microbiology** Pharmaceuticals, biologics, and biopharmaceuticals; Introduction to pharmaceutical products; Biopharmaceuticals and pharmaceutical biotechnology; History of the pharmaceutical industry; The age of biopharmaceuticals; Biopharmaceuticals: current status and future prospects; Traditional pharmaceuticals of biological origin: Pharmaceuticals of animal origin, Pharmaceutical substances of plant origin, Pharmaceutical substances of microbial origin.	13
II	**The drug development process** Drug discovery; The impact of genomics and related technologies upon drug discovery, Microbial drugs, Rational drug design, Combinatorial approaches to drug discovery, Initial product characterization, Patent and types, Delivery of biopharmaceuticals, pre-clinical and clinical studies.	13
III	**The Drug Manufacturing Process** Guides to good manufacturing practice, The manufacturing facility: clean rooms, Cleaning, decontamination and sanitation (CDS), CDS of the general manufacturing area, CDS of process equipment, Water for biopharmaceutical processing, Generation of purified water and water for injections (WFI), Distribution system for WFI, Documentation, Specifications, Manufacturing formulae, processing and packaging instructions, Records, Generation of manufacturing records.	13
IV	**Upstreaming and Down streaming** E. coli as a source of recombinant, Expression of recombinant proteins in animal cell culture systems, Upstreaming process: Production of final product-Cell banking systems, Microbial cell fermentation, Mammalian cell culture systems. Down streaming process: Initial product recovery, Cell disruption, removal of nucleic acid, Product concentration.	13

V	**Regulatory aspects in pharmaceuticals** Good laboratory/manufacturing practices for pharmaceutical production, validation, and regulation; Government regulatory practices and policies for the pharmaceutical industry: Food and Drug Administration (FDA), The Central Drugs Standard Control Organization (CDSCO), the Drug Controller General of India (DCGI); patenting of pharmaceutical products. Good documentation practices in the pharmaceutical industry.	12

References

Text Books:

1. Geoff Hanlon & Norman A (2013). Hodges Essential Microbiology for Pharmacy and Pharmaceutical Science, Wiley-Blackwell
2. Madhu Raju Saghee, Tim Sandle, Edward C. Tidswell (2011). Microbiology and Sterility Assurance in Pharmaceuticals and Medical Devices, Business Horizons.
3. Geoff Hanlon, Norman A. Hodges (2013). Essential Microbiology for Pharmacy and Pharmaceutical Science, Wiley-Blackwell.

Reference Books:

1. Stephen P. Denyer, Norman A. Hodges, Sean P. Gorman, Brendan F. Gilmore (2011). Hugo and Russell's Pharmaceutical Microbiology, Wiley-Blackwell.
2. Prahlad Singh Mehra (2011). A Textbook of Pharmaceutical Microbiology, I K International Publishing House.
3.Gary Walsh (2003). Pharmaceutical Biotechnology Biochemistry and Biotechnology. Jhon Wiley & Sons, Ltd.

E-Resources

1. https://www.microbe.net/resources/microbiology/web-resources/
2.https://www.omicsonline.org/medicalmicrobiology-diagnosis.php

Course Outcomes

Upon completion of this course, students be able to:

CO1: Outline the fundamental concepts of pharmaceutical microbiology
CO2: Discuss the drug development process in industries
CO3: Explain the mechanisms of production process
CO4: Analyze the sources, upstreaming, and downstreaming process
CO5: Describe the role of various agencies in the regulation of manufacturing

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	1	1	3	3
CO2	3	2	1	3	3
CO3	3	3	2	3	3
CO4	3	1	1	3	3
CO5	3	3	2	3	3

SEMESTER	SEVENTH	COURSE CODE	24MBUC4124
Course Title	BACTERIOLOGY		
No. of credits	4	No. of contact hours per week	4
New Course Revised Course	New Course	If revised, percentage of Revision effected	-
Category	Core Major		
Scope of the Course (May be more than one)	❖ Basic understanding on the morphology and functions of the structures with the prokaryotes and eukaryotes ❖ Skill development in microbial cultures ❖ Creates employability scope in microbiological laboratories / hospitals / industries		
Cognitive Levels addressed by the course	K-1 Ability to remember historical and recent developments K-2 Grasp the comprehensive knowledge on Systematic bacteriology K-3 Use microbiological tools for better understanding of microbial structures and their functions K-4 Capacity to analyse factors influencing microbial growth K-5 Make new techniques to study microbial activity in nature K-6 Assessment of disease-causing microorganisms		
Course Objectives	The course aims to: • Enhance the student's knowledge in historical aspects • Acquire an overall knowledge on the morphology and functions of the structures with the prokaryotes and eukaryotes. • Make the students knowledgeable on the various cultural techniques involved in the microbiological lab • Give an overview on the disease caused by various microorganisms		

UNIT	Content	No. of Hours
I	**Introduction and classification** Introduction-Major Characteristics Used in Taxonomy - Bacterial classification according to Bergey's manual of Systematic Bacteriology. - Haekel's three kingdom concept-Whittaker's five kingdom concept -three domain concept of Carl Woese.	13
II	**Morphology, arrangement, Structure and Function** Morphology -Cell size, shape and arrangement. Ultra structure of bacteria.Cell-wall-Composition and detailed structure of Gram-positive and Gram-negative cell walls, archaebacterial cell wall. Cell membrane – structure, composition and properties. Structure and function of flagella, fimbriae, pili and gas vesicles – Chromosomes, carboxysomes – Cell division –Spores.	13
III	**Characteristics of Bacteria** Gram negative and Gram-positive bacteria: characteristics and examples. Study of typical bacteria -*Bacillus, Clostridium, Staphylococcus, Streptococcus, Escherichia, Salmonella, Shigella, Vibrio, Helicobacter, Mycoplasma* and *Chlamydia.*	12
IV	**Cultivation & Nutritional types and Reserve food materials** Cultivation of bacteria- aerobic – anaerobic. Culture media: natural and synthetic media, complex media, selective, differential, enriched and enrichment media. Growth –growth curve, batch culture, continuous culture. Factors affecting bacterial growth. Reserve food materials-Polyhydroxybutyrate-Polyphosphate Granules-Oil droplets-Cyanophycin granules and sulphur inclusions.	13
V	**Applied Bacteriology** General features- Role bacteria in biotechnology- Application of bacteria in food industry –Flavor, texture, Baking and Enzymes. Secondary metabolites: Pharmaceutical-Erythromycin, Bacteriocin- Probiotics and applications. Agriculture- Biofertilizers, *Azotobacter, Azospirillum- Phosphobacteria- Biological control- Bacterial insecticides-Bacillus thuringiensis.*	13

References

Text Books:

1. Jeffery C. Pommerville (2016). Alcamo's Fundamentals of Microbiology (Third Edition). Jones and Bartlett Learning. LLC, Burlington, MA 01803.
2. Tortora, G.J, Funke B.R. and Case, C.L..2010. Microbiology: An introduction 10th Ed, Benjamin Cummings, N.Y.
3. Wiley, J.M., Sherwood, L.M. and Wodverton, C.J. 2009. Prescott's principle of Microbiology, Mc Graw Hill, N.Y.
4. Dubey, R.C and Maheswari, D.K 2005. A text book of Microbiology, Revised Edt., S. Chand Publishers, New Delhi. Pelczar, Jr., Michael, Chan E. C. S. and Kreig Noel. 2000. Microbiology. 5th Ed. Tata McGraw Hill Book Company.

Reference Books:

1. Prescott, M. J.,Harley,J.P. and Klein, D. A. Microbiology. 5th Edition WCB Mc Graw Hill,New York,

(2002).
2. Tortora, G.J., Funke, B.R. and Case, C.L. Microbiology: An Introduction. PearsonEducation, Singapore, (2004).
3. Stanier, Y. Roger, John L. Ingrahm, Mark L. Wheelis and Page R. Painter. 2003. General Microbiology. V Ed. MacMillan Press Ltd. New Jersey. pp: 621-626; 655-670.
4. Sundararajan, S. 2003. Microorganisms. I Ed. Anmol Publications Pvt. Ltd. New Delhi
5. Hans G. Schlegel. 2012(Reprint). General Microbiology. VII Ed. Cambridge University Press. UK.
6. Salle, A. J. 2001. Fundamental and Principles of Bacteriology. 7th Ed. Tata McGraw Hill Publishing Co. Ltd.
7. John L. Ingrahm and Catherine Ingrahm, 2000. Introduction to Microbiology. II Ed. Brooks/Cole, Thompson Learning division. USA.
8. Lansing M. Prescott, John P. Harley and Donald A. Klein. 2002. Microbiology. V Ed. WCB/McGraw Hill Company.
9. Brock, T. D., Smith, D. W and Madigene, M. T. 1997. Biology of Microorganisms: Milestones in Microbiology.
Prentice-Hall International Inc. London.
10. Talaro, K and Talaro, A. 1996. Foundations in Microbiology, 2en Ed., Wm. C. Brown publishers, Toront

Web resources:

1. https://www.cliffsnotes.com › biology › microbiology
2. https://www.livescience.com
3. https://www.nature.com › ... › microbiology techniques

Course Outcomes

On completion of the course, students should be able to:

CO 1: Discuss important milestones and accomplishments to appreciate the historical aspect
CO2: Identify key organelles and their functions in both eukaryotes and prokaryotes
CO3: Describe the overall classification and diversity of microorganisms
CO4: Demonstrate the different cultural techniques in bacteriology
CO5: Explain the disease caused by various microorganisms

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	1	1	1
CO2	3	2	1	1	1
CO3	3	2	2	1	2
CO4	3	2	2	1	2
CO5	3	3	3	3	3

SEMESTER	**SEVENTH**	**COURSE CODE**	**24MBUC4125**
Course Title	**MYCOLOGY**		
No. of credits	**4**	No. of contact hours per week	**4**
New Course Revised Course	New Course	If revised, percentage of Revision effected	-
Category	Core Major		
Scope of the Course (May be more than one)	❖ Basic understanding on the morphology and functions of the fungus ❖ Skill development in fungal cultures ❖ Creates employability scope in microbiological laboratories / hospitals / industries		
Cognitive Levels addressed by the course	K-1 Ability to remember historical and recent developments in mycology K-2 Grasp the comprehensive knowledge on mycology K-3 Use microbiological tools for better understanding of fungal structures and their functions K-4 Capacity to analyses factors influencing growth K-5 Make new techniques for production of industrial products K-6 Assessment of disease-causing fungus		
Course Objectives	The course aims to: • Enhance the student's knowledge in historical aspects • Acquire an overall knowledge on the morphology and functions of the structures in fungus • Make the students knowledgeable on the various industrial techniques involved in the lab • Give an overview on the disease caused by various microorganisms		

UNIT	**Content**	**No. of Hours**
I	**Introduction, Structure, Growth and Ecosystem of fungi** Introduction, -Characteristics, classification, cellular & thallus organization of fungi. General features, structure, nutrition, reproduction of different fungi group - Zycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes. Hyphae and non-motile unicells and multicells, motile cells, spores, dormancy, growth, population and colonies- Effect of environment on growth, prevention of fungal growth. Saprophytes.	13

II	**Fungi—Zygomycotina and Ascomycotina** Zygomycotina-Zygomycetes, Trichomycetes- General Characteristics, Life cycle and Economic importance of Mucor, Dimargaris, Chlamidoabsidia Ascomycotina-Hemiascomycetes, Plectomecetes, Pyrenomycetes, Discomycetes Laboulberiomycetes- General Characteristics, Life cycle and Economic importance of Penicillium, Candida, Claviceps.	12
III	**Fungi-Basidiomycotina and Deutromycotina** Basidiomycotina-Teliomycetes, Hymenomycetes- General Characteristics, Life cycle and Economic importance of Agaricus, Ustilago and Puccinia. Deutromycotina-Hypomycetes-Coelomycetes-Blastomycetes General Characteristics, Life cycle and Economic importance of Alternaria, Colletotrichum and Trichoderma.	13
IV	**Applied Mycology** General features, Role of fungi in biotechnology, Mushroom cultivation, Application of fungi in food industry –Flavor, texture, Baking and Enzymes. Secondary metabolites: Pharmaceutical-Penicillin. Agriculture- Biofertilizers, Mycorrhiza - ectomycorrhiza, endomycorrhiza. Biological control- Myco insecticides-*Beaveria* and *Mettarrhizium*-Fungi and bioremediation.	13
V	**Mycopathology** Terms and concepts; General symptoms; Geographical distribution of diseases. Host-Pathogen relationships; disease cycle and environmental relation; prevention and control of plant diseases. Important plant diseases caused by fungi- symptoms, disease cycles and control-Late & Early blight, Blackrust, Smut, Wilt and Red rot. Important animal diseases caused by fungi- Dermatomycosis, systemic mycosis and candidiasis.	13
References	**Text Books:** 1. B. K. Mishra (2017), Mycology and Phytopathology, Kalynai Publishers, New Delhi. 2. Fundamentals of Mycology, J.H Burnett, Publisher:Edward.Arnold Crane Russak 3. The Fungi. M.Charlile & S.C. Atkinson, Publisher: Academic press 4. Fundamentals of Mycology. E.Moore – Landeekeer, Publisher: PrenticeHall **Reference Books:** 1. Sharma, P. D. (2017). Mycology and Phytopathology Rastogi Publication, Meerut. 2. Agrios, G.N. 1997 Plant Pathology, 4th edition, Academic Press, U.K. 3. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, JohnWiley &Sons (Asia) Singapore. 4th edition. 4. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press,Cambridge. 3rd edition. 5. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, MacmillanPublishers India Ltd. 6. Mehrotra, R. S.(2011). Plant Pathology. Tata McGraw-Hill Publishing CompanyLimited, NewDelhi **Web resources:** 4. https://www.cliffsnotes.com › biology › microbiology 5. https://www.livescience.com 6. https://www.nature.com › ... › microbiology techniques	
Course Outcomes	**On completion of the course, students should be able to:** CO 1: Discuss important milestones and accomplishments to appreciate the historical aspect CO2: Identify key organelles and their functions in fungus CO3: Describe the overall classification and diversity of fungus CO4: Demonstrate the different cultural techniques in mycology CO5: Explain the disease caused by fungus	

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	1	1	1
CO2	3	2	1	1	1
CO3	3	2	2	1	2
CO4	3	2	2	1	2
CO5	3	3	3	3	3

SEMESTER	SEVENTH	COURSE CODE	24MBUC4126
Course Title	**ADVANCED BIOCHEMISTRY**		
No. of credits	3	No. of contact hours per week	3
New Course / Revised Course	New Course	If revised, percentage of Revision effected	-
Category	Core Major		
Scope of the Course (May be more than one)	❖ Basic understanding on the various biological molecules and their importance ❖ Skill development for analysis of enzymatic reaction ❖ Creates employability scope in the biochemical laboratories / hospitals / industries		
Cognitive Levels addressed by the course	K-1 Ability to remember basics of biomolecules K-2 Develop comprehensive knowledge on classification of protein, carbohydrates, lipids & nucleic acid K-3 Use biochemical tools for better understanding of structures of biomolecules and their functions K-4 Capacity to analyse the functions of carbohydrates, proteins, and lipids K-5 Make new techniques to study Biochemical importance and regulation K-6 Assessment of metabolic pathways and their biochemical importance		
Course Objectives	The course aims to: • Understand the chemical nature of biological molecules and their importance • Highlight the salient feature on the structural and chemical properties of various biological molecules • Acquire overall knowledge on enzymes and their kinetics • Impart knowledge on the generation and flow of energy in living systems • Create interest on the metabolic pathways of carbohydrates, proteins and lipids		

UNIT	Content	No. of Hours
I	**The foundation of Biochemistry** Cellular foundation: Cells are the structural and functional units of all living organisms, Phylogeny of the three domains of life, organisms differ widely in their sources of energy and biosynthetic precursors. Chemical foundation: Biomolecules are compounds of carbon with variety of functional group, cells contain a universal set of small molecules, Macromolecules are the major constituents of cells, Interaction between biomolecules are stereospecific. Physical foundation: living organisms exist in dynamic steady state, organisms transform energy and matter from their surroundings, flow of electron provides energy for the organisms, Enzymes promotes sequence of chemical reactions, metabolism is regulated to achieve balance and economy. Genetic foundation: genetic continuity is vested in single DNA molecule; the structure of DNA allows for its replication and repair with three-dimensional structure.	13
II	**Biological Macromolecules** Classification, Structure, chemistry, and functions of macromolecules: Nucleic acid – purine, pyrimidine, nucleosides and nucleotides; RNA, DNA, A-form, B-form, and Z-form of DNA. Proteins – aminoacids;, primary, secondary, tertiary and quaternary structures of proteins. Carbohydrates – monosaccharides, disaccharides, oligosaccharides and polysaccharides; structure, physical and chemical properties. Lipids Lipids – simple, compound and derived. – Phospholipids, Glycolipids, Lipoproteins and Steroids. Structure; physical and chemical properties of lipids.	13
III	**Enzyme classification and catalysis** General introduction of enzymes, enzyme classification, Enzymes are biological biocatalysts, Reversible reactions, The specificity of substrate binding, Factors influencing the rate of an enzyme-catalysed reaction, Inhibitors and their effects on enzyme, specificity, active site, activity unit, isozymes. Enzyme kinetics: Michaelis - Menton equation for simple enzymes, determination of kinetic parameters, multistep reactions and rate limiting steps, enzyme inhibition, allosterism, principles of allosteric regulation.	13
IV	**Cellular metabolism of Biomolecules** Basic principles – anabolism and catabolism. Biosynthesis of macromolecules: synthesis of carbohydrates, nucleic acids (salvage and de novo pathway), protein and lipids (Triglyceride synthesis). Breakdown of carbohydrates (Glycolysis, Pentose – Phosphate pathway, Krebs cycle), lipids (β – oxidation), proteins (aminoacid oxidation, Glucogenic, ketogenic, urea synthesis) and nucleic acids.	14
V	**Signal transduction pathways** Generalized signal transduction pathway and organization, basic concept of signals, Receptors: soluble receptor, transmembrane receptor, enzyme coupled receptor, G-protein coupled receptor, Ion-channel receptor. Second messengers- cyclic nucleotide(cAMP, cGMP), Ca^{2+}. Amplifies-protein kinases, G-protein. Integrators and Inhibitors. Basic concepts of acids, base, pH and buffers.	11
Refere	**Text Books:** 1. David L. Nelson and Michael M. Cox (2017). Lehninger Principles of Biochemistry, 7th edition, W.H.	

nces	Freeman and Company, New York. 2. Donald Voet, Judith G. Voet, Charlotte W. Pratt (2016). Fundamentals of Biochemistry Fifth Edition. John Wiley & Sons Inc, New York. 3. J.L. Jain 2003 Fundamental of Biochemistry S. Chand of company Ltd, New Delhi.S 4. G.S. Sandhu 2002 Textbook of biochemistry 18th Edn. Campus books International, New Delhi. 5. A.C. Deb. 2000 Fundamentals of Biochemistry New Central book Agency, Ltd, Calcutta. J.H. Well 1997. General biochemistry. 6th Edn. New Age International (P) Ltd pub; New Delhi. 6. Hiram F. Gilbert. Basic concepts in biochemistry Mc Graw Hill publication 7. U. Sathyanarayana, U. Chakrapani .2013. Biochemistry. 4th edition. Elsevier publication **Reference Books:** 1. D. Papachristodoulou, A. Snape, W.H. Elliott and D. C. Elliott (2014). Biochemistry and Molecular Biology. 5th Edn. Oxford University Press 2. Jeremy M Berg, John L Toymoczko and Lubert Stryer Stryer (2006). Biochemistry VI Edition. W.H. Freeman and Company, New York 3. Lansing M. Prescott, John P. Harley and Donald A. Klein (2002). Microbiology. Mc Graw Hill companies. 4. Buchanan, Gruissum and Jones, (2000). Biochemistry and Molecular Biology of Plant; ASPP, USA. 5. David Rawn (2012). Biochemistry. Panima Publishers. **Web resources:** 1. Onlinelearning.hms.harvad.edu/biochemistry 2. Aldrin.tripod.com/biochemistry 3. https://study.com/biochemistry-class-online.html 4. Canterbury.libguides.com/bchm/websites
Course Outcomes	**On completion of the course, students should be able to:** CO 1: Explain the basic concepts in biochemistry and nature of the biomolecules. CO2: Discuss the classification, structural and chemical properties of carbohydrates, protein, nucleic acids and lipids CO3: Demonstrate classification of enzymes and can understand the characteristics of enzyme reactions. CO4: Outline the concepts of bioenergetics. CO5: Describe the metabolic pathways and their biochemical importance.

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	2	1	2	2
CO2	2	2	1	2	2
CO3	2	2	1	2	2
CO4	2	2	1	2	2
CO5	2	2	1	2	2

SEMESTER	**SEVENTH**	**COURSE CODE**	**24MBUC4127**
Course Title	**PRACTICAL VIII: BACTERIOLOGY AND MYCOLOGY AND ADVANCED BIOCHEMISTRY**		
No. of credits	1	No. of contact hours per week	3
New Course / Revised Course	New Course	If revised, percentage of Revision effected	-
Category	Core Major		
Scope of the Course (May be more than one)	❖ Basic knowledge on the important aspects of bacteria and fungus ❖ Developing skills in the isolation and handling of microorganisms & Developing skills in estimation of protein, carbohydrates, and lipids ❖ Creates employability scope in microbiological laboratories/ diagnostic centres/ industries		
Cognitive Levels addressed by the course	K-1 Ability to remember safety measures and rules to be followed in a microbiological laboratory K-2 Comprehensive knowledge on Handling and Care of Microbiological Instruments K-3 Use of microbiological Instruments for better understanding of microbes K-4 Capacity to analyze microbes from soil, water, and air K-5 Assessment of pure culture techniques, methods of culturing preservation and maintenance of microorganisms K-6 Comprehensive knowledge on various biomolecules and their importance		
Course Objectives	The course aims to: • To enhance the student's knowledge and impress upon them on the important aspects of microorganisms • To provide practical knowledge and skills in the isolation and handling of microorganisms • To understand the working procedure and principles of microscopes. • To know pure culture techniques, methods of culturing preservation and maintenance of microorganisms & gain skill in isolation of microorganisms from various samples. • Impart a practical knowledge on estimation of protein, carbohydrates, and lipids		

Practical	Topics covered	Hours
1.	Safety measures and rules of conduct to be followed in a microbiological laboratory and Cleaning of Glassware.	4
2.	Microscopic Examination and Measurement of bacterial and fungal spore using Micrometry.	4
3.	Bacterial staining techniques – Gram's staining & Fungal staining techniques – Lactophenol cotton blue staining	4
4.	Preparation and sterilization of different media: synthetic media, complex media- Nutrient agar, McConkey agar and EMB agar.	4
5.	Demonstration techniques for pure culture of bacteria- serial dilution technique, pour plate, spread plate and streak plate technique.	4
6.	Preparation of Potato Dextrose Medium & Introduction to the world of fungi - Unicellular, septate mycelium	4
7.	Enumeration and isolation of Bacteria and Fungi from soil using serial dilution and plating technique.	3
8.	Isolation and identification of pathogenic and non-pathogenic fungi.	3
9.	Study of the vegetative and reproductive structures of following genera through temporary and permanent slides: *Mucor* and *Saccharomyces, Aspergillus and Penicillium:* study of asexual stage from temporary mounts.	4
10.	Qualitative Analysis of Carbohydrates	4
11.	Estimation of Maltose from any Fruit Juice & Estimation of Proteins - Folin Lowry's method	4
12.	Qualitative Analysis of Amino acids & Qualitative Analysis of Lipids	3
13.	Estimation of urea DAM method.	3
References	1. James. G. Cappucino. And Natabe Sherman, 2004. Microbiology – A Laboratory Manual, VI Ed., (I Indian Reprint). Pearson Education (Singapore) Pvt. Ltd., India. 2. Dubey, R.C and Maheswari, D.K. 2002. Practical Microbiology, I Ed., Chand and Company Ltd., India. 3. Aneja. K.R, 2002. Experiments in Microbiology plant pathology tissue culture and mushroom production technology, III Ed. New Age International publishers (P) Ltd, New Delhi. 4. Breed and Buchanan. Bergey's Manual of Systematic Bacteriology. Edition (Volumes. 1 – 5) (2001 – 2003). 5. B. K. Mishra (2017), Mycology and Phytopathology, Kalynai Publishers, New Delhi. 6. Fundamentals of Mycology, J.H Burnett, Publisher:Edward.Arnold Crane Russak. 7. Sengar, R.S. Reshu Chaudhary (2014) Laboratory Manual of Biochemistry.	
Course Outcomes	**On completion of the course, students should be able to:** CO 1: Demonstrate standard methods for the isolation, identification and culturing of microorganisms. CO2: Explain the ubiquitous nature of microorganisms CO3: Identify the different groups of microorganisms from different habitats. CO4: Demonstrate the different cultural techniques in mycology & Explain the disease caused by fungus CO5: Discuss the concepts in qualitative analyse of sugar, amino acid, Lipid & Identify the different methods in quantification of Protein and urea	

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	2	2	2
CO2	3	3	2	2	2
CO3	3	3	2	2	2
CO4	3	3	2	2	2
CO5	3	3	2	2	2

SEMESTER	SEVENTH	COURSE CODE	24MBUC4211
Course Title	PLANT AND ANIMAL CELL CULTURE TECHNIQUES		
No. of Credits	4	No. of contact hours per week	4
New Course/ Revised Course	New Course	If revised, Percentage of Revision effected	--
Category	Core Minor		
Scope of the Course (may be more than one)	• Students will be able to develop their skills on plant and animal cell culture techniques. • Students will be able to develop employability skills.		
Cognitive Levels addressed by the Course	**K-1** Remember Concept and scope of plant cell culture. **K-2** Understands requirement for cell culture lab. **K-3** Apply various conditions for culture animal cells. **K-4** Evaluate various methods for the characterization of the cultured cells. **K-5** Create knowledge on therapeutic application.		
Course Objectives (Maximum:5)	**The Course aims** • The students will learn about of tissue culture technique. • The student will able to learn fundamental scientific principles on tissue culture technique. • The students will learn about development of primary culture and cell line. • The student will able to learn the cell biology techniques. • The student will able to learn the cell culture Applications.		

UNIT	Content	No. of Hours
I	**Introduction to plant cell culture.** Concept and history of plant tissue culture; pioneering work and significant achievements of Indian scientists. Plant tissue culture laboratory design; basic requirements and sterilization practices, Explants selection, sterilization and inoculation; Various media preparations; MS, B5, SH PC L-2.	**13**
II	**Plant cell culture technique** Washing, packing and sterilization of glassware; composition, types, preparation and sterilization of culture media; selection, isolation, surface sterilization and inoculation of explants; establishment of *in vitro* cultures, ideal conditions for incubation of cultures, maintenance of cultures and subculture; regeneration of plantlets; acclimatization of tissue cultured plantlets in greenhouse/polyhouse.	**13**
III	**Basics of Cell Culture** History of development of animal cell culture techniques-laboratory design and layout, equipment, aseptic technique, culture vessels and substrates, preparation and sterilization of media, defined media and supplements, serum-free media.	**13**
IV	**Cell culture and characterization** Explants selection, sterilization and inoculation-primary culture, subculture, criteria for subculture, growth cycle and split ratio, cell concentration at subculture, propagation in suspension cell line- cryopreservation -characterization, species identification, lineage or tissue markers, chromosome content and banding, DNA content, RNA and protein expression, enzyme activity, antigenic markers.	**13**
V	**Application of cell culture** Cell culture in virus isolation, cell biology, cancer research, vaccine production, drug discovery, regenerative medicine, manufacturing of biopharmaceuticals, toxicology, production of monoclonal antibodies, cellular agriculture, tissue engineering and CRISPR-Cas in gene function studies.	**13**

References

Text books:

10. Ian Freshney, R. 2010. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 6th Edition, John Wiley & Sons, Inc.
11. John M. Davis. 2011. Animal cell culture essential methods, John Wiley & Sons, Inc.
12. Kesavachandran, R. and Peter, K.V. 2008. Plant Biotechnology: Methods in Tissue culture and gene transfer. University Press Ltd. Hyderabad.
13. Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture: Theory and Practice (revised edition). Elsevier Science Publishers, New York, USA
14. Jain, S.M. Sopory, S.K. and Veilleux, R.E.1996. In Vitro Haploid Production in Higher Plants, Vols. 1-5, Fundamental Aspects and Methods. Kluwer Academic Publishers, Dordrecht, The Netherlands

Reference Books

5. Michael Butler. 2004. Animal Cell Culture and Technology, 2nd Edition Bios Scientific Publishers Taylor & Francis Group London and New York.
6. Vasil, I.K. and Thorpe, T.A.1994. Plant Cell and Tissue Culture. Kluwer Academic Publishers, The Netherlands

	E-Resources: **1.** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7325846/
Course Outcomes	**On completion of the course, students should be able to do** **CO1**: To understand the basic principles and methodologies of plant tissue culture **CO2**: To understand the different standard protocol for the production of viable clones **CO3**: Understand to development of cell line **CO4**: Evaluate the differences in characterization of cultures cells. **CO5**: Understands the therapeutic application of cultured cells.

Mapping of Cos with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	2	3	3	2
CO3	3	3	3	3	3
CO4	3	2	3	3	3
CO5	2	3	3	3	2

SEMESTER	**EIGHTH**	**COURSE CODE**	**24MBUC4112**
Course Title	**CLINICAL LAB TECHNOLOGY**		
No. of Credits	4	No. of contact hours per Week	4
New Course /Revised Course	New Course	If revised, Percentage of Revision effected	-
Category	Core Minor		
Scope of the Course	• Students will be able to develop their skills on clinical lab technology and knowtheir uses in hospitals • Students can execute field Projects on the clinical technology		
Cognitive Levels addressed bythe Course	K-1: Remember the basics of medical diagnostic technology K-2: Understand various types of infection K-3: Apply to know host parasite relationship and virulence factors associated with the pathogen. K-4: Analyze diseases caused by bacterial and protozoa K-5: Evaluation various viral and fungal diseases K-6: Create knowledge on the types and mode of action of various antimicrobial compounds and antimicrobial resistance		
Course Objectives	The Course aims to: • Make the students knowledgeable on the Collection of clinical specimens • Give an outline on the methods in urine examination • Give an in-depth knowledge on blood count • Make students learn Histopathological Examination. • Expose the students on the stool sample analysis.		

UNIT	Content	No. of Hours
I	**Collection of clinical specimens** Basic laboratory principles -Code of conduct -Safety measures. Methods of collection of urine, blood, sputum, stool etc. The techniques of preservation of samples – chemical preservatives. Blood plasma and serum preparation – anticoagulants.	7
II	**Urine Examination** Collection and preservation of urine, physical examination –chemical examination-microscopic examination of deposits, organised and unorganised sediments- pregnancy tests. Urine culture test.	6
III	**Analysis of Blood** Blood- various compositions and their function, recent collecting method - blood coagulation. Blood groups. Blood smear prep - TC, DC and WBC count-Peripheral blood smear examination and morphological abnormalities- Reticulocyte count- absolute eosinophil count-E.S.R, P.C.V, Blood indices - Platelet count: BT, CT, - Prothrombin time. Examination for malarial parasites.	7
IV	**Microtome - Histopathological Examination** Tissue reception, labelling, fixation for different tissue and sectioning -Preparation of paraffin blocks (Dehydration, clearing, embedding, blocking)- section cutting. Preparation of common stains technique - Hematoxylin, eosin, congo red, methyl violet, Leishman stain.	6
V	**Stool sample analysis** Stool – Collection and preservation. Normal and abnormal constituents. Microscopic examination – concentration methods ova & cyst - Stool culture test.	6
References	**Text Books:** 1. C.F.A. Culling. Handbook of Histopathological and Histochemical Technique – Third Edition. Butterworths. London.	

	2. P.B. Godkar, Text Book of Medical Laboratory Technology, 2nd Edn.2003. Bhalani Publication. **Reference Books:** 1.John A. Washington. Medical Microbiology. University of Texas Medical Branch at Galveston; 1996. 2.Talib. V.H. Handbook of Medical Microbiology. CBS Publishers. 2nd Edition. 2008.
	E-Resources: 1. https://clinlab.ucsf.edu/ 2. https://library.med.utah.edu/WebPath/TUTORIAL/URINE/URINE.html 3. http://www.hematologyatlas.com/principalpage.htm 4. https://www.bloodline.net/ 5. http://www.protocol-online.org/prot/Histology/index.html
Course Outcomes	**Upon completion of this course, students should be able to:** CO1: Discuss the method of Collection of clinical specimens CO2: Outline the methods in urine examination CO3: Explain total and differential blood count. CO4: Delineate the histopathological sample preparation and examination. CO5: Describe the stool sample analysis

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	2	3	3
CO2	3	3	2	3	3
CO3	3	3	2	3	3
CO4	3	3	2	3	3
CO5	3	3	2	3	3

SEMESTER	**EIGHTH**	**COURSE CODE**	**24MBUC4231**
Course Title	**BIOINSTRUMENTATION AND RESEARCH METHODS**		
No. of Credits	4	No. of contact hours per week	4
New Course/ Revised Course	New Course	If revised, Percentage of revision effected	-
Category	Core Major		
Scope of the Course (may be more than one)	1. Facilitate the students to understand the instrumentation techniques 2. Learning the fundamental and working principles of instruments 3. Understand the concept of research methodology.		
Cognitive Levels addressed by the Course	**K1**- Enrich the knowledge in the field of bioinstrumentation **K2**- Gaining factual ideas in bioinstrumentation and research methods **K3**- Application of recent instrumentation techniques in research **K4**- Focus on the working principles of instruments in the field of Biology **K5**- Developing competence and writing skills in thesis and publications **K6**- Promote and establish the research activities in the field of Zoology		
Course Objectives (Maximum:5)	The Course aims • To understand the principles and applications of ordinary and electron microscopes • To learn the techniques in isolation and separation of cell organelles, micro and macromolecules. • To imbibe the principle and applications of Electrophoresis, colorimetry and calorimeter • To understand the research methods, thesis writing and presentation • To learn the article publication, ethics and IPR.		

Unit	**Content**	**No. of Hours**
I	**Microscopy, pH and Buffer** Microscopy- Principle and Applications- phase contrast, Confocal– Electron Microscopy -SEM and TEM - pH basic principles – pH electrodes- Principles, application and preparation of common buffers- Citrate, acetate, tris and phosphate	11

II	**Centrifugation and Chromatography** Homogenization- Manual, mechanical and sonication- Centrifugation techniques- Basic principles, Different types of Centrifuges, Analytical and preparative ultracentrifugation methods – Chromatography- Paper, thin layer, Ion-exchange, column- separation of amino acids and sugars- Gas liquid chromatography, HPLC. Isolation of cellular constituents- Chloroplasts, mitochondria, nucleic acids and enzymes-	13
III	**Electrophoresis, Colorimetry and Calorimeter** Electrophoresis- General Principles Horizontal & Vertical gel electrophoresis and immune electrophoresis -Electrophoresis of proteins and nucleic acids- Spectroscopic techniques- UV-Visible and FT-IR – Flame photometer, Bomb calorimeter, AAS, Mass Spectra, NMR – Principle and applications. Radioisotophic techniques.	13
IV	**Research, Thesis writing and Presentation** Research- Definition, objectives, types and importance- Research methods in Biological Sciences- Research process- Literature and reference collection – sources- Role of Libraries in research-e-journals and e-books- Scientific databases- Indexing data bases, Citation data bases: Web of Science, Scopus, Google Scholar-Research report writing- Parts of Thesis and Dissertation- Presentation in seminars and conferences	13
V	**Article Publication, Ethics and Intellectual Property Rights** Writing scientific paper- Organization of scientific paper- Publication in research journals-Standards of Research journals- Peerreview-Types- Impact factor- citation index, h-index, i10 index-Preparation of manuscript- Proof correction- proof correction symbols- Method of correcting proof- Ethics in research-Plants and animals-Intellectual Property Rights- Origin and history of Indian Patent system-Basis of patentability- Patent application procedure in India.	14

References	**Text Books** 1. Veerakumari.2019.Bioinstrumentation.MJP Publishers, Chennai. p.39-98;113-153;185-375. 2. C.R. Kothari and Gaurav Garg.2019. Research Methodology- Methods and Techniques. New Age International Publishers, New Delhi.pp.1-25. 3. Biju Dharmapalan 2012 Scientific Research Methodology. Narosa Publishing House, New Delhi. 4. S. Palanichamy and M. Shunmugavelu 2009. Research methods in biological sciences. Palani paramount publications, Palani 5. G.R. Chatwal and S.K. Anand. 2014. Instrumental Methods of Chemical Analysis. Himalaya Publishing House
	Reference Books 1. N. Gurumani 2010 Research Methodology for Biological Sciences. MJP Publishers, Chennai. 2. G.H. Mitchell 2017. Gel Electrophoresis: Types, Applications and Research. Nova Science Publishers Inc 3. B.K. Sharma 2014 Instrumental Method of Chemical Analysis. Krishna Prakashan Media(P) Ltd. 4. Sahu, P.K. 2013. Research Methodology: A Guide for Researchers in Agricultural Science, Social Science and other related fields. Springer, New Delhi. 5. Keith Wilson and John Walker 2002 Practical biochemistry – Principles and techniques. Fifth Edn. Cambridge Univ. Press.
	E-Resources 1. http://nptel.ac.in/syllabus.php?subject Id= 102107028. 2. http://b-ok.xyz/book/674611/288bc3 3. http://www.researchgate.net/publication/317181728- Lecture Notes on Laboratory Instrumentation and Techniques. 4. iiscs.wssu.edu/drupal/node/4673 5. http://www.studocu.com/en/search/research methodology?languages=language_en&type =document *(NPTEL) -National Programme on Technology Enhanced Learning.
Course Outcomes	**On completion of the course, students should be able to:** CO1: Enabling the students to understand the principles and applications of different types of microscopes, pH meter and buffers. CO2: Providing excellence in isolation and separation techniques. CO3: Enhance the application and separation techniques of various micro and macromolecules CO4: Explain the basic information on research methods CO5: Crate awareness on the importance of article publication and IPR.

Mapping of COs with PSOs

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	2	3	3	2
CO3	3	3	3	3	3
CO4	3	2	3	3	3
CO5	2	3	3	3	2

SEMESTER	EIGHTH	COURSE CODE	24MBUC 4229
Course Title	ADVANCED GENETICS AND MOLECULAR BIOLOGY		
No. of credits	3	No. of contact hours per week	3
New Course / Revised Course	New Course	If revised, percentage of Revision effected	-
Category	Core Major		
Scope of the Course (May be more than one)	• Basic understanding on the molecules of life • Developing skills to for analysis mutagenesis • Creates employability scope in the molecular screening laboratories		
Cognitive Levels addressed by the course	**K-1** Ability to remember historical developments of genetics and molecular biology **K-2** Comprehensive knowledge on molecules of life **K-3** Capacity to analyse mutagenesis and molecular recombination **K-4** Use molecular techniques for better understanding of structures of DNA, RNA and Proteins **K-5** Make new techniques to study molecular mechanism of antisense molecules **K-6** Assessment of functions of DNA, RNA and Proteins		
Course Objectives	The course aims to: • Impart information on the historical developments of genetics and molecular biology. • Give an in-depth knowledge on mutagenesis. • Make the student knowledgeable on concepts and mechanism of DNA replication process • Expose the students on mechanisms of transcription process in prokaryotes and in eukaryotes. • Enhance student's interest to distinguish translation processes in prokaryotes with eukaryotes.		

UNIT	Content	No. of Hours
I	**Introduction to genetics and molecular biology** A Brief Overview of the Modern History of Genetics-The Three General Areas of Genetics-Classical, Molecular, and Evolutionary Genetics-Mendel's Experiments, Segregation, Dominance, Independent Assortment-Genotypic Interactions-Epistasis, Mechanism of Epistasis- Biochemical Genetics, Inborn Errors of Metabolism, One-Gene-One-Enzyme Hypothesis-Genetic Material-Early observation on the mechanism of heredity, DNA and RNA as genetic material, Properties of Genetic material. Structure of DNA -primary, secondary and different forms (A, B & Z). Prokaryotic and Eukaryotic Chromosome Organization-Genes – definition, types and functional organization. Fine structure of gene-Central dogma of Molecular biology.	13
II	**Mutagenesis and Recombination at the molecular level** Mutation – Types – Molecular and biochemical basis of mutation. Mutagenesis – Spontaneous and induced – Base – analog, physical agents, chemical mutagens, intercalating substances and mutator genes. Reversion – definition – Types – Mechanisms – application (Ames test). Mutants – Types and Uses – bacterial mutants-Recombination at the molecular level. Crossing over during cell division breakage and re-joining of intact DNA molecules, Holliday model of homologous recombination – events at the molecular level; role of recA, recBC and chi sequences, Site- specific recombination – eg. Bacteriophage λ; FLP/FRT and Cre/Lox recombination.	13
III	**DNA Replication** Basic rule. The Geometry of DNA replication – Semi-conservative replication of double – stranded DNA and Circular DNA molecules. Enzymology – DNA Polymerases, DNA ligase and DNA gyrase. Events in the replication fork – Continuous and discontinuous. Plasmid and ØX174 DNA replication- DNA damages – DNA repair mechanism – photoreactivation, excision repair, recombinant repair and SOS function.	13
IV	**Transcription** Basic factors of RNA Synthesis - RNA polymerases – I, II and III - Transcription Mechanisms in prokaryotes and eukaryotes – chain Initiation, elongation and termination. Significance of pribnow box, TATA box, CAAT box and enhancers in transcription initiation. Rho dependent and Rho independent termination of transcription. Classes of RNA Molecules – Messenger, ribosomal and transfer RNA. Post –transcriptional modification - RNA splicing – role of lysozyme – Spliceosomes, Group I and Group II introns Self-splicing. Capping and tailing of 5' and 3' termini of Eukaryotic mRNA molecules. Antisense and Ribozyme technology – Molecular mechanism of antisense molecules -inhibition of splicing, polyadenylation, and transition – disruption of RNA structure and capping -biochemistry of ribozyme (hammerhead, hairpin, and other ribozyme).	13
V	**Translation** Genetic code – Definition, deciphering of codons – Universality of the code – Wobble hypothesis and codon degeneracy - codon dictionary. Mechanism of protein synthesis	12

	-importance of Initiation (IF), elongation (EF) and releasing factors (RF) - post translational modifications – protein splicing and folding – role of molecular chaperones. Regulation of gene expression in prokaryotes –Operon concept – inducible and repressible operons Eg. lac, trp.- Bacterial small RNA (sRNA) and its role in regulation of gene expression. Functional genomics, Validation of gene function. Gene silencing, PTGS, RNAi, Antisense technology, Applications. Molecular Pharming. Genome Editing CRISPR-Cas9.	
References	**Text Books** 1. E.J. Gardner, M.J. Simmons, D.P. Snustad, 2006. Principles of Genetics (8th Ed.) John Wiley & Sons, New York. 2. Robert H. Tamarin, Principles of Genetics, 2001, McGraw-Hill Higher Education. 3. Benjamin Pierce, Genetics: A Conceptual Approach, 2016, WH Freeman 4. David Freifelder, 2020, Molecular Biology, 4th Reprint., Narosa Publishing House, New Delhi, India. 5. Lansing M. Prescott, John P. Harley and Donald A. Klein (2020). Microbiology (11thEd.). Mc Graw Hill companies. 6. Michael M. Cox, Molecular Biology Principles and Practice, 2012 by W. H. Freeman and Company. 7. James D. Watson, Molecular biology of the gene, 7th Edition,2014, Cold Spring Harbor Laboratory. **Reference Books** 1. Geoffrey M. Cooper - The Cell A Molecular Approach, 8th Edition, Oxford University Press (2019). 2. Lizabeth A. Allison., Fundamental Molecular Biology, 2nd Edition, 2012 John Wiley & Sons, Inc. 3. David P. Clark, Molecular Biology, 3 rd Edition, 2019 Elsevier Inc. 4. Robert F. Weaver, Molecular Biology, 5th Edition 2012 by The McGraw-Hill Companies, Inc. 5. Bruce Alberts, Molecular Biology of Cell, 6th Edition,2015, Garland Science, Taylor & Francis Group, LLC **Web resources** 1. www.cellbio.com/education.html 2. https://www.loc.gov/rr/scitech/selected- interval/molecular.html 3. global.oup.com/uk/orc/biosciences/molbio/ 4. https://www.loc.gov/rr/scitech/selected-internet/molecular.html	
Course Outcomes	**Upon completion of this course, students be able to:** CO1: Outline the fundamental concepts of molecules of life CO2: Discuss the various kinds of mutagenesis and their importance CO3: Explain the mechanisms of DNA replication & repair mechanisms CO4: Evaluate the differences of transcription process in prokaryotes with eukaryotes CO5: Compare the mechanisms of translation in prokaryotes with that in eukaryotes	

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	2	1	2	2
CO2	2	2	1	2	2
CO3	2	2	1	2	2
CO4	2	2	1	2	2
CO5	2	2	1	2	2

SEMESTER	EIGHTH	COURSE CODE	24MBUC 4230
Course Title	**PRACTICAL IX: BIOINSTRUMENTATION AND ADVANCED BACTERIAL GENETICS AND MOLECULAR BIOLOGY**		
No. of credits	1	No. of contact hours per week	
New Course / Revised Course	New Course	If revised, percentage of Revision effected	-
Category	Core Major		
Scope of the Course (May be more than one)	❖ Rewarding opportunity to update the recent techniques in bioinstrumentation ❖ Basic knowledge on the measurement: criteria of reliability, precision, accuracy, sensitivity, specificity ❖ Creates employability scope in laboratories/ diagnostic centres/ industries		
Cognitive Levels addressed by the course	K-1 Ability to remember safety measures and rules to be followed in a microbiological laboratory & Exposure to the instruments in biological sciences K-2 Comprehensive knowledge on various biomolecules and their importance K-3 Handling and use of Instruments used to analyse biomolecules K-4 Capacity to analyse and quantify DNA, RNA and sugar K-5 Make use of techniques to demonstrate antibiotic resistance mechanism K-6 Assessment of DNA isolation and transformation protocol		
Course Objectives	The course aims to: • Imbibe the techniques involved in bioinstrumentation • Impart a practical knowle&dge on estimation of protein, carbohydrates, and lipids Acquire practical knowledge on estimation of sugar, DNA, and RNA. • Develop art of practical skills to estimate lipid, sugar, and nucleic acid • Develop skills to demonstrate antibiotic resistance mechanism • Develop skills to isolate chromosomal and plasmid DNA		

Practical	Topics covered	Hours
1.	Safety in the laboratory	1
2.	Separation of amino acids and sugars using thin layer chromatography	4
3.	Separation of pigments by column chromatography	4
4.	Separation of gas and organic acids using GC and HPLC (Demonstration)	4
5.	Estimation of sodium, potassium, calcium and magnesium using Flame photometer	4
6.	Demonstration of Biological samples using SEM, FT-IR, AAS, NMR	6
7.	Estimation of DNA by DPA method	4
8.	Estimation of RNA by spectrophotometry	4
9.	Isolation of chromosomal DNA from *E.coli.*	4
10.	Plasmid DNA isolation	4
11.	Bacterial transformation	4
12.	isolation of antibiotic resistant mutants	4

Course Outcomes	**On completion of the course, students should be able to:** CO1: Separate amino acids and sugars using paper and thin layer chromatography, Estimate proteins, sodium, potassium, calcium and magnesium using spectrophotometer and flame photometer CO2:Know the biological applications of SEM, FT-IR, AAS and NMR CO3:Discuss the concepts in qualitative analyse of sugar, amino acid, Lipid & Identify the different methods in quantification of Protein and urea CO4: Evaluate the DNA and RNA present in the biological sample & Describe the Isolation of Genomic DNA and RNA from the bacterial strain CO5: Identify the AMR bacteria from the natural environment	**Course Outcomes**

References

1. C.R. Kothari and Gaurav Garg.2019. Research Methodology- Methods and Techniques. New Age International Publishers, New Delhi.pp.1-25.
2. G.R. Chatwal and S.K. Anand. 2014. Instrumental Methods of Chemical Analysis.Himalaya Publishing House
3.Michael M. Cox, Molecular Biology Principles and Practice, 2012 by W. H. Freeman and Company.
4.James D. Watson, Molecular biology of the gene, 7th Edition,2014, Cold Spring Harbor Laboratory.
5.Sengar, R.S. Reshu Chaudhary (2014) Laboratory Manual of Biochemistry.
6.Kavita Rawat; Shailendra Singh; Naresh Kurachiya; Swatantra Singh and Rajesh Vandre, Deepika D. Caesar (20) Practical Manual on Advance Techniques in Biochemistry, Mahi Publication
7.Keith Wilson And John Walker (2010). Principles and Techniques of Biochemistry and Molecular Biology Seventh edition Cambridge University Press
8.Sambrook J and Russell DW (2001). Molecular cloning - A laboratory manual, Cold Spring Laboratory Press, New York, 3rd Edition. Vol. 1, 2, 3.

	9.Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd Edition; ASM press; 2007.
Web resources	.1. http://nptel.ac.in/syllabus.php?subject Id= 102107028. 2. http://b-ok.xyz/book/674611/288bc3 3. http://www.researchgate.net/publication/317181728- Lecture Notes on Laboratory Instrumentation and Techniques. 4. global.oup.com/uk/orc/biosciences/molbio/ 5. https://www.loc.gov/rr/scitech/selected-internet/molecular.html

Mapping of Cos with PSOs:

PSO / CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	2	3	1
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	3	3	3	1

SEMESTER	**FIRST**	**COURSE CODE**	**24BIUI1101**
Course Title	**MULTIDISCIPLINARY COURSE : BASICS OF LIFE SCIENCES**		
No. of Credits	3	No. of contact hours per week	3
New Course/ Revised Course	New Course	If revised, Percentage of revision effected	-
Category	Multidisciplinary Course		
Scope of the Course (may be more than one)	1. Understand the basics of biology 2. Learn the concept of cell, muscles, nerves and different organs. 3. Know the classification and function of biomolecules and vitamins.		
Cognitive Levels addressed by the Course	K1-Classification of living organisms and structural organization of plants and animals. K2- Make the students to understand the structure and functions of cells K3-Inculcate the functions of muscles, nerves and organs K4-Analyze the biological importance of carbohydrates, proteins and lipids. K5- Know the mechanism of heredity through genes, DNA and RNA.		
Course Objectives	The Course aims • To know the basic concepts of biology • To reveal the fundamental of cells and cell division • To analyse the structure and functions of muscles, nerves and organs • To learn the biological importance of carbohydrates, proteins and lipids. • To understand the principles of inheritance and evolution of man.		

Unit	**Content**	**No. of Hours**
I	**Introduction to Biology**: Definition-Scope and importance of biology-Different fields of biology-Classification of living organisms-Nomenclature-Structural organization of plants and animals- Ecosystem-Biotic and abiotic factors-Freshwater and marine ecosystem-Producers, consumers, decomposers-Food chain-Food web-importance of environment conservation.	11
II	**Cell Biology**: Cell-the unit of life-structure and functions of prokaryotic and eukaryotic cell-Cell organelles-Golgi bodies, Endoplasmic reticulum, Mitochondria-Cell cycle and cell division-Mitosis and meiosis-significance of cell division.	14
III	**Physiology**: Muscles and nerves-types, structure and function-Organ and organ systems-digestive, respiratory, circulatory and excretory system-Endocrine glands-Pituitary, pancreas, adrenal and thyroid glands-hormones and their functions.	13
IV	**Biochemistry**: Biomolecules-classification and importance of carbohydrates, proteins and lipids-Vitamin-classification and function-Vitamin deficiency.	13

V	**Genetics and Evolution**: Heredity-genotype-phenotype-Mendelian law of inheritance-Chromosomes and their disorders-Genes-Concept of gene-DNA and RNA-role of genes in evolution-Origin of life-Darwin's theory of natural selectin-Human evolution-fossil evidences of human evolution.	13

References	**Text Books** 1. N.C Nair, A. Thangamani, S. Leelavathy, S. Prasanakumar, N. Soundrapandian, T. Murugan L. M. Narayanan and N. Arumugam, 2017, Animal diversity (Invertebrata& Chordata), Saras Publication, Nagarcoil. 2. P.S.Verma and V.K.Agarwal. 2019. Environmental Biology.S.Chand and Company,NewDehi. 3. Aminul Islam. 2018. Essentials of Cell Biology. Books and Allied (P)Ltd, Kolkotta. 4. S. Rajan and R.Selvichristy. Biochemistry.2020. CBS Publishers & Distributors Pvt.Ltd.New Delhi.pp.1-60;144-160. 5. Futuyama, D. 2005. Evolution. Sinauer Associates, INC.
	Reference Books 1. 1. R. L. Koptal- 2017, Animal Diversity, Rastogi Publication, Meerut. 2. G.Tyler Miller and Scott E. Spoolman. 2019. Environmental Science.Cengage Learning India Pvt.Ltd.Delhi. 3. K. V. Sastry& Priyanka, Mathur- 2018, Animal Physiology and Biochemistry, Rastogi Publication, Meerut. 4. Satyesh Chandra Roy and Kalyan Kumar De. 2018. Cell Biology. New Central Book Agency(P)Ltd 5. Hartl, D. L. 2005. Principles of Population Genetics. 4 th ed. Sinauer Associates.
	E-Resources 1. https://www.yourgenome.org 2. https://ncert.nic.in
Course Outcomes	**On completion of the course, students should be able to:** CO1: Understand classification of living organisms and their zoological nomenclature. CO2: Describe the structure and functions of cell and cell organelles CO3: Understand the structure and functions of muscles, nerves and organs CO4: Understand the biological importance of carbohydrates, proteins and lipids CO5: Understand the basis of heredity and evolution of man.

Mapping of COs with PSOs:

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	2	3	2	3
CO2	2	2	3	3	3
CO3	2	2	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

SEMESTER	FOURTH	COURSE CODE	24MBUA2201
Course Title	**ABILITY ENHANCEMENT COURSE (AEC):QUALITY CONTROL AND ASSURANCE MICROBIOLOGY**		
No. of credits	3	No. of contact hours per week	3
New Course / Revised Course	New Course	If revised, percentage of Revision effected	-
Category	Ability Enhancement Course		
Scope of the Course	❖ Students will be able to develop their skills in microbial quality analysis. ❖ Students can execute good laboratory practices quality control and its applications.		
Cognitive Levels addressed by the course	K-1 Ability to remember basic concepts good laboratory practices. K-2 Comprehensive knowledge on quality management, maintenance of records and reports K-3 Use techniques for quality control of media and stains. K-4 Capacity to analyze alternate energy resources K-5 Make newer approaches to develop microbial quality control in pharmaceutical products. K-6 Assessment of hazards in foods and drinking.		
Course Objectives	**The course aims to:** • To impart knowledge and the concepts in quality control and assurance microbiology. • To provide in-depth knowledge on quality management and reports. • To enhance quality diagnostic kit. • To understand quality of pharmaceutical products. • Hazard analysis in food and pharmaceutical products.		

UNIT	Content	No. of Hours
I	**Good laboratory practices (GLPs)** Management of laboratory hazards and knowledge in First aid procedures. Quality assurance – Introduction and overview – Definition, Designing of microbiology laboratory – Quality Control and its Applications.	13
II	**Quality assessment** Quality assessment of Equipment, Chemicals, Glass wares and Laboratory environments–Variance – Quality control calculations – Quality management – Maintenance of records and reports.	13
III	**Quality assurance** Quality assurance in Sterilization and Disinfection - Preservation of stock cultures, media and diagnostic kits – Quality control of media and stains.	13
IV	**Quality management** Quality assessment of Disposal, Decontaminated matters and other biological effluents. Quality management in transportations of cultures. National control of biological references and standards. Microbial quality control of pharmaceutical products.	13
V	**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.	12

References	**Text Books** 1. Philip Kotler, R, 2014, "Quality assurance of pharmaceuticals: A compendium of guidelines and related materials", Volume 2. Prentice Hall, Delhi. 2. W.B.Hugo and A.D.Russel, 2007, "Pharmaceutical Microbiology", 4th Edition, Blackwell Scientific Publications, New Jersey. **Reference Books** 1. Baird RM, Hodges NA and Denyer SP, 2019, Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, CRC Press, USA. 2. Dr Norman Hodges and Professor Geoffrey Hanlon (University of Brighton), 2013, Industrial Pharmaceutical Microbiology, Vol I &Vol II: standards & controls" Wiley - Blackwell Publication, New Jersey. 3. Madigan M.T. 2017. Brock Biology of Microorganisms 14th Edition. Pearson-Prentice Hall, USA.
Course Out comes	**Upon completion of this course, students be able to:** CO 1: Explain the role and management of laboratory hazards and knowledge in first aid procedures CO2: Discuss and demonstrates the quality management and maintenance of records and reports CO3: Quality assurance in stock cultures, media and diagnostic kits. CO4: Apply the different aspects of microbial quality control of pharmaceutical products. CO5: Evaluate the quality assurance by HACCP.

Mapping of COs with PSOs:

CO \ PSO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	1	1	3	3
CO2	3	2	2	3	3
CO3	3	2	1	3	3
CO4	3	2	2	3	3
CO5	3	2	2	3	3

SEMESTER	**THIIRD**	**COURSE CODE**	**24MBUA2202**
Course Title	**ABILITY ENHANCEMENT COURSE (AEC):BIOLOGY FOR ENTREPRENEURSHIP**		
No. of Credits	**3**	No. of contact hours per Week	**3**
New Course/ Revised Course	**New Course**	If revised, Percentage of Revision effected	-
Category	Ability Enhancement Course		
Scope of the Course	❖ Basic understanding on basic concepts in rural biotechnology ❖ Skill development for mushroom culture and *Spirulina* cultivation technology ❖ Creates employability scope		
Cognitive Levels addressed by the Course	K-1 Ability to remember basic concepts in rural biotechnology K-2 Comprehensive knowledge on biogas technology K-3 Use techniques for composting K-4 Capacity to analyze the Spirulina cultivation technology K-5 Make newer approaches to mushroom culture technology K-6 Assessment of Ornamental Fish culture technology		
Course Objectives (Maximum:5)	**The course aims to:** • To create interest on the fundamentals of biogas technology • To expose the technologies related to composting • To impart information on scope of mushroom culture technology • To impart knowledge on *Spirulina* cultivation technology • To know Ornamental Fish culture technology		

UNIT	**Content**	**No. of Hours**
I	**Biogas technology** Introduction and history – anaerobic digestion – microbes involved – factors influencing methane production – Stages of methane generation – Wastes used in methanogenesis – various bioreactors used for methane generation – Advantages and disadvantages.Visit to biogas production units with field demonstration.	7
II	**Composting technology** Historical background – waste availability – factors influencing – methods- biomaturity-enrichment of Compost and crop productivity. Vermiculture Technologies: History – species – life cycles – methods – different types of waste suitable for vermicomposting. Utilization of vermicompost for crop production. Visit to vermicompost industries with field demonstration.	7
III	**Mushroom technology** Bioconversion of organic wastes into protein - Oyster mushroom technology, paddy mushroom technology, milky mushroom and button mushroom technology, post-harvest technology. Mushroom farming and prospects. Visit to mushroom farms with field demonstration.	6
IV	***Spirulina* cultivation technology** Biology of *Spirulina* - cultivation methods, post-harvest technology and single cell protein formulation. Visit to *Spirulina* industries with field demonstration.	6
V	**Ornamental Fish culture** Present status and importance – popular varieties – artificial and live feeds – breeding techniques of egg layers – gold fish, angel fish, fighter and barbs – live bearers – guppy, molly, platy and sword tail – economics. Visit to ornamental fish farms with field demonstration.	6

References

Text Books:

1. Tripati, G. 2003. Vermiresources technology, 1st Ed., Discovery Publication House, New Delhi.
2. Anita Saxena, 2003. Aquarium management. Daya Pub. House, New Delhi.
3. Kaul, T.N. 1999. Introduction to mushroom science, Oxford & IBH Co., Pvt. Ltd.,New Delhi.
4. Kumar, H.D., 1991. A Textbook on Biotechnology, II Edition, East-west Press Pvt. Ltd., New Delhi.
5. Chawla O.P. 1986. Advances in Biogas Technology, ICAR, New Delhi.
6. R.C.Dubey, D.K.Maheswari 2000. A textbook of Microbiology. Revised edition

References:

	1. Srivastava, C.B.L, 2002. Aquarium fish keeping. Kitab Mahal, Allhabad. 2. Gaur, A.C., 1999. Microbial technology for Composting of Agricultural Residues by 3. Improved Methods, 1st print, ICAR, New Delhi. 4. Subba Rao, N.S., 1999. Soil Microbiology, 4th Ed., Oxford IBH Publishing Co. Pvt. Ltd., New Delhi. 5. Philip G. Miles, Shu-Ting Chang, 1997. Mushroom biology, World Scientific,Singapore. 6. Chatwal, G.R., 1995. Textbook of Biotechnology, Anmol Publications Pvt. Ltd., New Delhi 7. Bahl, N. 1988. Handbook on mushrooms. Oxford & IBH Publishing Co., Pvt. Ltd., New Delhi.
Course Outcomes	**Upon completion of this course, students should be able:** CO1: Evaluate the different aspects of biogas production technology CO2: Discuss the different types of composting technologies and how to establish composting units CO3: Explain the methods of mushroom culture and start a mushroom farm CO4: summarize *Spirulina* cultivation by low cost method CO5: to culture different ornamental fish and establish an aquarium farm

Mapping of Cos with PSOs

PSO / CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	3	3	3
CO2	3	2	2	3	3
CO3	3	2	2	3	3
CO4	3	1	1	3	3
CO5	3	1	2	3	3