PERIYAR UNIVERSITY

Salem-636011

(NAAC 'A++' Grade - State University - NIRF Rank 59)

DEPARTMENT OF MICROBIOLOGY

M.Sc., DEGREE

[Choice Based Credit System (CBCS)]

OBE Based Curriculum

(Effective from the academic year 2023-2024 and thereafter)

OBE BASED SYLLABUS

(With effect from the academic year 2023-2024 onwards)

Preamble

Post graduate Microbiology is a course focus on microbiology and its complete diversity exploring their relationship with various environments. Curriculum includes General Microbiology, Immunology & Vaccinology, Pharmaceutical Chemistry, Medical Bacteriology and Parasitology, Medical Mycology and Virology, Bioresource Technology, Molecular Biology and Applied Biotechnology, Bio Nano-technology and Infectomics, and Research Methodology and Computational Biology. M.Sc., Microbiology program designed by integrating the knowledge of cutting edge technologies like omics technologies and recombinant technologies for the heterologous expression allowing the generation of new and improved products and services in microbiology. It is envisaged to produce competitive graduates with a great spectrum of proficiency, interdisciplinary focus at par with international qualification. The detailed syllabus for each paper is constructed to inculcate the graduate with outcome based education pattern which provide space for Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation (K1 –K6).

1. General Graduate Attributes

- **Communication skills**

  The students gain the ability to accurately and effectively communicate information on microbiology using written, visual and oral reporting formats.

- **Research related skills**

  The students thinking ability increases with the ability to apply the principles of scientific experimental design and methods to investigate microbiologically relevant problems. They may gain the ability to analyze critique scientific papers in microbiologically relevant research areas.

- **Team work**

  The postgraduates acquires the ability to work effectively as a member and leader within a team. They are capable to employ the scientific method effectively as part of a

collaborative team. And understands the role of network building in career development and has the ability to interact effectively with people from a wide range of backgrounds.

- **Knowledge**

  The students will gains integrated knowledge on various scientific disciplines such as, Microbiology, Immunology & Vaccinology, Pharmaceutical Chemistry, Medical Bacteriology and Parasitology, Medical Mycology and Virology, Molecular Biology and Applied Biotechnology, Bio Nano-technology and Infectomics, Food, Soil and Environmental Microbiology, Research Methodology and Computational biology.

- **Global Perspective**

  The graduates may acquire the current and emerging worldwide microbiological technologies, issues, and perspectives during their course period.

- **Critical thinking**

  The graduates sustains the skill to apply the scientific process, including ability to acquire, assimilate, synthesize, analyze and critique microbiological information.

- **Problem solving**

  The postgraduate students will have the attitude to evaluate and solve the problems with scientific evidences.

- **Analytical reasoning**

  The students were enhanced in logical reasoning, critical data evaluation and formation of evidence-based opinions.

- **Scientific reasoning**

  The students gain demonstrative understanding and evaluation of knowledge as the key to knowledge creation. An intellectual integrity, rigour, reasoning, analysis and interpretation of scientific and technical data.

- **Reflective thinking**

  The student potential in self-discipline, planning, organizational and time management skills and the ability to work independently will be enhanced.

- **Digital literacy**

  The data analysis ability to apply specific skills in acquiring, organizing, analyzing, evaluating and presenting microbiological information, in particular incorporating the increasing importance of digital-based activity.

- **Multicultural competence**

  The students acquire an awareness of and appreciation for, the social and cultural context of the implications of microbiology and microbiological knowledge and investigation.

2. Programme Specific Qualification Attributes

Programme specific qualification attributes achieved through courses in the programme in terms of

- Knowledge and understanding level (K1 and K2)
- Application level (K3)
- Analytical level (K4)
- Evaluation capability level (K5)
- Scientific or synthesis level (K6)

1. **Vision**

   Aspires to be a reference center for microbiology, committed to an academic excellence and to attain the national and international recognition for the quality of its education, research, and service activities in agriculture, medical and public health

2. **Programme Outcomes (Pos)**

PO1: Problem Solving Skill

Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context.

PO2: Decision Making Skill

Foster analytical and critical thinking abilities for data-based decision-making.

PO3: Ethical Value

Ability to incorporate quality, ethical and legal value-based perspectives to all Organizational activities.

PO4: Communication Skill

Ability to develop communication, managerial and interpersonal skills.

PO5: Individual and Team Leadership Skill

Capability to lead themselves and the team to achieve organizational goals.

PO6: Employability Skill

Inculcate contemporary business practices to enhanceemployability skills in the competitive environment.

PO7: Entrepreneurial Skill

Equip with skills and competencies to become an entrepreneur.

PO8: Contribution to Society

Succeed in career endeavors and contribute significantly to society.

PO 9 Multicultural competence

Possess knowledge of the values and beliefs of multiple cultures and a global perspective.

PO 10: Moral and ethical awareness/reasoning

Ability to embrace moral/ethical values in conducting one's life.

Programme Specific Outcomes(PSOs):

PSO1 – Placement

To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.

PSO 2 - Entrepreneur

To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.

PSO3 – Research and Development

Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development.

PSO4 – Contribution to Business World

To produce employable, ethical and innovative professionals to sustain in the dynamic business world.

PSO 5 – Contribution to the Society

To contribute to the development of the society by collaborating with stakeholders for mutual benefit.

3. Candidate's eligibility for admission

Candidate who has passed the B.Sc. degree in any Life Sciences [Microbiology/ Applied Microbiology/ Industrial Microbiology/ Botany/ Plant Sciences and Plant Biotechnology/ Zoology/ Biochemistry/ Bioinformatics/ Biology/Chemistry with Botany/ Zoology as Allied Subjects] of this university or an examination of any other university accepted by the syndicate as equivalent thereto shall be eligible for admission to M.Sc. Degree Course in Microbiology.

4. Duration of the programme

The duration of the course is for two academic years consisting of four semesters.

5. Examinations

There shall be four semester examinations: first semester examinations at the middle of the first academic year and the second semester examination at the end of the first academic year. Similarly, the third and fourth semester examinations shall be held at the middle and end of the second academic year, respectively.

6. Scheme for Evaluation and Attainment Rubrics

Evaluation will be done on a continuous basis and will be evaluated four times during the course work. The first evaluation will be in the 7^{th} week, the second in the 11^{th} week, third in the 16^{th} week and the end- semester examination in the 19^{th} week. Evaluation may be by objective type questions, short answers, essays or a combination of these, but the end semester examination is a University theory examination with prescribed question paper pattern.

Attainment Rubrics for Theory Courses

External	: 75 Marks
Internal	: 25 Marks
Total	: 100 Marks
Time	: 3 hours

The following procedure will be followed for Internal Marks:

Theory Papers Internal

Best two tests out of 3	:	10 marks
Attendance	:	5 marks
Seminar	:	5 marks
Assignment	:	5 marks
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		25 marks

Question Paper Pattern (Theory)

Section	Approaches	Mark Pattern	K Level	CO coverage
A	One word (Answer all questions)	20 x 1=20 (Multiple choice questions)		
B	100 to 200 words (Answer any three out of five questions)	3 x 5=15 (Analytical type questions)		
C	500 to 1000 words (Either or type one pair from each unit)	5 x 8=40 (Essay type questions)		

Attainment Rubrics for Lab courses

Practical (External) : 60 Marks

Major Experiment	:	25 marks
Minor Experiment	:	15 marks
Spotters	:	10 marks
Viva	:	05 marks
Record	:	05 marks

Practical (Internal) :40 Internal Marks

Attendance : 5 marks

Practical Test : 30 marks

(Best 2 out of 3)

Record : 5 marks

Attainment Rubrics for Research

Project

Internal Mark : 20 marks

Viva - voce : 20 marks

Project Report : 60 marks

7. Grading System

Evaluation of performance of students is based on ten-point scale grading system as given below.

RangeofMarks	GradePoints	LetterGrade	Description
90 -100	9.0 – 10.0	O	Outstanding
80 -89	8.0 – 8.9	D+	Excellent
75 -79	7.5 – 7.9	D	Distinction
70 -74	7.0 – 7.4	A+	VeryGood
60 -69	6.0 – 6.9	A	Good
50 -59	5.0 – 5.9	B	Average
00 -49	0.0	U	Re-Appear
ABSENT	0.0	AAA	Absent

8. ClassificationofFinalResult

CGPA	Grade	ClassificationofFinalResult
9.5 – 10.0	O+	FirstClasswithExemplary*
9.0and abovebutbelow9.5	O	
8.5and abovebutbelow9.0	D++	FirstClasswithDistinction*
8.0and abovebutbelow8.5	D+	
7.5and abovebutbelow8.0	D	
7.0and abovebutbelow7.5	A++	FirstClass
6.5and abovebut below7.0	A+	
6.0and abovebutbelow6.5	A	
5.5and abovebutbelow6.0	B+	SecondClass
5.0and abovebutbelow5.5	B	
0.0and abovebutbelow5.0	U	Re-Appear

*Thecandidateswhohavepassedinthefirstappearanceandwithintheprescribedsemesterofthe PG Program areeligible.

Template for P.G., Programmes

Semester –I	Credit	Hours	Semester II	Credit	Hours	Semester III	Credit	Hours	Semester IV	Credit	Hours
Core I	5	7	Core IV	5	6	Core VII	5	6	Core XI	5	6
Core II	5	7	Core V	5	6	Core VIII	5	6	Core XII	5	6
Core III	4	6	Core VI	4	6	Core IX	4	6	Project with viva voce	**7**	10
Elective I	3	5	Elective III	3	6	Core X	5	6	Elective VI	3	4
Elective II:	3	5	Elective IV	3	6	Elective V	3	3	Skill Enhancement course / Professional Competency Skill	2	4
						NME II	2	3	Extension Activity	1	-
			Swayam/ MooC	2	-	Internship/ Industrial Activity	2	-	Credit Seminar	1	-
			Human Rights	1	-						
	20	**30**		**23**	**30**		**26**	**30**		**24**	**30**
Total Credit Points -93											

Credit Distribution for M.Sc Microbiology

First Year

Semester-I

Part	Course	Course Title	Credit	No. of Hours
	Core I	General Microbiology and Microbial Diversity	5	6
	Core II	Immunology, Immunomics and Microbial Genetics	5	6
	Core III	Practical-I	4	6
	Elective I	Forensic Science/ Health Hygiene/ Micro algal Technology (Among the three choices anyone can be chosen by the student)	3	6
	Elective II	Bioinstrumentation/ Herbal Technology and Cosmetic Microbiology / Essentials of Laboratory Management and Biosafety (Among the three choices anyone can be chosen by the student)	3	6
		Total	**20**	**30**

Semester-II

Part	Course	Course Title	Credit	No. of Hours
	Core IV	Medical Bacteriology and Mycology	5	6
	Core V	Medical Virology and Parasitology	5	6
	Core VI	Practical-II	4	6
	Elective III	Epidemiology/ **Bioremediation** Clinical Diagnostic Microbiology/ (Among the three choices anyone can be chosen by the student)	3	6
	Elective IV	Bioinformatics/Nano biotechnology/ **Clinical Research and Clinical Trials** (Among the three choices anyone can be chosenby the student)	3	6
		Swayam / Mooc	2	
		Human Rights	1	
		Total	**23**	**30**

Second Year

Semester-III

Part	Course	Course Title	Credit	No. of Hours
	Core VII	Soil and Environmental Microbiology	5	6
	Core VIII	Recombinant DNA Technology and Biotechnology	5	6
	Core IX	Practical's III	4	6
	Core X (Industry Module)	Fermentation Technology and Pharmaceutical Microbiology	5	6
	Elective V	Biosafety, Bioethics and IPR/ Toxicology/ Water Conservation and Water Treatment (Among the three choices anyone can be chosen by the student)	3	3
	NME-I	Organic Farming and Bio fertiliser Technology	2	3
		Internship / Industrial Activity	2	-
			26	**30**

Semester-IV

Part	Course	Course Title	Credit	No. of Hours
	Core XI	Food & Dairy Microbiology	5	6
	Core XII	Research Methodology & Biostatistics	5	6
	Project	Project with Viva Voce	7	10
	Elective VI	Bioenergy/ Marine Microbiology/ Life Science for Competitive Examinations (Among the three choices anyone can be chosen by the student)	3	4
Skill Enhancement Course		Microbial Quality Control and Testing	2	4
Extension Activity			1	-
		Credit Seminar	1	
			24	**30**

Curriculum Structure

Semester	Paper Code	Title of the Paper	Hrs/ Week	Credits	Marks		
					CIA	EA	Total
I	23UPMBC1C01	Core- I- General Microbiology and Microbial Diversity	7	5	25	75	100
	23UPMBC1C02	Core II- Immunology, Immunomics and Microbial Genetics	7	5	25	75	100
	23UPMBC1L01	Core Course III-Practical I	6	4	40	60	100
	23UPMBC1E01	Elective Course I- Forensic Science	5	3	25	75	100
	23UPMBC1E02	Health Hygiene					
	23UPMBC1E03	Micro algal Technology					
	23UPMBC1E04	Elective Course II- Bioinstrumentation	5	3	25	75	100
	23UPMBC1E05	Herbal Technology and Cosmetic Microbiology					
	23UPMBC1E06	Essentials of Laboratory Management and Biosafety					
II	23UPMBC1C03	Core Course IV- Medical Bacteriology and Mycology	6	5	25	75	100
	23UPMBC1C04	Core Course V Medical Virology and Parasitology	6	5	25	75	100
	23UPMBC1L02	Core Course VI- Practical II	6	4	40	60	100
	23UPMBC1E07	Elective Course III – Epidemiology	6	3	25	75	100
	23UPMBC1E08	Clinical Diagnostic Microbiology					
	23UPMBC1E09	Bioremediation					
	23UPMBC1E10	Elective Course IV- Bioinformatics	6	3	25	75	100
	23UPMBC1E11	Nano biotechnology					
	23UPMBC1E12	Clinical Research and Clinical Trials					
		Swayam/ Mooc	-	2	-	-	-
	23UPPGC1C1H01	Human Rights	-	1	25	75	100

III	23UPMBC1C05	Core Course VII- Soil and Environmental Microbiology	6	5	25	75	100
	23UPMBC1C06	Core Course VIII-Molecular Biology and Recombinant DNA Technology	6	5	25	75	100
	23UPMBC1L03	Core Course IX- Practical's	6	4	40	60	100
	23UPMBC1C07	Core Course X- Fermentation technology and Pharmaceutical Microbiology (Industry Module).	6	5	25	75	100
	23UPMBC1E13	Elective Course V Biosafety, Bioethics and IPR	3	3	25	75	100
	23UPMBC1E14	Toxicology					
	23UPMBC1E15	Water Conservation and Water Treatment Technologies					
	23UPMBC1N02	NME- I- Organic Farming and Bio fertilizer Technology	3	2	25	75	100
	23UPMBC1I01	Internship / Industrial Activity	-	2	40	60	100
IV	23UPMBC1C08	Core Course XI- Food and Dairy Microbiology	6	5	25	75	100
	23UPMBC1C09	Core Course XII-Research Methodology and Biostatistics	6	5	25	75	100
	23UPMBC1P01	Project with Viva voce	10	7	40	60	100
	23UPMBC1E16	Elective Course VI- Bioenergy	4	3	25	75	100
	23UPMBC1E17	Marine Microbiology					
	23UPMBC1E18	Life Science for Competitive Examinations					
	23UPMBC1S01	Skill Enhancement Course III- Microbial Quality Control and Testing	4	2	25	75	100
	23UPMBC1X01	Extension Activity	-	1	-	-	-
	23UPMBC1CS1	Credit Seminar	-	1	40	60	100
		Total		93	750	1650	2400

FIRST YEAR

SEMESTER-I

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1C01	**General Microbiology and Microbial Diversity**	**Core Course I**	**Y**	**Y**	**-**	**-**	**5**	**7**	**25**	**75**	**100**

Course Objectives

CO1	Acquire knowledge on the principles of different types of microscopes and their applications.
CO2	Compare and contrast the structure of bacteria and fungi. Illustrate nutritional requirements and growth in bacteria.
CO3	Exemplify, isolate and cultivate microalgae from diverse environmental sources.
CO4	Explain various pure culture techniques and discuss sterilization methods.
CO5	Discuss the importance and conservation of microbial diversity.

UNIT	Details	No. of Hours	Course Objectives
I	History and Scope of Microbiology. Microscopy – Principles and applications. Types of Microscopes - Bright field, Dark-field, Phase-contrast, Fluorescence microscope, Transmission electron microscope (TEM) and Scanning electron microscope (SEM). Sample preparation for SEM & TEM. Atomic force, Confocal microscope. Micrometry – Stage, Ocular and its applications.	20	CO1
II	BacterialStructure, properties and biosynthesis of cellular components – Cell wall. Actinomycetes and Fungi - Distribution, morphology, classification, reproduction and economic importance. Sporulation. Growth and nutrition - Nutritional requirements, Growth curve, Kinetics of growth, Batch culture, Synchronous growth, Measurement of growth and factors affecting growth.	20	CO2
III	Algae - Distribution, morphology, classification, reproduction and economic importance. Isolation of algae from soil and water. Media and methods used for culturing algae, Strain selection and large-scale cultivation. Life cycle - *Chlamydomonas*, *VolvoxSpirogyra* (Green algae), *Nostoc* (Cyanobacteria)*Ectocarpus, Sargassum* (Brown algae), *Polysiphonia*, *Batrachospermum* (Red algae).	15	CO3

IV	Microbial techniques - Safety guidelines in Microbiology Laboratories. Sterilization, Disinfection and its validation. Staining methods – Simple, Differential and Special staining. Automated Microbial identification systems - Pure cultures techniques – Cultivation of Anaerobic organisms. Maintenance and preservation of pure cultures. Culture collection centres - National and International.	15	CO4
V	Biodiversity - Introduction to microbial biodiversity – Thermophiles - Classification, Thermophilic Archaebacteria and its applications. Methanogens - Classification, Habitats, applications. Alkaliphiles and Acidophiles - Classification, discovery basin, its cell wall and membrane. Barophiles - Classification and its applications. Halophiles - Classification, discovery basin, cell walls and membranes – purple membrane, compatible solutes, Osmoadaptation / halotolerance - Applications of halophiles. Conservation of Biodiversity.	20	CO5
	Total	90	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Examine various microbes employing the microscopic techniques learnt. Measure and compare the size of microbes.	PO1, PO4, PO11
CO2	Differentiate and appreciate the anatomy of various microbes. Plan the growth of microbes for different environmental conditions.	PO1, PO4
CO3	Identify and cultivate the algae understanding their habitat. Analyze the morphology, classify and propagate depending on its economic importance.	PO7, PO8, PO9
CO4	Create aseptic conditions by following good laboratory practices.	PO3, PO4,PO7
CO5	Categorize and cultivate a variety of extremophiles following standard protocols for industrial applications.	PO5, PO7, PO8, PO9

Text Books

1.	Kanunga R. (2017). Ananthanarayanan and Panicker's Text book of Microbiology. (10th Edition). Universities Press (India) Pvt. Ltd.
2.	Chan E.C.S., Pelczar M. J. Jr. and Krieg N. R. (2010). Microbiology. (5th Edition). Mc.Graw Hill. Inc, New York.
3.	Prescott L. M., Harley J. P. and Klein D. A. (2004). Microbiology. (6th Edition). McGraw - Hill company, New York.
4.	White D. Drummond J. and Fuqua C. (2011). The Physiology and Biochemistry of Prokaryotes, Oxford University Press, Oxford, New York.
5.	Dubey R.C. and Maheshwari D. K. (2009). Textbook of Microbiology. S. Chand, Limited.

REFERENCES BOOKS	
1.	Tortora G. J., Funke B. R. and Case C. L. (2015). Microbiology: An Introduction (12th Edition).Pearson, London, United Kingdom
2.	Webster J. and Weber R.W.S. (2007). Introduction to Fungi. (3rd Edition). Cambridge University Press, Cambridge.
3.	Schaechter M. and Leaderberg J. (2004). The Desk encyclopedia of Microbiology. Elseiver Academic Press, California.
4.	Ingraham, J.L. and Ingraham, C.A. (2000) Introduction to Microbiology. (2nd Edition). Books / Cole Thomson Learning, UK.
5.	Madigan M. T., Bender K.S., Buckley D. H. Sattley W. M. and Stahl (2018) Brock Biology of Microorganisms. (15th Edition). Pearson.
Web Resources	
1.	http://sciencenetlinks.com/tools/microbeworld
2.	https://www.microbes.info/
3.	https://www.asmscience.org/VisualLibrary
4.	https://open.umn.edu/opentextbooks/BookDetail.aspx?bookId=404
5.	https://www.grsmu.by/files/file/university/cafedry//files/essential_microbiology.pdf

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (K1)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyze (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M			M							S			
CO2	L			S										
CO3							S	S	M					
CO4			S	S			S							
CO5					S		S	S	S					

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
23UPMBC1C02	**Immunology, Immunomics and Microbial Genetics**	**Core Course II**	**Y**	**Y**	**-**	**-**	**5**	**7**	**25**	**75**	**100**

Course Objectives	
CO1	Discuss immunity, organs and cells involved in immunity. Compare the types of antigens and their properties.
CO2	Describe immunoglobulin and its types. Categorize MHC and understand its significance.
CO3	Elucidate the mechanisms of different hypersensitivity reactions. List out the Vaccines and discuss their development.
CO4	Acquire knowledge the structure DNA in prokaryotes and eukaryotes
CO5	Explain out gene transfer studies in microbes.

UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Introduction to biology of the immune system – Cells and organs of Immune System. T and B lymphocytes – Origin, development, differentiation, lymphocyte subpopulation in humans. Innate immunity- Complement, Toll-like receptors and other components. Acquired immunity – Active and Passive immunity. Antigens - features associated with antigenicity and immunogenicity. Basis of antigen specificity. MHC genes and products, Structure of MHC molecules, Genetics of HLA Systems – Antigens and HLA typing. Antigen processing and presentation to T- lymphocytes.	20	CO1
II	Immunoglobulins. Theories of antibody production. Class switching and generation of antibody diversity. Monoclonal and polyclonal antibodies. Complement system – mode of activation- Classical, Alternate and Lectin pathways, biological functions. Antigen recognition – TCR, Diversity of TCR, T cell surface alloantigens, lymphocyte activation, clonal proliferation and differentiation. Physiology of	20	CO2

	acquired immune response – various phases of HI, CMI – Cell mediated cytotoxicity, DTH response.		
III	Hypersensitivity – Types and mechanisms, Autoimmunity, Tumor Immunity and Transplantation immunology. Immunodeficiency-Primary immunodeficiency and Secondary immunodeficiencies. Genetics of Immunohematology – Genetic basis and significance of ABO and other minor blood groups in humans, Bombay blood group, Secretors and Non-secretors, Rh System and genetic basis of D- antigens. Diagnostic Immunology - Precipitation reaction, Immunodiffusion methods - SRID, ODD. Immunoelectrophoresis - Rocket and Counter current electrophoresis. Agglutination - Hemagglutination - Hemagglutination inhibition. Labeled Assay- Immunofluorescence assay, Radio immunoassay, FISH, ELISA. Flow cytometry. Immune regulation mechanisms – immuno-induction, immuno- suppression, immuno-tolerance, immuno-potentiation, Immunomodulation. Role of cytokines, lymphokines and chemokines. Introduction to Vaccines and Adjuvants - Types of vaccines. Development of vaccines and antibodies in plants. Immunomics - Introduction and Applications. Antigen engineering for better immunogenicity and use for vaccine development-multiepitope vaccines. Reverse vaccinology.	25	CO3
IV	Structural of prokaryotic and eukaryotic genome. Introduction to prokaryotic genomic structure, Eukaryotic Genome - Structure of chromatin, chromosome, centromere, telomere, nucleosome. Modifications- methylation, acetylation, phosphorylation and its effect on structure and function of chromatin, DNA methylation and gene imprinting, organelle genome.	13	CO4
V	Gene Transfer Mechanisms- Conjugation and its uses. Transduction, Generalized and Specialized, Transformation– Natural Competence and Transformation. Transposition and Types of Transposition reactions. Insertion sequences, complex and compound transposons – T10, T5, and Retroposon. Mechanism – Transposons of *E. coli*, Bacteriophage and Yeast. Importance of transposable elements in horizontal transfer of genes and evolution.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Categorize the immune response to a variety of antigens. Identify different immune cells involved	PO1, PO4, PO6, PO7, PO9

	in immunity.	
CO2	Justify the significance of MHC molecules in immune response and antibody production.	PO1, PO4, PO5,PO6, PO9
CO3	Design antibodies and evaluate immunological assays in patient samples.	PO4, PO6, PO7, PO8, PO9, PO10
CO4	Analyze genomic DNA of prokaryotes and eukaryotes.	PO4,PO5, PO6, PO7, PO9, PO10
CO5	Summarize gene transfer mechanisms for experimental study.	PO4,PO5, PO6, PO7, PO9, PO10

Text Books	
1.	Coico R., Sunshine G. and Benjamini E. (2003). Immunology – A Short Course. (5th Edition). Wiley-Blackwell, New York.
2.	Owen J. A., Punt J., Stranford S. A. and Kuby J. (2013). Immunology, (7th Edition). W. H. Freeman and Company, New York.
3.	Abbas A. K., Lichtman A. H. and Pillai S. (2021). Cellular and Molecular Immunology. (10thEdition).Elsevier.
4.	Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi.
5.	Gardner E. J. Simmons M. J. and Snusted D.P. (2006). Principles of Genetics. (8th Edition). Wiley India Pvt. Ltd.
References Books	
1.	Travers J. (1997). Immunobiology - The Immune System in Health and Disease. (3rd Edition). Current Biology Ltd. New York.
2.	Delves P.J., Martin S., Burton D. R. and Roitt I. M. (2006). Roitt's Essential Immunology. (11th Edition). Wiley-Blackwell.
3.	Hay F. C. and Westwood O. M. R. (2002). Practical Immunology (4thEdition). Wiley-Blackwell.
4.	Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press.
5.	Russell P.J. (2010). Genetics - A Molecular Approach. (3rd Edition). Pearson New International Edition.
Web Resources	
1.	https://www.ncbi.nlm.nih.gov/books/NBK279395/
2.	https://med.stanford.edu/immunol/phd-program/ebook.html
3.	https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/
4.	[PDF] Lehninger Principles of Biochemistry (8th Edition) By David L. Nelson and Michael M. Cox Book Free Download - StudyMaterialz.in

5.	https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S			M		M	S		S					
CO2	S			S	M	S			S					
CO3				S		S	S	S	S	M				
CO4				S	M	S	M		S	M				
CO5				S	M	S	M		S	S				

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
23UPMBC1L01	**Practical I**	**Core Course III-Practical I**	**-**	**-**	**Y**	**-**	**4**	**6**	**60**	**40**	**100**

Course Objectives	
CO1	Gain knowledge on the fundamentals, handling and applications of microscopy, sterilization methods. Identify microbesby different staining methods.

CO2	Prepare media for bacterial growth. Discuss plating and growth measurement techniques.		
CO3	Acquire adequate skills to perform blood grouping and serological reactions.		
CO4	Provide fundamental skills in preparation, separation and purification of immunoglobulin.		
CO5	Apply the knowledge of molecular biology skills in clinical diagnosis.		
UNIT	**Details**	**No.of Hours**	**Course Objectives**
I	Microscopic Techniques: Light microscopy: Hay infusion broth. Wet mount to show different types of microbes, hanging drop. Dark field microscopy – Motility of Spirochetes. Washing and cleaning of glass wares: Sterilization methods: moist heat, dry heat, and filtration. Quality control check for each method. Staining techniques - Simple staining, Gram's staining, Acid fast staining, Meta chromatic granule staining, Spore, Capsule, Flagella.	20	CO1
II	Media Preparation: Preparation of liquid, solid and semisolid media. Agar deeps, slants, plates. Preparation of basal, enriched, selective and enrichment media. Preparation of Biochemical test media, media to demonstrate enzymatic activities. Microbial Physiology: Purification and maintenance of microbes. Streak plate, pour plate, and slide culture technique. Aseptic transfer. Direct counts – Total cell count, Turbidometry. Viable count - pour plate, spread plate. Bacterial growth curve. Effect of physical and chemical factors on growth. Anaerobic culture methods.	20	CO2
III	Hematological reactions - Blood Grouping – forward and reverse, Rh Typing Identification of various immune cells by morphology – Leishman staining, Giemsa staining. Agglutination Reactions- Latex Agglutination reactions- RF, ASO, CRP. Detection of HBs Ag by ELISA. Precipitation reactions in gels– Ouchterlony double immunodiffusion (ODD) and Mancini's single radial immunodiffusion (SRID) Immuno-electrophoresis and staining of precipitin lines- Rocket immuno electrophoresis and counter current immuno electrophoresis.	20	CO3
IV	Preparation of lymphocytes from peripheral blood by density gradient centrifugation.	10	CO4

	Purification of immunoglobulin– Ammonium Sulphate Precipitation. Separation of IgG by chromatography using DEAE cellulose or Sephadex.		
V	Western Blotting – Demonstration. Isolation of genomic DNA from *E. coli* and analysis by agarose gel electrophoresis Estimation of DNA using colorimeter (Diphenylamine reagent) Separation of proteins by polyacrylamide gel electrophoresis (SDS-PAGE) UV induced mutation and isolation of mutants by replica plating technique. Plasmid DNA isolation from *E.coli*. RNA isolation from yeast. RNA estimation by Orcinol method.	20	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Apply microscopic techniques and staining methods in the identification and differentiation of microbes.	PO1, PO6, PO7, PO8, PO9, PO11
CO2	Apply the knowledge on the sterilization of glass wares and media by different methods and measurement of cell growth.	PO1, PO6, PO7, PO8, PO9, PO11
CO3	Perform and evaluate immunological reactions to aid diagnosis.	PO5, PO7, PO8, PO9, PO11
CO4	Assess the level of lymphocytes in a blood sample and purify immunoglobulin employing appropriate techniques.	PO6, PO7, PO8, PO9, PO11
CO5	Perform DNA extraction and gene transfer mechanisms, analyze and identify by gel electrophoresis	PO6, PO7, PO8, PO9, PO11

Text Books

1.	Dubey R.C. and Maheshwari D. K. (2010).Practical Microbiology. S. Chand.
2.	Cappuccimo, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6^{th} Edition). Pearson Education, Publication, New Delhi.
3.	Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2^{nd} Edition). - Taylor &Francis.
4.	Rich R. R., Fleisher T. A., Shearer W. T., Schroeder H, Frew A. J. and Weyand C. M. (2018). Clinical Immunology: Principles and Practice. (5^{th} Edition). Elsevier.
5.	Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5^{th} Edition). ASM Press.

References Books	
1.	Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie& McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi.
2.	Gupta P. S. (2003). Clinical Immunology. Oxford University Press.
3.	Brown T.A. (2016). Gene Cloning and DNA Analysis. (7th Edition). John Wiley and Jones, Ltd.
4.	Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rdEdition). John Wileys and Sons Ltd. 2012.
5.	Maloy S. R., Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2nd Edition). Narosa Publishing Home Pvt Ltd.
Web Resources	
1.	http://textbookofbacteriology.net/
2.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/
3.	https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/
4.	[PDF] Lehninger Principles of Biochemistry (8th Edition) By David L. Nelson and Michael M. Cox Book Free Download - StudyMaterialz.in
5.	https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	40 Marks
	Attendance and Class Participation	
External Evaluation	End Semester Examination	60 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples,Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14
CO1	M					S	M	M	S		M			
CO2	M					S	M	M	S		M			

CO3					S		S	M	S		M			
CO4						S	S	M	S		S			
CO5						S	S	M	S		S			

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
23UPMBC 1E01	**Forensic Science**	**Elective CourseI (Choice -1)**	**3**	**1**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives	
CO1	Understand the Scope, need and learn the tools and techniques inforensic science.
CO2	Comprehend organizational setup of a forensic science laboratory.
CO3	Identify and Examine body fluids for identification.
CO4	Extract DNA from blood samples for investigation.
CO5	Recognizemedico legal post mortem procedures and their importance.

UNIT	**Details**	**No.of Hours**	**Course Objectives**
I	Forensic Science - Definition, history and development of forensic science. Scope and need of forensic science in present scenario. Branches of forensic science. Tools and techniques of forensic science. Duties of a forensic scientist.	12	CO1
II	Forensic science laboratories - Organizational setup of a forensic science laboratory. Central and State level laboratories in India. Mobile forensic science laboratory and its functions. Forensic microbiology - Types and identification of microbial organisms of forensic significance.	12	CO2
III	Forensic serology - Definition, identification and examination of body fluids - Blood, semen, saliva, sweat and urine. Forensic examination and identification of hair and fibre.	12	CO3
IV	DNA profiling - Introduction, history of DNA typing. Extraction of DNA from blood samples -Organic and Inorganic extraction methods. DNA fingerprinting - RFLP, PCR, STR. DNA testing in disputed paternity.	12	CO4
V	Forensic toxicology - Introduction and concept of forensic toxicology. Medico legal post mortem and their examination. Poisons - Types of poisons and their mode of action.	12	CO5
	Total	60	

Course Outcomes	On completion of this course, students will;	
CO1	Identify the scope and need of forensic science in the present scenario.	PO1, PO6, PO7, PO8, PO9

CO2	Plan for the organizational setup and functioning of forensic science laboratories.	PO1, PO6, PO7, PO8, PO9
CO3	Analyze the biological samples found at the crime scene.	PO1, PO5, PO7, PO8, PO9
CO4	Perform extraction and identification of DNA obtained from body fluids.	PO1, PO6, PO7, PO8, PO9
CO5	Discuss the concept of forensic toxicology.	PO1, PO6, PO7, PO8, PO9

Text Books	
1.	Nanda B.B. and Tewari R.K. (2001) Forensic Science in India: A Vision for the Twenty First Century. Select Publishers, New Delhi. ISBN- 10:8190113526 / ISBN-13:9788190113526.
2.	James S.H. and Nordby,J.J. (2015) Forensic Science: An Introduction to Scientific and Investigative Techniques. (5thEdition). CRC Press. ISBN-10:9781439853832 / ISBN-13:978-1439853832.
3.	Li R. (2015) Forensic Biology. (2nd Edition). CRC Press, New York. ISBN-13:978-1-4398-8972-5.
4.	Sharma B.R (2020) Forensic science in criminal investigation and trials. (6thEdition)Universal Press.
5.	Richard Saferstein (2017). Criminalistics- An introduction to Forensic Science. (12th Edition).Pearson Press.
Reference books	
1.	Nordby J. J. (2000). Dead Reckoning. The Art of Forensic Detection- CRC Press, New York. ISBN:0-8493-8122-3.
2.	Saferstein R. and Hall A.B.(2020). Forensic Science Hand book, Vol.I, (3rd Edition). CRC Press, New York. ISBN-10:1498720196.
3.	Lincoln, P.J. and Thomson, J. (1998). (2ndEdition). Forensic DNA Profiling Protocols. Vol. 98. Humana Press. ISBN:978-0-89603-443-3.
4.	Val McDermid (2014). Forensics. (2nd Edition). ISBN 9780802125156.
5.	Vincent J. DiMaio., Dominick DiMaio. (2001). Forensic Pathology (2nd Edition). CRC Press.
Web resources	
1.	http://clsjournal.ascls.org/content/25/2/114
2.	https://www.ncbi.nlm.nih.gov/books/NBK234877/
3.	https://www.elsevier.com/books/microbial-forensics/budowle/978-0-12-382006-8
4.	https://www.researchgate.net/publication/289542469_Methods_in_microbial_forensics

5.	https://cisac.fsi.stanford.edu/events/microbial forensics

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	L					S	M	M	S					
CO2	M					S	M	M	S					
CO3	L				S		S	M	S					
CO4	M					S	S	M	S					
CO5	M					S	S	M	S					

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
23UPMBC1E02	**Health and Hygiene**	**Elective CourseI (Choice- 2)**	**Y**	**Y**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives

CO1	Acquire knowledge on hygiene and live healthy.		
CO2	Provide insights on health laws for food safety and hygiene.		
CO3	Explainhealth, physical exercises and their importance.		
CO4	Illustrate mental hygiene and involved in mental hygiene.		
CO5	Describe the various health and health education programmes by the government.		
UNIT	**Details**	**No.of Hours**	**Course Objectives**
I	Introduction to hygiene and healthful live. Factors affecting health, health habits and practices. Recognizing positive & negative practices in the community. Scientific principles related to health.	12	CO1
II	Nutrition and Health – Balanced diet, Food surveillance, food Fortification, adulteration and preventive measures. Health laws for food safety. Environmental and housing hygiene. Ventilation and lighting.	12	CO2
III	Physical health, physical exercises and their importance – Walking, jogging, yoga and meditation, stress relief. International control of health, WHO. Personal hygiene, Sun bathing, Colon Hygiene. Health destroying habits and addictions - Pan, supari, ganja, drinking, smoking, tea and coffee.	12	CO3
IV	Mental hygiene- factors responsible, developmental tasks, basic needs, emotional stability. Mental hygiene and health in infancy, early childhood, adolescence, adulthood and old age. Mental health occupational hazards.	12	CO4
V	Health programme and health education – Malaria control, Tuberculosis control, AIDS control programmes and Immunization Programmes. Family planning, Reproductive and Child health programmes (RCH).	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Identify factors affecting health and health habits.	PO1, PO5, PO10
CO2	Execute the knowledge of ventilation and lighting.Justify Health laws for food safety and hygiene.	PO5, PO10
CO3	Followpersonal hygiene to avoid diseases and Prevent people from health-destroying habits and addictions.	PO5, PO10
CO4	Explore Mental hygiene and maintain emotional stability.	PO5, PO10
CO5	Participate in health education programmes	PO1, PO5, PO10

Text Books	
1.	Bamji M. S., KrishnaswamyK. and BrahmamG. N. V. (2019). Textbook of Human Nutrition. (4th Edition). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi
2.	Swaminathan (1995)Food& Nutrition (Vol I) (2nd Edition). The Bangalore Printing &Publishing Co Ltd., Bangalore.
3.	Paniker J. C. K. and Ananthanarayan R. (2017). Textbook of Microbiology. (10th Edition). Universities Press (India) Pvt. Ltd
4.	Lindsay Dingwall.(2010). **Personal Hygiene Care** Print ISBN:9781405163071 |Online ISBN:9781444318708 |DOI:10.1002/9781444318708
5.	Walter C. C. Pakes(1900). The Science of Hygiene: a Text-book of Laboratory Practice. (London: Methuen and Co.,).
References Books	
1.	Khader V. (2000) Food, Nutrition and Health, Kalyan Publishers, New Delhi.
2.	Srilakshmi, B. (2010)Food Science, (5th Edition) New Age International Ltd., New Delhi.
3.	Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand.
4.	Park K. 2007, Park's text book of Preventive and Social Medicine, Banarsidas Bhanot publishers, India.
5.	Srilakshmi, 2002, Dietetics, New Age Publications, India
Web Resources	
1.	Health and Hygiene - Personal Hygiene, Community Hygiene and Diseases (vedantu.com)
2.	Chapter-32.pdf (nios.ac.in)
3.	Menstrual Health and Hygiene Guide | Student Health and Counseling Services (ucdavis.edu)
4.	https://nap.nationalacademies.org/read/11756/chapter/13
5.	http://ecoursesonline.iasri.res.in/mod/page/view.php?id=112325

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	L				S					M				
CO2					S					M				
CO3					S					L				
CO4					S					M				
CO5	L				S					M				

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPM BC1E03	**Micro algal Technology**	**Elective CourseI (Choice -3)**	**Y**	**Y**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives

CO1	Characterize the different groups of algae.
CO2	Describe the cultivation and harvesting of algae.
CO3	Identify the commercial applications of various algal products.
CO4	Apply microalgae for environmental applications.
CO5	Employ microalgae as alternate fuels.

UNIT	Details	No.of	Course

		Hours	Objectives
I	Introduction to Algae - General characteristics. Classification of algae according to Fritsch. Salient features of different groups of algae. Distribution - Freshwater, brackish water and marine algae. Identification methods. An overview of applied Phycology. Economically important microalgae.	12	CO1
II	Cultivation of freshwater and marine microalgae - Growth media. Isolation and enumeration of microalgae. Laboratory cultivation and maintenance. Outdoor cultivation - Photobioreactors - construction, types and operation; raceway ponds - Heterotrophic and mixotrophic cultivation -Harvesting of microalgae biomass.	12	CO2
III	Microalgae in food and nutraceutical applications - Algal single cell proteins. Cultivation of *Spirulina* and*Dunaliella*. Microalgae as aquatic, poultry and cattle feed. Microalgalbiofertilizers. Value-added products from microalgae. Pigments - Production of microalgal carotenoids and their uses. Phycobiliproteins - production and commercial applications. Polyunsaturated fatty acids as active nutraceuticals. Microalgal secondary metabolites - Pharmaceutical and cosmetic applications.	12	CO3
IV	Microalgae in environmental applications.Phycoremediation - Domestic and industrial waste water treatment. High-rate algal ponds and surface-immobilized systems - Treatment of gaseous wastes by microalgae. Sequestration of carbon dioxide. Scavenging of heavy metals by microalgae. Negative effects of algae. Algal blooms, algicides for algal control.	12	CO4
V	Microalgae as feed stock for production of biofuels - Carbon-neutral fuels. Lipid-rich algal strains - *Botryococcusbraunii*. Drop-in fuels from algae - hydrocarbons and biodiesel,bioethanol, biomethane, biohydrogen and syngas from microalgae biomass. Biocrude synthesis from microalgae. Integrated biorefinery concept. Life cycle analysis of algae biofuels.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Acquire knowledge in the field of microalgal technology and their characteristics.	PO1
CO2	Identify the methods of algal cultivation and harvesting.	PO1, PO6
CO3	Recognize and recommend the useof microalgae as food,	PO7,PO8,PO9

	feed and fodder.	
CO4	Promote microalgae in phycoremediation.	PO7,PO9,PO11,PO14
CO5	Compare and critically evaluate recent applied research in these microalgal applications.	PO7,PO8,PO9

Text Books	
1.	Lee R.E. (2008). Phycology. Cambridge University Press.
2.	Sharma O.P. (2011). Algae. Tata McGraw-Hill Education.
3.	Shekh A., Schenk P., Sarada R. (2021). Microalgal Biotechnology. Recent Advances, Market Potential andSustainability. Royal Society of Chemistry.
4.	Lele. S.S., Jyothi Kishen Kumar (2008). Algal bio process technology. New Age International P(Ltd)
5.	Das., Mihirkumar. Algal Biotechnology. Daya Publishing House, New Delhi.

References Books	
1	Andersen R.A. (2005). Algal culturing techniques. Academic Press, Elsevier.
2	Bux F. (2013). Biotechnological Applications of Microalgae: Biodiesel and Value-added Products. CRCPress.
3	Singh B., Bauddh K., Bux, F. (2015). Algae and Environmental Sustainability. Springer.
4	Das D. (2015). An algal biorefinery: An integrated approach. Springer.
5	Bux F. and Chisti Y. (2016). Algae Biotechnology: Products and Processes. Springer.
Web Resources	
1	https://www.classcentral.com/course/algae-10442
2	https://onlinecourses.nptel.ac.in/noc19_bt16/preview
3	https://freevideolectures.com/course/4678/nptel-industrial-biotechnology/46
4	https://nptel.ac.in/courses/103103207
5.	https://www.sciencedirect.com/topics/earth-and-planetary-sciences/microalgae

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S													
CO2	S					M								
CO3							S	S	S					
CO4							S		S		M			M
CO5							M	S	S					

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1E04	**Bioinstrumentation**	**Elective Course II(Choice - 1)**	**Y**	**Y**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives

CO1	Explain the principles and working mechanisms of laboratory instruments.
CO2	Discuss chromatography techniques and molecular biology techniques.
CO3	Illustrate molecular techniques in biological applications.
CO4	Acquire knowledge on spectroscopic techniques
CO5	Demonstrate the use of radio isotopes in various techniques.

UNIT	Details	No.of Hours	Course Objectives
I	Basic laboratory Instruments. Aerobic and anaerobic incubator – Biosafety Cabinets - Fume Hood, pH meter, Lyophilizer, Flow cytometry. Centrifugation techniques: Basic principles of centrifugation - Standard sedimentation	12	CO1

	coefficient - measurement of sedimentation co-efficient; Principles, methodology and applications of differential, rate zonal and density gradient centrifugation - Applications in determination of molecular weight.		
II	General principles of chromatography - Chromatographic Performance parameters; Types- Thin layer chromatography, Paper Chromatography, Liquid chromatography (LPLC &HPLC), Adsorption, ion exchange, Gel filtration, affinity, Gas liquid (GLC). Flash Chromatography and Ultra Performance convergence chromatography. Two dimensional chromatography. Stimulated moving bed chromatography (SEC).	12	CO2
III	Electrophoresis: General principles - moving boundary electrophoresis - electrophoretic mobility – supportive materials – electro endosmosis – types (horizontal, vertical and two dimensional electrophoresis) - Principle and applications - paper electrophoresis, Serum electrophoresis, starch gel electrophoresis, Disc gel, Agarose gel, SDS – PAGE, Immuno electrophoresis. Blotting techniques - Southern, northern and western blotting.	12	CO3
IV	Spectroscopic techniques: Principle, simple theory of absorption of light by molecules, electromagnetic spectrum, instrumentation and application of UV- visible, Raman, FTIR spectrophotometer, spectrofluorimetry, Atomic Absorption Spectrophotometer, Flame spectrophotometer, NMR, ESR, Emission Flame Photometry and GC-MS. Detection of molecules in living cells - FISH and GISH. Biophysical methods: Analysis of biomolecules by Spectroscopy UV/visible.	12	CO4
V	Radioisotopic techniques: Principle and applications of tracer techniques in biology. Radioactive isotopes - radioactive decay; Detection and measurement of radioactivity using ionization chamber, proportional chamber, Geiger- Muller and Scintillation counters, auto radiography and its applications. Commonly used isotopes in biology, labeling procedures and safety aspects.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Make use of the laboratory instruments- laminar air flow, pH meter, centrifugation methods, biosafety cabinets following SOP.	PO4, PO6, PO7, PO8, P11
CO2	Apply chromatography techniques in the separation of	PO4, PO6, PO7,

	biomolecules.	PO8, P11
CO3	Perform molecular techniques like mutagenesis and their detection.	PO4, PO6, PO7, PO8, P11
CO4	Estimate molecules in biological samples by adopting UV spectroscopic techniques.	PO4, PO6, PO7, PO8, P11
CO5	Cultivate organisms anaerobically.	PO4, PO6, PO7, PO8, P11

Text Books	
1.	Sharma B. K. (2014). Instrumental Method of Chemical Analysis. Krishna Prakashan Media (P) Ltd.
2.	Chatwal G. R and Anand S.K. (2014.) Instrumental Methods of Chemical Analysis. Himalaya Publishing House.
3.	Mitchell G.H. (2017). Gel Electrophoresis: Types, Applications and Research. Nova Science Publishers Inc.
4.	Holme D. Peck H. (1998). Analytical Biochemistry. (3rd Edition). Prentice Hall.
5.	Jayaraman J. (2011). Laboratory Manual in Biochemistry. (2ndEdition). Wiley Eastrn Ltd., New Delhi.
References Books	
1.	Pavia D. L. (2012) Spectroscopy (4th Edition). Cengage.
2.	Skoog A. and West M. (2014). Principles of Instrumental Analysis. (14th Edition). W.B.Saunders Co., Philadephia.
3.	Miller J. M. (2007). Chromatography: Concepts and Contrasts (2nd Edition) Wiley-Blackwell.
4.	Gurumani N. (2006). Research Methodology for Biological Sciences. (1st Edition) MJP Publishers.
5.	Ponmurugan P. and Gangathara P. B. (2012). Biotechniques. (1st Edition). MJP Publishers.
Web Resources	
1.	https://norcaloa.com/BMIA
2.	http://www.biologydiscussion.com/biochemistry/centrifugation/centrifuge-introduction- types-uses-and-other-details-with-diagram/12489
3.	https://www.watelectrical.com/biosensors-types-its-working-and-applications.
4.	http://www.wikiscales.com/articles/electronic-analytical-balance/
5.	https://study.com/academy/lesson/what-is-chromatography-definition-types-uses.

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks

	Total	100 Marks
Methods of Assessment		
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions	
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview	
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain	
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge	
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons	
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations	

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1				S		M	M	S			S			
CO2				S		M	M	S			S			
CO3				S		S	S	S			S			
CO4				S		M	S	S			S			
CO5				S		M	S	S			L			

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
23UPMBC1E05	**Herbal Technology and Cosmetic Microbiology**	**Elective Course II (Choice 2)**	**Y**	**Y**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives	
CO1	Impart knowledge of Indian Medicinal Plants and their applications in microbiology.
CO2	Promote the technical skills involved in preparation of different types of plant extracts.
CO3	Explain methods to analyze the antimicrobial activity of medicinal plants.
CO4	Acquire knowledge on cosmetic microbiology and role of microorganisms in cosmetics.

CO5	Gain insight into pharmacopeial microbial assays and biosafety.		
UNIT	**Details**	**No.of Hours**	**Course Objectives**
I	Herbs, Herbal medicine - Indian medicinal plants: Scope and Applications of Indian medicinal plants in treating bacterial, fungal and viral diseases. Basic principles involved in Ayurvedha, Sidha, Unani and Homeopathy.	12	CO1
II	Collection and authentication of selected Indian medicinal plants: *Emblica officinalis, Withaniasomnifera, Phyllanthus amarus, Tinospora cordifolia, Andrographis paniculata, Piper longum, Ocimum sanctum, Azardirchata indica, Terminalia chebula, Allium sativum*. Preparation of extracts- Hot and cold methods. Preparation of stock solutions.	12	CO2
III	Antimicrobial activity of selected Indian medicinal Plants: - In vitro determination of antibacterial and fungal activity of selected whole medicinal plants/ parts – well-diffusion methods. MIC - Macro and micro dilution techniques. Antiviral activity- cell lines- cytotoxicity, cytopathic and non-cytopathic effect.	12	CO3
IV	History of Cosmetic Microbiology – Need for cosmetic microbiology, Scope of cosmetic microbiology, - Role of microbes in cosmetic preparation. Preservation of cosmetics. Antimicrobial properties of natural cosmetic products – Garlic, neem, turmeric, aloe vera and tulsi. Sanitary practices in cosmetic manufacturing - HACCP protocols in cosmetic microbiology.	12	CO4
V	Cosmetic microbiology test methods - Antimicrobial preservative efficacy, microbial content testing and biological toxicological testing. Validation methods - bioburden and Pharmacopeial microbial assays. Preservatives of cosmetics - Global regulatory and toxicological aspect of cosmetic preservatives.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Identify the applications of Indian medicinal plants in treating diseases.	PO1, PO5
CO2	Identify and authenticate herbal plants.	PO6, PO7
CO3	Evaluate the antimicrobial activity of medicinal plants.	PO4, PO6, PO9
CO4	Describe the role of microorganisms and their metabolites in the preparation of cosmetics.	PO1, PO5, PO7
CO5	Validate procedures and biosafety measures in the mass production of cosmetics.	PO6, PO7

Text Books	
1.	Ayurvedic Formulary of India. (2011). Part 1, 2 & 3. Pharmacopoeia Commission for Indian Medicine and Homeopathy. ISBN-10:8190648977.
2.	Panda H. (2004). Handbook on herbal medicines. Asia Pacific Business Press Inc. ISBN:8178330911.
3.	Mehra P. S. (2019). A Textbook of Pharmaceutical Microbiology. Dreamtech Press. ISBN 13:9789389307344.
4.	Geis P. A. (2020). Cosmetic microbiology: A Practical Approach. (3rd Edition). CRC Press.ISBN:9780429113697.
5.	Brannan D. K. (1997). Cosmetic microbiology: A Practical Handbook. CRC Press.ISBN-10:0849337135.
References Books	
1.	Indian Herbal Pharmacopoeia (2002). Vol. I &II Indian Drug Manufacturers Association, Mumbai.
2.	British Herbal Pharmacopoeia.(1990).Vol.I.British Herbal Medicine Association.ISBN: 0903032090.
3.	Verpoorte R. and Mukherjee, P. K. (2010). GMP for Botanicals: Regulatory and Quality issues on Phytomedicines. In GMP for botanicals: regulatory and quality issues on phytomedicines. (2nd edition). Saujanya Books, Delhi.ISBN-10:81-900788-5-2/8190078852. ISBN-13:978-81-900788-5-6/9788190078856.
4.	Turner R. (2013). Screening methods in Pharmacology. Elsevier. ISBN:9781483264233.
5.	Cupp M. J. (2010). Toxicology and Clinical Pharmacology of Herbal Products (pp. 85-93). M. J. Cupp. Humana Press.Totowa, NJ, USA. ISBN-10:1617371904.
Web Resources	
1.	https://www.academia.edu/50236711/Modern_Extraction_Methods_for_Preparation_of_Bioactive_Plant_Extracts
2.	https://www.nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl
3.	https://pubmed.ncbi.nlm.nih.gov/17004305/
4.	https://www.fda.gov/cosmetics/potential-contaminants-cosmetics/microbiological-safety-and-cosmetics
5.	https://pubmed.ncbi.nlm.nih.gov/15156038/

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions

Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M				S									
CO2						S	M							
CO3				S		S			M					
CO4	M				S		S							
CO5						M	S							

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
23UPMBC1E06	**Essentials of Laboratory Management and Biosafety**	**Elective Course II (Choice 3)**	**Y**	**Y**	**-**	**-**	**3**	**5**	**25**	**75**	**100**

Course Objectives

CO1	To utilize containment principles to ensure biosafety.
CO2	To enrich the student role and responsibilities of laboratory hazards and their control.
CO3	To know the importance of first aid technique for various common lab accidents.
CO4	To acquire knowledge of biosafety level, risk assessment and maintain proper hygiene in the laboratory.
CO5	To discuss the biosafety regulations and guidelines and implementation of safety

	programs.		
UNIT	**Details**	**No.of Hours**	**Course Objectives**
I	Introduction to the laboratory and laboratory hazards - General laboratory facilities – Occupational safety- Lab accidents - Fires, chemical burns, slips and falls, Animal bites. Cuts from broken glass. Toxic fume inhalation. General laboratory rules, Good laboratory practice (GLP). Laboratory plan.	12	CO1
II	Common hazards in laboratory: Chemical hazards- Safe handling of chemicals and gases, hazard labels and symbols. Material safety datasheet (MSDS), Chemical handling-Fume hood, Storage of chemicals. Chemical Waste Disposal Guideline. Physical hazards - Physical agent data sheets (PADS), Electric hazards- Electrical shock, Electrical explosions, Electrical burns. Safe work practices. Potential ignition sources in the lab. Stages of Fire. Fire Extinguishers. Fire Response.	12	CO2
III	Prevention and First aid for laboratory accidents. Personal protective equipment (PPE), Proper attire (Eye/Face Protection, laboratory coats, gloves, respirators. Disposal/Removal of PPE. Emergency equipment safety - Showers/ Eye Washes. Laboratory security and emergency response. First aid for- Injuries caused by broken glass, Acid/Alkali splashes on the skin, swallowing acid/alkali, burns caused by heat, electric shock.	12	CO3
IV	Biosafety - Historical background. Blood borne pathogens (BBP) and laboratory-acquired infections. Introduction to biological safety cabinets. Primary containment for biohazards. Biosafety levels of specific microorganisms. Recommended biosafety. Levels for infectious agents and infected animals. Risk groups with examples - Risk assessment. Safety levels. Case studies - Safe working, hand hygiene. Laboratory instruments, packing, sending, transport, import and export of biological agents. Hygiene, disinfection, decontamination, sterilization.	12	CO4
V	Biosafety regulations and guidelines. Centers for disease control and prevention and the National institutes of health. Occupational safety and health administration. Recombinant DNA advisory committee(RDAC), Institutional biosafety committee(IBSC), Review committee on genetic manipulation(RCGM), Genetic engineering approval committee (GEAC). Implementation of biosafety guidelines.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Employ skills on laboratory safety and avoid laboratory accidents.	PO1, PO2, PO3, PO7, PO11
CO2	Prevent laboratory hazards by practicing safety strategies.	PO2, PO5, PO7, PO11
CO3	Practice various first aid procedures during common laboratory accidents.	PO1, PO2, PO3, PO5, PO10, PO11
CO4	Ensure biosafety strategies in laboratory.	PO2, PO3, PO4, PO7, PO10, PO11
CO5	Recognize the importance of biosafety guidelines.	PO3, PO4, PO5, PO7, PO10, PO11

Text Books	
1.	Sateesh M. K. (2013).Bioethics and Biosafety, IK International Pvt Ltd.ISBN : 8190675702.
2.	Muthuraj M. and Usharani B. (2019). Biosafety in Microbiological Laboratories. (1sr Edition).Notion Press. ISBN 10: 1645878856
3.	Biosafety in Microbiological and Biomedical Laboratories- U.S. Health Department and Human Services. (2016). (5th Edition). Lulu.com.
4.	Kanai. L. Mukherjee. (Medical Laboratory Technology(4th Edition). CBS Publishers.
5.	Ramakrishnan (2012). Manual of Medical Laboratory Techniques. JP brothers.

References Books	
1.	World Health Organization, Biosafety programme management. (2010). (4th Edition). WHO Publications.
2.	Rashid N. (2013). Manual of Laboratory Safety (Chemical, Radioactive, and Biosafety with Biocides) (1st Edition).
3	Dayuan X. (2015). Biosafety and Regulation for Genetically Modified Organisms, Alpha Science International Ltd, ISBN-10 :1842657917
4.	Ochei J. Kolhatkar(2000). A. (Medical Laboratory Science – Theory and Practice. ISBN; 13:978-0074632239.
5.	Lynne S. Garcia. Clinical Laboratory Management (2nd Edition). ASM Press

Web Resources	
1.	https://www.cdc.gov/labs/pdf/CDC-BiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf
2.	https://ucanapplym.s3.ap-south-1.amazonaws.com/RGU/notifications/E_learning/0nline_study/PG-SEM-IV-Biosafety%20regulation.pdf
3.	https://consteril.com/biosafety-levels-difference/
4.	https://www.cdc.gov/labs/pdf/CDC-BiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf
5.	https://www.who.int/publications/i/item/9789240011311

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S	S	S				S				S			
CO2		S			S		S				S			
CO3	S	S	S		S					S	S			
CO4		S	S	M			S			S	S			
CO5			S	S	S		S			S	S			

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
23UPMBC 1C03	**Medical Bacteriology and Mycology**	**Core CourseI V**	**Y**	**Y**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

Course Objectives	
CO1	Acquire Knowledge on collection, transportation and processing of various kinds of clinical specimens.

CO2	Explain morphology, characteristics and pathogenesis of bacteria.		
CO3	Discuss various factors leading to pathogenesis of bacteria.		
CO4	Acquire knowledge on antifungal agents and their importance.		
CO5	Describe various diagnostic methods available for fungal disease diagnosis.		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Classification of medically important bacteria, Normal flora of human body, Collection, transport, storage and processing of clinical specimens, Microbiological examination of clinical specimens, antimicrobial susceptibility testing. Handling and maintenance of laboratory animals – Rabbits, guinea pigs and mice.	20	CO1
II	Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of *Staphylococci, Streptococci, Pneumococci, Neisseriae*., *Bacillus, Corynebacteria, Mycobacteria* and *Clostridium.*	20	CO2
III	Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by Enterobacteriaceae members, *Yersinia, Pseudomonas, Vibrio, Mycoplasma, Helicobacter, Rickettsiae, Chlamydiae, Bordetella, Francisella., Spirochaetes-Leptospira, Treponema* and *Borrelia*. Nosocomial, zoonotic and opportunistic infections -prevention and control.	20	CO3
IV	Morphology, taxonomy and classification of fungi. Detection and recovery of fungi from clinical specimens. Dermatophytes and agents of superficial mycoses. *Trichophyton, Epidermophyton &Microsporum*. Yeasts of medical importance – *Candida, Cryptococcus*. Mycotoxins. Antifungal agents, testing methods and quality control.	15	CO4
V	Dimorphic fungi causing Systemic mycoses, *Histoplasma, Coccidioides, Sporothrix, Blastomyces.* Fungi causing Eumycotic Mycetoma, Opportunistic fungi- Fungi causing secondary infections in immunocompromised patients. Immunodiagnostic methods in mycology- Recent advancements in diagnosis. Antifungal agents.	15	CO5
	Total	90	
Course Outcomes			
Course Outcomes	On completion of this course, students will;		
CO1	Collect, transport and process of various kinds of clinical	PO1,PO5,PO9	

	specimens.	
CO2	Analyze various bacteria based on morphology and pathogenesis.	PO1,PO5,PO9
CO3	Discuss various treatment methods for bacterial disease.	PO1,PO5,PO9
CO4	Employ various methods detect fungi in clinical samples and apply knowledge on antifungal agents..	PO5,PO9
CO5	Apply various immunodiagnostic method to detect fungal infections.	PO5,PO9

Text Books	
1.	Kanunga R. (2017). Ananthanarayanan and Panicker'sText book of Microbiology. (2017).Orient Longman, Hyderabad.
2.	Greenwood, D., Slack, R.B. and Peutherer, J.F. (2012) Medical Microbiology, (18th Edition). Churchill Livingstone, London.
3.	Finegold, S.M. (2000) Diagnostic Microbiology, (10th Edition). C.V. Mosby Company, St. Louis.
4.	Alexopoulos C. J., Mims C. W. and Blackwell M. (2007). Introductory Mycology, (4th Edition). Wiley Publishers.
5.	Chander J. (2018). Textbook of Medical Mycology. (4th Edition). Jaypee brothers Medical Publishers.
References Books	
1.	Salle A. J. (2007). Fundamental Principles of Bacteriology. (4th Edition). Tata McGraw-Hill Publications.
2.	Collee J.C. Duguid J.P. Foraser, A.C, Marimon B.P, (1996). Mackie & McCartney Practical Medical Microbiology. 14thedn, Churchill Livingston.
3.	Cheesbrough M. (2006). District Laboratory Practice in Tropical countries.- Part 22ndedn.Cambridge University Press. .
4.	Topley and Wilson's. (1998). Principles of Bacteriology.9thedn. Edward Arnold, London.
5.	Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7thedn. Elsevier, Mosby Saunders.
Web Resources	
1.	http://textbookofbacteriology.net/nd
2.	https://microbiologysociety.org/members-outreach-resources/links.html
3.	https://www.pathelective.com/micro-resources
4.	http://mycology.cornell.edu/fteach.html
5.	https://www.adelaide.edu.au/mycology/

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks
Methods of Assessment		
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions	
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview	
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain	
Analyze (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge	
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons	
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations	

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M				S				M					
CO2	M				S				M					
CO3	M				S				M					
CO4					S				M					
CO5					S				M					

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1C04	**Medical Virology and Parasitology**	**Core Course V**	**Y**	**Y**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

		Theory									
Course Objectives											
CO1	Describe the replication strategy and cultivation methods of viruses.										
CO2	Acquire knowledge about oncogenic virus and human viral infections.										
CO3	Develop diagnostic skills, in the identification of virus infections.										
CO4	Impart knowledge about parasitic infections.										
CO5	Develop diagnostic skills, in the identification of parasitic infections.										
UNIT	**Details**								**No. of Hours**	**Course Objectives**	
I	General properties of viruses - Structure and Classification - viroids, prions, satellite RNAs and virusoids. Cultivation of viruses -embryonated eggs, experimental animals and cell cultures. Purification and Assay of viruses – Physical and Chemical methods (Electron Microscopy, Protein and Nucleic acids studies.) Infectivity Assays (Plaque and end-point).								20	CO1	
II	Virus Entry, Host Defenses Against Viral Infections, Epidemiology, pathogenic mechanisms, Pathogenesis, laboratory diagnosis, treatment for the following viruses: DNA Viruses- Pox,Herpes,Adeno ,Papova and Hepadna , RNA Viruses- Picorna, Orthomyxo, Paramyxo, Rhabdo, Rota, HIV and other Hepatitis viruses, Arbo – Dengue virus, Ebola virus, Emerging and reemerging viral infections								20	CO2	
III	Bacterial viruses - ΦX 174, M13, MU, T4, lambda, Pi; Structural organization, life cycle and phage production. Lysogenic cycle-typing and application in bacterial genetics. Diagnosis of viral infections –conventional serological and molecular methods. Antiviral agents and viral vaccines.								15	CO3	
IV	Introduction to Medical Parasitology – Classification, host-parasite relationships. Epidemiology, life cycle, pathogenic mechanisms, laboratory diagnosis, treatment for the following: Protozoa causing human infections – *Entamoeba,* Aerobic and Anaerobic amoebae, *Giardia, Trichomonas, Balantidium. Toxoplasma, Cryptosporidium, Leishmania,* and *Trypanasoma.*								15	CO4	
V	Classification, life cycle, pathogenicity, laboratory diagnosis and treatment for parasites – Helminthes - Cestodes –*Taenia Solium, T. Saginata, T. Echinococcus*. Trematodes –*Fasciola Hepatica, FasciolopsisBuski, Paragonimus, Schistosomes*. Nematodes - *Ascaris, Ankylostoma, Trichuris, Trichinella, Enterobius,*								20	CO5	

	*Strongyloides*and*Wuchereria*. Other parasites causing infections in immune compromised hosts and AIDS. Cultivation of parasites. Diagnosis of parasitic infections – Serological and molecular diagnosis. Anti-protozoan drugs.		
	Total	90	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Cultivate viruses by different methods and aid in diagnosis. Perform purification and viral assay.	PO5, PO7, PO8, PO10
CO2	Investigate the symptoms of viral infections and presumptively identify the viral disease.	PO5, PO7, PO8, PO10
CO3	Diagnose various viral diseases by different methods.(serological, conventional and molecular)	PO5, PO7, PO8, PO10
CO4	Educate public about the spread, control and prevention of parasitic diseases.	PO5, PO7, PO8, PO10
CO5	Identify the protozoans and helminthes present in stool and blood specimens. Perform serological and molecular diagnosis of parasitic infections.	PO5, PO7, PO8, PO10

Text Books	
1.	Kanunga R. (2017). Ananthanarayanan and Panicker's Text book of Microbiology. (10th Edition). Universities Press (India) Pvt. Ltd.
2.	Dubey, R.C. and Maheshwari D.K. (2010). A Text Book of Microbiology. S. Chand & Co.
3.	Rajan S. (2007). Medical Microbiology. MJP publisher.
4.	Paniker J. (2006). Text Book of Parasitology. Jay Pee Brothers, NewDelhi.
5.	Arora, D. R. and Arora B. B. (2020). Medical Parasitology. (5thEdition). CBS Publishers & Distributors Pvt. Ltd. New Delhi.

Reference Books	
1.	Carter J. (2001). Virology: Principles and Applications (1st Edition). Wiley Publications.
2..	Willey J., Sandman K. and Wood D. Prescott's Microbiology. (11th Edition). McGraw Hill Book.
3.	Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A.
4.	Finegold S.M. (2000). Diagnostic Microbiology. (10th Edition). C.V. Mosby Company, St. Louis.
5.	Levanthal R. and Cheadle R. S. (2012). Medical Parasitology. (6th Edition). S.A. Davies Co. Philadelphia.

Web Resources	
1.	https://en.wikipedia.org/wiki/Virology
2.	https://academic.oup.com/femsre/article/30/3/321/546048
3.	https://www.sciencedirect.com/science/article/pii/S0042682215000859
4.	https://nptel.ac.in/courses/102/103/102103039/
5.	https://www.healthline.com/health/viral-diseases#contagiousness

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
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Analyses (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
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Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14
CO1					M		L	L		M				
CO2					M		L	L		M				
CO3					M		L	L		M				
CO4					M		L	L		M				
CO5					M		L	L		M				

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1L02	**Practical II**	**Core Course VI-Practical II**	**-**	**-**	**Y**	**-**	**4**	**6**	**40**	**60**	**100**

Course Objectives	
CO1	Develop skills in the diagnosis of bacterial infections and antimicrobial sensitivity.
CO2	Impart knowledge on fungal infections and its diagnosis.
CO3	Diagnose parasitic
CO4	To gain knowledge about industrially important microbes.
CO5	Screen and utilize microorganisms for effective industrial production of metabolites.

UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Staining of clinical specimens - Wet mount, Differential and Special staining methods. Isolation and identification of bacterial pathogens from clinical specimens - cultivation in basal, differential, enriched, selective and special media – Biochemical identification tests. Enumeration of bacteria in urine to detect significant bacteriuria. Antimicrobial sensitivity testing - Kirby Bauer method and Stokes method. Minimum inhibitory concentration (MIC) test. Minimum bactericidal concentration (MBC) test.	20	CO1
II	Identification and Classification of common fungi. Mounting and staining of VAM spores. Examination of different fungi by Lactophenol cotton blue staining. Examination of different fungi by KOH staining. Cultivation of fungi and their identification - *Mucor, Rhizopus, Aspergillus, Penicillium.* Microscopic observation of different asexual fungal spores. Microscopic observation of fungal fruiting bodies.	20	CO2

	Identification of Dermatophytes. Isolation and characterization of bacteriophage from natural sources by phage titration. Cultivation of viruses –Egg Inoculation methods. Diagnosis of Viral Infections –ELISA –HIA. Spotters of viral inclusions and CPE-stained smears.		
III	Examination of parasites in clinical specimens - Ova/cysts in faeces. Concentration: methods – Floatation methods-simple Saturated salt solution method – Zinc sulphate methods - Sedimentation methods-Formal ether method. Blood smear examination for malarial parasites. Thin smear by Leishman's stain – Thick smear by J.B. stain. Identification of common arthropods of medical importance - spotters of *Anopheles, Glossina, Phlebotomus, Aedes,* Ticks and mites.	20	CO3
IV	Good Laboratory Practices in Industrial Microbiology laboratory. Study of Bioreactor and its essential parts. Culturing and Characterization of microorganisms used in Dairy and Pharmaceutical industry. Screening for Enzyme producers (amylase /protease). Optimization of parameters for Amylase production. Screening for Organic acid producers (acetic acid/lactic acid). Screening for Antibiotic producers.	15	CO4
V	Immobilization of microbial cells and enzyme and its assessment. Microbiological assays of fermentation products – MIC- MBC. Microbiological assay of antibiotics by cup plate method and other methods. Sterility testing of pharmaceuticals.	15	CO5
	Total	90	

Course Outcomes

Course Outcomes	On completion of this course, students will;

CO1	Collection of different clinical samples, transport, culture and examination.	PO7, PO8, PO9
CO2	Identify medically important bacteria, fungus and parasites from the clinical samples by staining and biochemical tests.	PO7, PO8, PO9
CO3	Promote diagnostic skills; interpret laboratory tests in the diagnosis of infectious diseases.	PO7, PO8, PO9, PO10
CO4	Perform antibiotic sensitivity tests and compare with the standard tests.	PO7, PO8, PO9, PO10
CO5	Screening of industrially important microbes for metabolite production.	PO7, PO8, PO9

Text Books	
1.	Cullimore D. R. (2010). Practical Atlas for Bacterial Identification, 2nd Edition. Publisher-Taylor and Francis.
2.	Abbott A.C. (2010). The Principles of Bacteriology. Nabu Press.
3.	Parija S. C. (2012). Textbook of Practical Microbiology. Ahuja Publishing House.
4.	Cappuccimo, J. and Sherman, N. (2002) Microbiology: A Laboratory Manual, (6thEdition). Pearson Education, Publication, New Delhi.
5.	Morag C. and Timbury M.C. (1994).Medical Virology. 4th edn. Blackwell Scientific Publishers.
References Books	
1.	Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi.
2.	Chart H. (2018). Practical Laboratory Bacteriology. CRC Press.
3.	Moore V. A. (2017). Laboratory Directions for Beginners in Bacteriology. Triste Publishing Ltd.
4.	.Cheesbrough M. (2006). District Laboratory Practice in Tropical countries.-Part 22ndEdition.Cambridge University Press.
5.	Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7th Edition. Elsevier, Mosby Saunders

Web Resources	
1.	http://textbookofbacteriology.net/
2.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7173454/
3.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3768729/
4.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/
5.	https://www.intechopen.com/books/current-issues-in-molecular-virology-viral-genetics- and-biotechnological-applications/vaccines-and-antiviral-agents

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (K1)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1							M	M	M					
CO2							M	M	M					
CO3							M	M	L	L				

CO4							M	M	M	L				
CO5							M	M	M					

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1E07	**Epidemiology**	**Elective Course III (Choice 1)**	**Y**	**Y**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives	
CO1	Describe the role of epidemiology in public health.
CO2	Explain about epidemiology tools and disease surveillance methods.
CO3	Analyze various communicable and non-communicable diseases in India.
CO4	Discuss on mechanism of antimicrobial resistance.
CO5	Outline on National health programmes that have been designed to address the issues.

UNIT	Details	No. of Hours	Course Objectives
I	Fundamentals of epidemiology - Definitions of epidemiology – Epidemiology of infectious diseases in Public Health. Natural history of disease -Historical aspects of epidemiology. Common risk factors- Epidemiologic Triad-Agent factors, host factors and environmental factors. Transmission basics- Chain of infection, portal of entry. Modes of transmission-Direct and indirect. Stages of infectious diseases. Agents and vectors of communicable diseases of public health importance and dynamics of disease transmission. Epidemiology of Zoonosis- Factors, routes of transmission of bacterial, viral, parasitic and fungal zoonotic agents. Control of zoonosis.	12	CO1
II	Tools of Epidemiology - Measures of Disease -Prevalence, incidence. Index case. Risk rates. Descriptive Epidemiology - Cohort studies, measuring infectivity, survey methodology including census procedures. Surveillance strategies - Disease surveillance, geographical indication system, outbreak investigation in public health andcontact investigation.	12	CO2

III	Epidemiological aspects of diseases of national importance- Background to communicable and non-communicable diseases. Vector borne diseases in India. Diarrhoeal diseases. Zoonoses. Viral haemorrhagic fevers. Mycobacterial infections. Sexually transmitted diseases. Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS). Emerging disease threats- Severe Acute Respiratory Syndrome (SARS), Covid-19, Ebola, MDR-TB,Malaria, Mucor mycosis, Avian flu. Dengue, Swine Flu, Chikungunya. Epidemiology, prevention, and control of non-communicable diseases- Asthma, Coronary heart disease, Malignancy, diabetes mellitus, respiratory diseases, eye diseases, Dental disorders. Emerging and Re-emerging Diseases.	12	CO3
IV	Mechanisms of Antimicrobial resistance - Multidrug Efflux pumps, Extended Spectrum β-lactamases (ESBL). Hospital acquired infections-Factors, infection sites, mechanisms, Role of Multidrug resistant pathogens. Role of *Pseudomonas, Acinetobacter, Clostridium difficile,*HBV, HCV, Rotavirus, *Cryptosporidium* and *Aspergillus* in Nosocomial infections. Prevention and management of nosocomial infections.	12	CO4
V	National Programmes related to Communicable and Non-Communicable diseases - National Malaria Eradication Programme, Revised National Tuberculosis Control Programme, Vector Borne Disease Control Programme, National AIDS Control Programme, National Cancer Control Programme and National Diabetes Control Programme. Biochemical and immunological tools in epidemiology- Biotyping, Serotyping, Phage typing, FAME (Fatty acid methyl ester analysis), Curie Point PyMS (Pyrolysis Mass spectrometry), Protein profiling, Molecular typing methods.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Apply the knowledge acquired on concepts of epidemiology to clinical and public health environment.	PO1
CO2	Plan various strategies to trace the epidemiology.	PO4, PO5, PO6
CO3	Plan the control of communicable and non-communicable diseases.	PO1, PO5,
CO4	Analyze the implications of drug resistance in the society and design the control of antimicrobial resistance and its management.	PO5,

CO5	Employ National control programs related to Communicable and Non-Communicable diseases with the public.	PO4, PO5,

Text Books	
1.	Dicker R., Coronado F., Koo. D. and Parrish. R. G. (2012). Principles of Epidemiology in Public Health Practice., (3rd Edition). CDC.
2.	Gerstman B. (2013). Epidemiology Kept Simple: An Introduction to Classic and Modern Epidemiology. (3rd Edition). Wiley Blackwell.
3.	Greenwood, D., Slack, R. B. and Peutherer, J. F. (2012) Medical Microbiology, (18th Edition). Churchill Livingstone, London.
4.	Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A.
5.	Dimmok N. J. and Primrose S. B. (1994). Introduction to Modern Virology.5thedn. Blackwell Scientific Publishers.
References Books	
1.	Bhopal R. S. (2016).Concepts of Epidemiology - An Integrated Introduction to the Ideas, Theories, Principles and Methods of Epidemiology. (3rd Edition). Oxford University Press, New York.
2.	Celentano D. D. and Szklo M. (2018). Gordis Epidemiology. (6th Edition). Elseiver,USA.
3.	Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries- Part 2, (2nd Edition). Cambridge University Press.
4.	Ryan K. J. and Ray C. G. (2004). Sherris Medical Microbiology. (4th Edition), McGraw Hill, New York.
5.	TopleyW.W. C.,Wilson, G.S., Parker M.T. and Collier L. H. (1998). Principles of Bacteriology. (9th Edition). Edward Arnold, London.
Web Resources	
1.	https://www.scielo.br/j/rbca/a/mjDFGTtfWtBm786ZmR9TG9d/?lang=en
2.	https://hal.archives-ouvertes.fr/hal-00902711/document
3.	https://www.who.int/csr/resources/publications/whocdscsreph200212.pdf
4.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7187955/
5.	https://www.who.int/diseasecontrol_emergencies/publications/idhe_2009_london_outbreaks.pdf

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyze (K4)	Problem-solving questions, finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14
CO1	M													
CO2				L	L	S								
CO3	M				S									
CO4					S									
CO5				S	S									

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1E08	**Clinical and Diagnostic Microbiology**	**Elective Course III (Choice2)**	**Y**	**Y**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives	
CO1	Describe appropriate safety protocol and laboratory techniques for handling specimens and biomedical waste management.
CO2	Develop working knowledge of techniques used to identify infectious agents in the clinical microbiology lab.
CO3	Elucidate various diagnostic procedures in microbiology.
CO4	Acquire knowledge on different methods employed to check antibiotic sensitivity.
CO5	Gain knowledge on hospital acquired infections and their control measures.

UNIT	Details	No. of Hours	Course Objectives
I	Microbiology Laboratory Safety Practices -General Safety Guidelines, Handling of Biological Hazards, Infectious health care waste disposal - Biomedical waste management, Emerging and Re-emerging infections.	12	CO1
II	Diagnostic procedures - General concept of Clinical specimen collection, transport, storage and general processing in Microbiology laboratory - Specimen acceptance and rejection criteria.	12	CO2
III	Diagnosis of microbial diseases - Clinical, differential, Microbiological, immunological and molecular diagnosis of microbial diseases. Modern and novel microbial diagnostic methods. Automation in Microbial diagnosis.	12	CO3
IV	Antibiotic sensitivity tests - Disc diffusion - Stokes and Kirby Bauer methods, E test - Dilution - Agar dilution & broth dilution - MBC/MIC - Quality control for antibiotics and standard strains.	12	CO4
V	Nosocomial infections – common types, sources, reservoir and mode of transmission, pathogenesis and control measures. Hospital Infection Control Committee (HICC) – Functions.	12	CO5
	Total	60	

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Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Apply Laboratory safety procedures and hospital waste disposal strategies.	PO5, PO6, PO7
CO2	Collect various clinical specimens, handle, preserve and process safely.	PO6, PO7
CO3	Identify the causative agents of diseases by conventional and molecular methods following standard protocols.	PO6, PO7, PO9, PO11
CO4	Assess the antimicrobial susceptibility pattern of pathogens.	PO7, PO9
CO5	Trace the sources of nosocomial infection and recommend control measures.	PO5, PO7
TEXT BOOKS		
1.	Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi. ISBN-10:0443047219 / ISBN-13-978-0443047213.	

2.	Tille P. M. (2021). Bailey and Scott's Diagnostic Microbiology. (15th Edition). Elsevier. ISBN:9780323681056.
3.	Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A.
4.	Mukherjee K.L. (2000). Medical Laboratory Technology.Vol. 1-3. (2nd Edition). Tata McGraw-Hill Education. ISBN-10:0074632604.
5.	Sood R. (2009). Medical Laboratory Technology – Methods and Interpretations. (6thEdition). Jaypee Brothers Medical Publishers (P) Ltd. New Delhi. ISBN:9788184484496.
References Books	
1.	Murray P. R., Baron E. J., Jorgenson J. H., Pfaller M. A. and Yolken R.H. (2003). Manual of Clinical Microbiology. (8th Edition). American Society for Microbiology, Washington, DC. ISBN:1-555810255-4.
2.	BennettJ.E., Dolin R. and BlaserM.J. (2019). Principles and Practice of Infectious Diseases. (9thEdition). Elsevier. EBook ISBN:9780323550277. Hardcover ISBN:9780323482554.
3.	Ridgway G.L., Stokes E.J. and Wren M.W.D. (1987). Clinical Microbiology 7th Edition. Hodder Arnold Publication. ISBN-10:0340554231 / ISBN-13:9780340554234.
4.	Koneman E.W., Allen S.D., Schreckenberg P.C. and WinnW.C. (2020). Koneman's Color Atlas and Textbook of Diagnostic Microbiology. (7th Edition). Jones & Bartlett Learning. ISBN:1284322378 9781284322378.
5.	Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2nd Edition). Cambridge University Press. ISBN-13:978-0-521-67631-1 / ISBN-10:0-521-67631-2.
Web Resources	
1.	https://www.ncbi.nlm.nih.gov/books/NBK20370/
2.	https://www.msdmanuals.com/en-in/home/infections/diagnosis-of-infectious3disease/diagnosis-of-infectious-disease
3.	https://journals.asm.org/doi/10.1128/JCM.02592-20
4.	https://www.sciencedirect.com/science/article/pii/S2221169116309509
5.	http://www.textbookofbacteriology.net/normalflora_3.html

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyze (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14
CO1					S	M	M							
CO2						M	S							
CO3						M	S		M		S			
CO4							S		M					
CO5					S		M							

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1E09	**Bioremediation**	**Elective Course III (Choice 3)**	**Y**	**Y**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives	
CO1	Describe the nature and importance of bioremediation and use in real world applications.
CO2	Describe the typical composition of waste water and application of efficient technologies for water treatment.
CO3	Explain the fundamentals of treatment technologies and the considerations for its design and implementation in treatment plants.
CO4	Explain the potential of microbes in ore extraction and acquaint students with methods of reducing health risks caused by xenobiotics.

CO5	Familiarize the role of plants and their associated microbes in remediation and management of environmental pollution.		
UNIT	**Details**	**No.of Hours**	**Course Objectives**
I	Bioremediation- process and organisms involved. Bioaugmentation - Ex-situ and in-situ processes; Intrinsic and engineered bioremediation. Major pollutants and associated risks; organic pollutant degradation. Microbial aspects and metabolic aspects. Factors affecting the process. Recent developments and significance.	12	CO1
II	Microbes involved in aerobic and anaerobic processes in nature. Water treatment- BOD, COD, dissolved gases, removal of heavy metals, total organic carbon removal.Secondary waste water treatments - use of membrane bioreactor. Aquaculture effluent treatment. Aerobic sludge and landfill leachate process. Aerobic digestion.	12	CO2
III	Composting of solid wastes, anaerobic digestion - methane production and important factors involved, Pros and cons of anaerobic process, sulphur, iron and nitrate reduction, hydrocarbon degradation, degradation of nitroaromaticcompounds.Bioremediation of dyes, bioremediation in paper and pulp industries. Aerobic and anaerobic digesters – design. Various types of digester for bioremediation of industrial effluents.	12	CO3
IV	Microbial leaching of ores- process, microorganisms involved and metal recovery with special reference to copper and iron. Biotransformation of heavy metals and xenobiotics. Petroleum biodegradation - reductive and oxidative.Dechlorination. Biodegradable of plastics and super bug.	12	CO4
V	Phytoremediation of heavy metals in soil - Basic principles of phytoremediation - Uptake and transport, Accumulation and sequestration. Phytoextraction. Phytodegradation. Phytovolatilization. Rhizodegradation.Phytostabilization – Organic and synthetic amendments in multi metal contaminated mine sites. Role of Arbuscularmycorrhizal fungi and plant growth promoting rhizobacteria in phytoremediation.	12	CO5
	Total	60	
Course Outcomes			
Course Outcomes			
CO1	Differentiate Ex-situ bioremediation and In-situ	PO1,PO2,PO4,PO	

	bioremediation. Assess the roles of organisms in bioremediation.	5
CO2	Distinguish microbial processes necessary for the design and optimization of biological processing unit operations.	PO1,PO4, PO5,PO11
CO3	Identify, formulate and design engineered solutions to environmental problems.	PO5,PO7,PO8,PO 11
CO4	Explore microbes in degradation of toxic wastes and playing role on biological mechanisms.	PO5,PO6,PO7,PO 8,PO9
CO5	Establish the mechanisms of Arbuscular mycorrhizal fungi and Plant growth promoting *Rhizobacteria* in phytoremediation.	PO1,PO5,PO6,PO 7,PO8

Text Books

1.	Bhatia H.S. (2018). A Text book on Environmental Pollution and Control. (2nd Edition).Galgotia Publications.
2.	Chatterjee A. K. (2011). Introduction to Environmental Biotechnology. (3rd Edition). Printice-Hall,India.
3.	Pichtel, J. (2014). WasteManagementPractices:Municipal,Hazardous,andIndustrial,2nd edition, CRC Press.
4.	Liu,D.H.FandLiptak,B.G(2005).HazardousWastesandSolidWastes,Lewis Publishers. .
5.	Rajendran, P. & Gunasekaran, P. (2006). Microbial Bioremediation. 1st edition. MJP Publishers

References Books

1.	Sangeetha J., Thangadurai D., David M. and Abdullah M.A. (2016). Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development. (1st Edition). Apple Academic Press.
2.	Singh A. and Ward O. P. (2004).Biodegradation and Bioremediation. Soil Biology. Springer.
3.	Singh A., Kuhad R. C., and Ward O. P. (2009). Advances in Applied Bioremediation (1st Edition).Springer-Verlag Berlin Heidelberg, Germany.
4.	Atlas, R.M & Bartha, R. (2000). Microbial Ecology. Addison Wesley Longman Inc.
5.	Rathoure, A.K. (Ed.). (2017). Bioremediation: Current Research and Applications. 1st edition. I.K. International Publishing House Pvt. Ltd.

Web Resources

1.	Bioremediation- Objective, Principle, Categories, Types, Methods, Applications (microbenotes.com)
2.	https://agris.fao.org › agris-search
3.	https://www.sciencedirect.com/topics/earth-and-planetary-sciences/bioremediation

4.	https://www.intechopen.com/chapters/70661
5.	https://microbiologysociety.org/blog/bioremediation-the-pollution-solution.html

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S	M		M	S									
CO2	S			M	S						S			
CO3					S		S	S			S			
CO4					S	S	S	S	S					
CO5	M				S	M	S	S						

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1E10	**Bioinformatics**	**Elective Course IV**	**Y**	**Y**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

		Theory (Choice1)									

Course Objectives	
CO1	Discuss about various biological data mining concepts, tools.
CO2	Elucidate the principles and applications of sequence alignment methods and tools.
CO3	Demonstrate different phylogenetic tree construction methods and its uses in phylogenetic analysis.
CO4	Acquaint with various approaches in predicting 3D and 2D structure of proteins.
CO5	Describe various tools and techniques used in molecular docking, immunoinformatics and subtractive genomics.

UNIT	**Details**	**No.of Hours**	**Course Objectives**
I	Biological Data Mining –Exploration of Data Mining Tools. Cluster Analysis Methods. Data Visualization. Biological Data Management. Biological Algorithms – Biological Primary and Derived Databases. Concept of Alignment, Pairwise Sequence Alignment (PSA), Multiple Sequence Alignment (MSA), BLAST, CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).	12	CO1
II	Phylogenetic Tree Construction - Concept of Dendrograms. Evolutionary Trees - Distance Based Tree Reconstruction - Ultrametric trees and Ultrametric distances – Reconstructing Trees from Additive Matrices - Evolutionary Trees and Hierarchical Clustering - Character Based Tree Reconstruction - Maximum Parsimony Method, Maximum likelihood method - Reliability of Trees – Substitution matrices – Evolutionary models.	12	CO2
III	Computational Protein Structure prediction – Secondary structure – Homology modelling- Fold recognition and ab initio 3D structure prediction – Structure comparison and alignment – Prediction of function from structure. Geometrical parameters – Potential energy surfaces – Hardware and Software requirements-Molecular graphics – Molecular file formats-Molecular visualization tools.	12	CO3
IV	Prediction of Properties of Ligand Compounds – 3D Autocorrelation -3D Morse Code-Conformation Dependent and Independent Chirality Codes –Comparative Molecular Field Analysis – 4 D QSAR –HYBOT Descriptors – Structure Descriptors – Applications – Linear Free Energy Relationships – Quantity Structure - Property Relationships –Prediction of the Toxicity of Compounds	12	CO4
V	Molecular Docking- Flexible - Rigid docking- Target- Ligand preparation- Solvent accessibility- Surface volume calculation, Active site prediction- Docking algorithms- Genetic,	12	CO5

	Lamarckian - Docking analyses- Molecular interactions, bonded and nonbonded - Molecular Docking Software and Working Methods. Genome to drug discovery – Subtractive Genomics – Principles of Immunoinformatics and Vaccine Development.		
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Access to databases that provides information on nucleic acids and proteins.	PO1,PO4,PO6,PO7,PO9,PO10,PO13
CO2	Invent algorithms for sequence alignment.	PO7,PO9,PO10,PO13
CO3	Construct phylogenetic tree.	PO6, PO9, PO10
CO4	Predict the structure of proteins.	PO4, PO6,PO7,PO9,PO13
CO5	Design drugs by predicting drug ligand interactions and molecular docking.	PO4,PO5,PO6,PO7,PO9,PO10,PO13

Text Books

1.	Lesk A. M. (2002). Introduction to Bioinformatics. (4th Edition). Oxford University Press.
2.	Lengauer T. (2008). Bioinformatics- from Genomes to Therapies (Vol-1).Wiley- VCH.
3.	Rastogi S. C., Mendiratta N. and Rastogi P. (2014). Bioinformatics - Methods and Applications (Genomics,Proteomics and Drug Discovery) (4th Edition).Prentice-Hall of India Pvt.Ltd.
4.	Attwood, T.K. and Parry-Smith, D.J. (1999). Introduction to Bioinformatics. Addision Wesley Longman Limited, England.
5.	Mount D.W., (2013).Bioinformatics sequence and genome analysis, 2nd edn.CBS Publishers, New Delhi.

References Books

1.	BaxevanisA. D. andOuellette F. (2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. (2nd Edition). John Wiley and Sons.
2.	Bosu O. and Kaur S. (2007). Bioinformatics - Database, Tools, and Algorithms. Oxford University Press.
3.	David W. M. (2001). Bioinformatics Sequence and Genome Analysis (2nd Edition). CBS Publishers and Distributors(Pvt.)Ltd.
4.	Xiong J, (2011). Essential bioinformatics, First south Indian Edition, Cambridge University Press.
5.	HarshawardhanP.Bal, (2006). Bioinformatics Principles and Applications, Tata

	McGraw-Hill Publishing Company Limited.	
Web Resources		
1.	https://www.hsls.pitt.edu/obrc/	
2.	https://www.hsls.pitt.edu/obrc/index.php?page=dna	
3.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1669712/	
4.	https://www.ebi.ac.uk/	
5.	https://www.kegg.jp/kegg/kegg2.html	
Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
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Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14
CO1	M			M		M			M	M			M	
CO2							S		S	S			S	
CO3						S			S	S				
CO4				S		S	S		S				S	
CO5				S	S	S	S		S	S			S	

Subject	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst.**	**Marks**

Code								Hours	CIA	External	Total
23UPMBC1E11	Nanobiotechnology	Elective Course IV (Choice 2)	Y	Y	-	-	3	4	25	75	100

Course Objectives	
CO1	Analyze nanomaterials based on the understanding of nanobiotechnology.
CO2	Discuss the methods of fabrication of nanomaterials.
CO3	Gain Knowledge on characterization of nanomaterials.
CO4	Discover nanomaterials for targeted drug delivery.
CO5	Explain nanomaterials in nanomedicine and environmental pollution.

UNIT	Details	No.of Hours	Course Objectives
I	Introduction to nanobiotechnology, Nano size-changing phenomena at nano scale, Classification of nanomaterials based on their dimensions (0D, 1D, 2D and 3D materials) and based on realization of their applications (The First, second, third and fourth generation materials),Class of nanomaterials and their applications. Need for nanomaterials and the risks associated with the materials.	12	CO1
II	Fabrication of Nanomaterials-Top-down and Bottom-up approaches, Solid phase synthesis-milling, Liquid phase synthesis-Sol-gel synthesis, colloidal synthesis, micro emulsion method, hydrothermal synthesis and solvo thermal synthesis, Vapor/Gas phase synthesis-Inert gas condensation, flame pyrolysis, Laser ablation and plasma synthesis techniques. Microbial synthesis of nanoparticles.	12	CO2
III	Characterization of nanoparticles – Based on particle size/morphology- Dynamic light scattering (DLS), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM), Based on surface charge-zeta potential, Based on structure –X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), Energy dispersive X-ray analysis (EDX),Based on optical properties- UV – Spectrophotometer, Based on magnetic properties-Vibrating sample magnetometer(VSM).	12	CO3
IV	Nanomaterial based Drug delivery and therapeutics-surface modified nano particles, MEMS/NEMS based devices, peptide/DNA coupled nanoparticles, lipid and inorganic nano particles for drug delivery, Metal/metaloxide nano particles as antibacterial, antifungal and antiviral agents. Toxicity of nanoparticles and Toxicity Evaluation.	12	CO4
V	Nanomaterials in diagnosis-Imaging, nanosensors in detection of pathogens. Treatment of surface water, ground	12	CO5

	water and waste water contaminated by toxic metal ions, organic and inorganic solutes and microorganisms.		
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Employ knowledge in the field of nanobiotechnology for development.	PO1,PO9
CO2	Identify various applications of nanomaterials in the field of medicine and environment.	PO1,PO9
CO3	Examine the prospects and significance of nanobiotechnology.	PO1,PO6,PO11
CO4	Identify recent advances in this area and create a career or pursue research in the field.	PO1,PO5,PO7,PO9
CO5	Design non-toxic nanoparticles for targeted drug delivery.	PO1,PO5,PO7,PO9, PO11

Text Books	
1.	Brydson R. M., Hammond, C. (2005). Generic Methodologies for Nanotechnology: Characterization. In Nanoscale Science and Technology. John Wiley & Sons, Ltd.
2.	Leggett G. J., Jones R. A. L. (2005). Bionanotechnology. In Nanoscale Science and Technology. John Wiley & Sons, Ltd.
3.	Mohan Kumar G. (2016). Nanotechnology: Nanomaterials and nanodevices. Narosa Publishing House.
4.	Goodsell D. S. (2004). Bionanotechnology. John Wiley & Sons, Inc.
5.	Pradeep T. (2007). Nano: The Essentials-Understanding nanoscience and nanotechnology. Tata McGraw-Hill.
	References Books
1.	Nouailhat A. (2008). An Introduction to Nanoscience and Nanotechnology, Wiley.
2.	Sharon M. and Maheshwar (2012). Bio-Nanotechnology: Concepts and Applications. New Delhi. Ane books Pvt Ltd.
3.	Niemeyer C.M. and Mirkin C. A. (2005). Nanobiotechnology. Wiley Interscience.
4.	Rehm, B. (2006). Microbial Bionanotechnology: Biological Self-Assembly Systems and Biopolymer-Based Nanostructures. Horizon Scientific Press.
5..	Reisner, D.E. (2009). Bionanotechnology: Global Prospects. CRC Press

Web Resources	
1.	https://www.gale.com/nanotechnology
2.	https://www.understandingnano.com/resources.html
3.	http://dbtnanobiotech.com/index2.php

4.	http://www.istl.org/11-winter/internet1.html
5.	https://www.cdc.gov/niosh/topics/nanotech/default.html

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand/ Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14
CO1	S			M					M					
CO2	S								S					
CO3	S					M					S			
CO4	S				S		M		S					
CO5	S				S		M		S		S			

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**

23UPMBC1E12	**Clinical Research and Clinical Trials**	**Elective CourseIV (Choice 3)**	**Y**	**Y**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives			
CO1	Provide an overview of history and methods involved in conducting clinical research.		
CO2	Design the principles involved in ethical, legal, and regulatory issues in clinical research on human subjects.		
CO3	Describe principles and issues involved in monitoring patient-oriented research.		
CO4	Formulate a well- defined quality assurance and quality control plans.		
CO5	Acquire business development skills in the area of clinical research.		
UNIT	**Details**	**No.of Hours**	**Course Objectives**
I	Introduction to Clinical Research: Clinical Research: An Overview, Different types of Clinical Research. Clinical Pharmacology: Pharmacokinetics, Pharmacodynamics, Pharmacoepidemiology, Bioavailability, Bioequivalence, Terminologies and definition in Clinical Research. Drug Development Process: Drug Discovery Pipeline, Drug Discovery Process. Preclinical trail, Human Pharmacology (Phase-I), Therapeutic Exploratory trail (Phase-II), Therapeutic Confirmatory Trail (Phase-III) and Post marketing surveillance (Phase-IV).	12	CO1
II	Ethical Considerations and Guideline in Clinical Research: Historical guidelines in Clinical Research-Nuremberg code, Declaration of Helsinki, Belmont report. International Conference on Harmonization (ICH)-Brief history of ICH, Structure of ICH & ICH Harmonization Process, Guidelines for Good Clinical Practice. Regulation in Clinical Research-Drug and cosmetic act, FDA, Schedule-Y- Ethics Committee and their responsibilities. Clinical Research Regulatory Submission & approval Process- IND, NDA and ANDA submission Procedure. DCGI submission procedure. Other Regulatory authorities- EMEA, MHRA, PhRMA.	12	CO2
III	Clinical Trial Management: Key Stakeholders in Clinical Research, Ethics Committees and Institutional Review Board,Responsibilities of Sponsor. Responsibilities of Investigator, Protocol in Clinical Research Clinical Trial Design, Project Planning Project Managements - Informed Consent, Investigator's Brochure (IB), Selection of an Investigator and Site, Patient screening, Inclusion and exclusion criteria, Randomization, Blinding. Essential Documents in clinical research -IB, ICF, PIS, TMF, ISF, CDA & CTA.	12	CO3
IV	Quality Assurance, Quality Control & Clinical Monitoring:	12	CO4

	Defining the terminology-Quality, Quality system, Quality Assurance & Quality Control-QA audit plan.21 CRF Part 11,Site Auditing, Sponsor Compliance and Auditing, SOP For Clinical Research-CRF Review & Source Data Verification, Drug Safety Reporting Corrective and preventative action process.		
V	Business Development in the Clinical Research Industry: Introduction & Stages of Business Development-Start-up Phase, Growth Phase, Maturity Phase, Decline Phase. Outsourcing in Clinical Research, Reasons for outsourcing to contract research organizations, The India Advantage, Scope and Future of CRO, List of Clinical Research Organizations in India, List of IT companies offering services in Clinical Research. Role of business development manager.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Apprehend the Drug Development process and different phases of clinical trials.	PO1, PO2, PO3, PO5
CO2	Recognize the ethics and regulatory perspectives on clinical research trials activities.	PO3, PO5, PO6, PO9
CO3	Accentuate about clinical trials management concepts and documentation process.	PO2, PO4, PO6, PO9
CO4	Accomplish quality assurance and quality control to ensure the protection of human subjects and the reliability of clinical trial results.	PO2, PO4. PO6. PO7, PO9
CO5	To nurture skills recitation to commercial start up and industriousness.	PO4, PO8, PO9, PO11, PO13

Text Books	
1.	Gallin J. I., Ognibene F. P. and Johnson L. L. (2007). Principles and Practice of Clinical Research. (4th Edition). Elsevier, 2007.ISBN-10: 0128499052
2.	Friedman L. M., Furberg C. D. and Demets D. (1998). Fundamentals of Clinical Trials, Vol: XVIII. (3rd Edition). Springer Science & Business Media.
3.	Hulley S. B., Cummings S. R.,Browner W. S., Grady D. G. and Newman T. B. (2013). Designing Clinical Research. (4th Edition). Jaypee Medical. ISBN-13: 978-1608318049.
4.	Reed,G. (2004). Prescott and Dunn's Industrial Microbiology, 4thedn, CBS publication and distributors.
5.	Himanshu B. Text book of Clinical Research, Pee Vee books.
References Books	
1.	Friedman L.M., Fuberge C.D., DeMets D. and Reboussen, D.M. (2015).

	Fundamentals of Clinical Trials, Springer.
2.	Browner W. S., (2012). Publishing and Presenting Clinical Research. (3rd Edition). Lippincott Williams and Wilkins.
3.	Rondel R. K., Varley S. A. and Webb C. F. (2008). Clinical Data Management. (2nd Edition). Wiley.
4.	Peppler, H.J. and Pearl Man, D. (1979). Fermentation Technology, Vol 1 & 2, 2ndEdition Academic Press, London.
5.	E1-Mansi, E.M.T., Bryce, C.F.A., Demain, A.L. and Allman,A.R. (2007). Fermentation Microbiology and Biotechnology. 2ndEdition, CRC press, Taylor and Francis Group.
Web Resources	
1	https://www.hzu.edu.in/uploads/2020/10/Textbook-of-Clinical-Trials-Wiley-(2004).pdf
2	https://www.routledge.com/A-Practical-Guide-to-Managing-Clinical-Trials/Pfeiffer-Wells/p/book/9780367497828
3	https://www.auctoresonline.org/journals/clinical-research-and-clinical-trials
4	https://www.who.int/health-topics/clinical-trials#tab=tab_1
5	https://www.cancerresearchuk.org/about-cancer/find-a-clinical-trial/what-clinical-trials-are/types-of-clinical-trials

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand/ Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain.
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons.
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations.

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14
CO1	S	S	S		S									
CO2			S		S	S			S					
CO3		S		S		S			S					
CO4		S		S		S	S		S					
CO5				S				S	S		S		M	

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1N01	Vermitechnology	NME- I	Y	-	-	-	2	4	25	75	100

Course Objectives

CO1	Introduce the concepts of vermicomposting.
CO2	Explain the physiology, anatomy and biology of earthworms.
CO3	Acquire the knowledge of the vermicomposting process.
CO4	Explain the trouble shooting, harvesting and packaging of vermin composts.
CO5	Gain knowledge on applications of vermin composts and their value added products.

UNIT	Details	No.of Hours	Course Objectives
I	Introduction to Vermiculture - Definition, classification, history, economic importance- In sustainable agriculture, organic farming, earthworm activities, soil fertility & texture, soil aeration, water impercolation, decomposition & moisture, bait & food and their value in maintenance of soil structure. Its role in the bio transformation of the residues generated by human activity and production of organic fertilizers. Choosing the right worm. Useful species of earthworms. Local species of earthworms. Exotic species of earthworms. Factors affecting distribution of earthworms in soil.	6	CO1
II	Earthworm Biology and Rearing - Key to identify the species of earthworms. Biology of *Eisenia fetida.* a) Taxonomy Anatomy, physiology and reproduction of Lumbricidae. b) Vital cycle of *Eisenia fetida*: alimentation, fecundity, annual reproducer potential and limiting factors (gases, diet, humidity, temperature, PH, light, and climatic factors). Biology of	6	CO2

	Eudriluseugeniae. c) Taxonomy Anatomy, physiology and reproduction of Eudrilidae. d) Vital cycle of *Eudriluseugeniae*: alimentation, fecundity, annual reproducer potential and limit factors (gases, diet, humidity, temperature, PH, light, and climatic factors).		
III	Vermicomposting Process - Feeds for Vermitechsystems- Animal manures- Kitchen Waste and Urban waste- Paper pulp and card board solids- Compost and waste products- Industrial Wastes. Vermicomposting Basic process- Initial pre-composting phase- Mesophilic phase- Maturing and stabilization phase- Mechanism of Earthworm action. Methods of vermicomposting- a) windrows system; b) wedge system; c) container system-pits, tanks & cement rings; commercial model; beds or bins-top fed type, stacked type, d) Continuous flow system.	6	CO3
IV	Vermicomposting - Trouble Shooting-Temperature-Aeration- Acidity- Pests and Diseases- Ants, rodents, Birds, Centipedes, sour crop, Mite pests. Odour problems. Separation techniques- Light Separation-Sideways Separation-Vertical Separation-Gradual transfer. Harvesting Earthworms- manual method-migration method. Packing & Nutritional analysis of vermicompost.	6	CO4
V	Applications of Vermiculture - Vermiculture Bio-technology, use of vermi castings in organic farming/horticulture, as feed/bait for capture/culture fisheries; forest regeneration. Application quantity of vermicompost in Agricultural fields- crops, fruits, vegetables & flowers. By-products and value-added products- Verm wash- vermicompost tea-vermi meal-enriched vermicompost-pelleted vermicompost.	6	CO5
	Total	30	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Compare and contrast the uses of vermicompost to the soil.	PO1, PO4, PO5, PO9,
CO2	Recommend different species of earthworms after acquiring knowledge on its biology.	PO1, PO4, PO6, PO9
CO3	Design the vermicomposting process.	PO1, PO4, PO6, PO7, PO8
CO4	Assess the Best Practices of Vermicomposting	PO6,PO7, PO8,PO9,

CO5	Recommend the applications of vermicompost to different soils and for different crops.	PO1, PO4, PO5,PO6, PO7
Text Books		
1	Ismail S. A. (2005). The Earthworm Book, Second Revised Edition. Other India Press, Goa, India.	
2	Rathoure A. K., Bharati P. K. and Ray J. (2020). Vermitechnology, Farm and Fertilizer. Vermitechnology, Farm and Fertilizer Discovery Publishing House Pvt Ltd.	
3	Christy M. V. 2008. Vermitechnology, (1st Edition), MJP Publishers.	
4	The complete technology book on Vermiculture and Vermicompost with manufacturing Process, machinery equipment details and Plant Layout. AB Press.	
5	Keshav Singh (2014). A Textbook of vermicompost: Vermiwash and Biopesticide.	
References Books		
1	Roy D. (2018). Handbook of Vermitechnology. Lambert Academic Publishing.	
2	Kumar A. (2005).Verms andVermitechnology, A.P.H. Publishing Corporation, New Delhi.	
3	Lekshmy M. S., Santhi R. (2012). Vermitechnology, Sara Publications, New Delhi, India.	
4	Edwards CA, Arancon NQ ShermanRL. (2011) Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management 1st edn.CRC Press.	
5	Ismail, S.A. (1997). Vermicology-The Biology of Earthworm.1st edn. Orient longman.	
Web Resources		
1.	https://en.wikipedia.org/wiki/Vermicompost	
2.	http://stjosephs.edu.in/upload/papers/9567411a78c63d4ccfbbe85e6aa22840.pdf	
3.	https://www.kngac.ac.in/elearning-portal/ec/admin/contents/4_18K4ZEL02_2021012803204629.pdf	
4.	https://composting.ces.ncsu.edu/vermicomposting-2/	
5.	https://rodaleinstitute.org/science/articles/vermicomposting-for-beginners/	
Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14
CO1	S			M	S				S					
CO2	S			M		S			S					
CO3	S			S		S	S	S						
CO4						S	S	S	S					
CO5	S			M	S	M	S							

Second Year
Semester- III

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1C05	**Soil and Environmental Microbiology**	**Core Course VII**	**Y**	**Y**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

Course Objectives	
CO1	Explain the role of microorganisms in soil fertility.
CO2	Discuss the benefits of interactions among soil microbes and acquire awareness about microbes as biofertilizers and biocontrol agents.
CO3	Create awareness. about components of environment, environmental pollution, and detection methods.
CO4	Acquire in depth knowledge about solid and liquid waste treatments.

CO5	Develop knowledge about organic matter degradation, bioremediation, and the environment risk assessment.		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Soil Microbiology– Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity, and distribution of major group of microorganisms in soil. Quantification of soil microflora, role of microorganism in soil fertility. Mineralization of Organic & Inorganic Matter in Soil. Biological Nitrogen fixation- Chemistry and Genetics of BNF. Phytopathology and Disease cycle of Plant pathogens - Tikka and Citrus canker, Types of disease symptoms, Structural and Inducible biochemical defenses - Systemic Acquired Resistance (SAR), pathogenesis related (PR) proteins, Plantibodies, Phenolics, Phytoalexins	20	CO1
II	Microbial Interactions - Mutualism, Commensalism, Amensalism, Synergism, Competition, Rhizosphere-Rhizosphere effect, Mycorrhizae – Types, Endophytes, PGPR- Plant growth promoting bacteria– symbiotic (*Bradyrhizobium, Rhizobium, Frankia*), Non-Symbiotic (*Azospirillum, Azotobacter*, Mycorrhizae, MHBs, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs. Biofertilizers and Biocontrol agents – Types, benefits and application. Advantages, social and environmental aspects - Bt crops, golden rice.	20	CO2
III	Components of Environment: Hydrosphere, lithosphere, atmosphere, and biosphere – definitions with examples; Energy flow in the ecosystem- Carbon, Nitrogen, Sulfur and Phosphorous cycles. Physical factors affecting distribution of microorganisms in various environments. Predisposing factors for Environmental diseases – infectious (water and air borne) and pollution related, spread and control of these diseases. Treatment and safety of drinking (potable) water, methods to detect potability of water samples. Space microbiology - Microbiological research in space environment.	15	CO3
IV	Waste management – Solid waste - Types - management - Factors affecting solid waste generation rates. Industrial effluent treatment, primary, secondary, tertiary, and advanced treatment process. Quality assessment of decontaminated matters and other biological effluents. Biological reference standards. Utilization of Solid Waste as Food, Feed and Fuel-Composting, Vermicomposting, Bio manure and Biogas production. E waste management.	15	CO4

V	Degradation of organic matter - lignin, cellulose, hemicellulose, pectin, common pesticides- herbicides (2,4-D) and pesticides (DDT), heavy metals. Biodegradation of Xenobiotics - Recalcitrant Halocarbons, Recalcitrant TNTs, PCBs and Synthetic polymers. Biodegradation of Hydrocarbons. Biodeterioration of Textiles and Leather. Pollution Control Bodies and Environmental laws in India. Environmental impact assessment, EIA guidelines, US Environment protection Agency norms.	20	CO5
	Total	90	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Depict diversity and significance of soil microbes and predict the role of microbes in biological nitrogen fixation.	PO1
CO2	Utilize the knowledge of microbial interactions, with beneficial application of biofertilizers for sustainable agriculture and benefits of biopesticides.	PO1, PO7, PO8
CO3	Explain the different types of microorganisms in water. Identify the causes of water pollution and the methods for quality assessment of water and control of water borne diseases.	PO1, PO5, PO6, PO7, PO8
CO4	Apply knowledge about waste treatments and microbial decomposition and bio-remediation process in environmental cleanup.	PO1, PO5
CO5	Plan a clear approach on environmental issues. Control pollution and explain protection laws to public.	PO1, PO5

Text Books

1.	Subba Rao. N.S. (2017). Soil Microbiology. (5thEdition). MedTech Publishers.
2.	Daniel. C.J. (2006). Environmental Aspects of Microbiology. (2nd Edition). Bright Sun Publications.
.3.	Rangaswami. G. and Mahadevan. A. (2006). Diseases of Crop Plants in India. (4th Edition). Prentice–Hall of India Pvt. Ltd.
4.	Sharma P.D. (2010). Microbiology and Plant pathology. (2nd Edition). Rastogi Publications.
5.	Subba Rao. N.S. (2005). Soil microorganisms and Plant Growth. (4th Edition). Oxford and IBH Publishing Pvt. Ltd.

References Books

1.	Pepper I.L., Gerba C.P. and Gentry T.J. (2014). Environmental Microbiology (1st Edition). Academic Press, Elsevier.
2.	Bitton, G. (2011). Wastewater Microbiology. (4thEdition). Wiley-Blackwell.
3.	Bridgewater L. (2012). Standard Methods for the Examination of Water and Wastewater. American Public Health Association.

4.	Shrivastava A.K. (2003). Environment Auditing. A.P.H. Publishing Corporation.
5.	Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan.
Web Resources	
1.	https://academic.oup.com/femsec/article/93/5/fix044/3098413
2.	http://www.fao.org/3/t0551e/t0551e05.htm
3.	www.environmentshumail.blogspot.in/
4.	https://www.frontiersin.org/articles/10.3389/fpls.2017.01617/full
5.	https://serc.carleton.edu/microbelife/index.html

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand/ Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M													
CO2	M						M	M						
CO3	M				S	S	S	S						

CO4	M				M									
CO5	M				M									

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1C06	**Molecular Biology and Recombinant DNA Technology**	**Core Course VIII Theory**	**4**	**2**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

Course Objectives

CO1	Provide knowledge on the structure, replication and repair mechanisms of DNA. Illustrate the structure, functions and significance of RNA.
CO2	Discuss the gene regulatory mechanisms in prokaryotes and eukaryotes and importance of mutations.
CO3	Provide in depth knowledge about artificial gene transfer mechanisms and selection of Recombinants.
CO4	Impart knowledge on various molecular techniques and their importance in biotechnology.
CO5	Explain the applications of genetic engineering in various fields.

UNIT	Details	No. of Hours	Course Objectives
I	DNA replication – modes and enzymes involved. Detailed mechanism of semi-conservative replication. Prokaryotic and eukaryotic transcription. Structure and processing of m-RNA, r-RNA and t-RNA. Ribosomes. Genetic Code and Wobble hypothesis, Translation in prokaryotes and eukaryotes, post translational modifications.	20	CO1
II	Gene regulation and expression – Lac operon, arabinose and tryptophan operons. Gene regulation in eukaryotic systems-repetitive DNA, gene rearrangement, promoters, enhancer elements. Molecular basis of gene mutation - Types of mutations - base substitutions, frame shift, deletion insertion, duplication, inversion. Silent, conditional and lethal mutation. Chemical mutagenesis. Repair of DNA damage. Photoreactivation. SOS repair mechanism. Base excision repair. Nucleotide excision repair. Detection and analysis of mutations (Replica plating, Antibiotic enrichment, Ames test).	20	CO2
III	Tools and methods in gene cloning. Restriction endonucleases – nomenclature, classification and characteristics - DNA methylases, DNA polymerases, Ligases. Adapters, linkers and	20	CO3

	homopolymer tailing. Artificial gene transfer techniques - electroporation, microinjection, protoplast fusion and microparticle bombardment. Screening for recombinants. Gene cloning vectors for prokaryotes and eukaryotes - cloning properties and types of plasmids vectors (pBR322 and derivatives, pUC vectors and pGEM3Z) - Phage Vectors(M13 and Lambda), cosmids, phasmids, phagemids and BACs - Eukaryotic vectors - Yeast vectors – Animal and plant vectors – expression vectors. Shuttle vectors - Expression of foreign genes in bacteria, animal, plant, algae and fungi – merits and demerits.		
IV	Genomic DNA and cDNA library-Construction and Screening. Substrative hybridization for tissue specific DNA libraries. Techniques in genetic engineering Characterization of cloned DNA: Hybrid arrested translation (HAT) - Restriction mapping - restriction fragment length polymorphism (RFLP) - Polymerase chain reaction (PCR) – Principles, types and their applications. DNA sequencing - Primer walking, Sanger's method and automated sequencing methods. Pyrosequencing – DNA chips and micro array. Protein engineering and techniques Site directed mutagenesis – methods - Design and construction of novel proteins and enzymes, Basic concepts in enzyme engineering, engineering for kinetic properties of enzymes. protein folding, protein sequencing, protein crystallization. Applications of protein engineering.	15	CO4
V	Plant biotechnology - constituents and concepts of sterilization - preparation, isolation and selection of explant. Suspension cell culture, callus culture, protoplast isolation, culture & fusion. Anther and pollen culture for production. Animal biotechnology – equipment and media used for animal cell culture technology. Primary and established cell line culture and culture media. Applications of animal cell cultures. Serum protein media viability and cytotoxicity. Applications of Genetic Engineering - transgenic animals, Recombinant Cytokines and their use in the treatment of animal infections. Monoclonal Antibodies in Therapy- Vaccines and their Applications in Animal Infections - Human Gene Therapy-Germline and Somatic Cell Therapy-Ex-vivoGene Therapy. In-vivoGene Therapy. Vectors in Gene Therapy-Viral and Non-Viral Vectors. Transgenic Plants.	15	CO5
	Total	90	
Course Outcomes			
Course	On completion of this course, students will;		

Outcomes		
CO1	Analyze, demonstrate and appreciate DNA replication and protein synthesis.	PO4, PO6, PO9
CO2	Investigate the types of mutation and its impact on microbes. Illustrate various strategies on gene cloning.	PO4, PO6, PO9
CO3	Analyze, modify and characterize DNA modifying enzymes.	PO4, PO6, PO9
CO4	Illustratively assess the molecular techniques for DNA and protein analysis.	PO4, PO6, PO9
CO5	Adopt the applications of Genetic Engineering in the field of agriculture and medicine towards scientific research.	PO1, PO3, PO4, PO5, PO6, PO7, PO8, PO9

Text Books

1.	Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi.
2.	Snusted D.P. and Simmons M. J. (2019). Principles of Genetics. (7th Edition). John Wiley and Soms, Inc.
3.	Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd.
4.	Primrose S.B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics. (7th Edition). Blackwell Publishing.
5.	Maloy S. R. Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2nd Edition). Narosa Publishing House Pvt. Ltd.

References Books

1.	Brown T. A. (2016). Gene Cloning and DNA Analysis- An Introduction. (7th Edition). John Wiley and Sons, Ltd.
2.	Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press.
3.	Russell P.J. (2010). Genetics - A Molecular Approach. (3rd Edition). Pearson New International Edition.
4.	Synder L., Peters J. E., Henkin T.M. and Champness W. (2013). Molecular Genetics of Bacteria. (4th Edition). ASM Press Washington-D.C. ASM Press.
5.	Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd.

Web Resources

1.	https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/
2.	https://geneticeducation.co.in/what-is-transcriptomics
3.	https://www.molbiotools.com/usefullinks.html
4.	https://geneticeducation.co.in/what-is-transcriptomics

5.	https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1				S	M	S	L	L	S	L	L			
CO2				S	M	S	L	L	S	L	M			
CO3				S	M	S	L	L	S	L	M			
CO4				S	M	S	L	L	S	L	L			
CO5	S		S	S	S	S	S	S	S	M	L			

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1L03	**Practical III**	**Core Course IXPractical's**	**-**	**-**	**6**	**-**	**4**	**6**	**40**	**60**	**100**

Course Objectives

CO1	Illustrate the significance of artificial transformation and mutations.
CO2	Discuss blotting techniques and PCR.
CO3	Analyze and estimate water quality and potability
CO4	Prepare Biofertilizers, vermicompost and test their efficiency
CO5	Familiarize with common plant infections

UNIT	Details	No. of Hours	Course Objectives
I	Artificial Transformation Detection of Antibiotic resistant mutants Identification of mutants by replica plating method	20	CO1
II	Amplification of DNA by PCR Western blotting - Demonstration Southern blotting – Demonstration	15	CO2
III	Detection of Water hardness Microbiological analysis of water Total Heterotrophic Count B) Test for indicative organisms 1) MPN 2) Membrane Filtration Physical, chemical, assessment of water Physical - Color, pH, Chemical - alkalinity, acidity, DO, BOD, COD Enumeration of bacteria and fungi from air – Air sampler Isolation of free-living nitrogen fixers from soil and *Rhizobium* from root nodules of leguminous plants. Isolation and enumeration of phosphate-solubilizing bacteria from soil	15	CO3
IV	Preparation of Biofertilizers and testing the efficiency of prepared biofertilizers R:S ratio of soil microbes Estimation of soil enzymes- urease and phosphatase Study of phylloplane microflora by leaf impression method Isolation of cellulose degrading bacteria Preparation of a vermicompost Isolation of VAM fungi from soil Isolation of plant pathogen - *Alternaria* &*Curvularia*spps., Cultivation of edible mushroom from solid waste Cultivation of *Azolla*	20	CO4
V	Visual examination, observation, and identification of some common plant infections. To test Koch postulates using plant pathogens Collection of 5 herbarium specimens of infected leaves.	20	CO5

	Total	90	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Utilize various molecular techniques for gene manipulation and detection of mutants.	PO4, PO6, PO7, PO9, PO11
CO2	Undertake novel research with techniques like PCR and blotting analysis.	PO4, PO6, PO7, PO10, PO11
CO3	Assess the microbial quality of water and air and relate the results to standards.	PO1, PO4, PO5, PO7, PO8
CO4	Synthesize biofertilizers and vermicompost. Cultivate mushrooms using solid waste.	PO1, PO4, PO5, PO7, PO8
CO5	Identify various plant pathogens	PO5, PO10

Text Books

1.	Russell P. J. (2019). Genetics – A Molecular Approach (3rd Edition). Pearson Education, Inc.
2.	Glick B. R. and Patten C. L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA (5th Edition). ASM Press.
3.	Gunasekaran P. (2007). Laboratory Manual in Microbiology. New Age International.
4.	James G Cappucino. and Natalie Sherman. (2016). Microbiology – A laboratory manual. (5th Edition). The Benjamin publishing company. New York.
5.	Hurst, C.J., Crawford R.L., Garland J.L., Lipson D.A., Mills A.L. and Stetzenbach L.D. (2007). Manual of Environmental Microbiology. (3rd Edition). American Society for Microbiology.

References Books

1.	Sambrook J. and Russell D.W. (2001). Molecular Cloning: A Laboratory Manual. (7th Edition). Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press.
2.	Brown T.A. (2016). Gene Cloning and DNA Analysis. (7th Edition). John Wiley and Jones, Ltd.
3.	Dale J. W., Schantz M. V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd.
4.	Pepper I., Gerba C. and Brendecke J. (2004). Environmental Microbiology - A Laboratory Manual. (2nd Edition). Academic Press, Elsevier.
5.	Yates M.V., Nakatsu C.H., Miller R.V. and Pillai, S.D. (2016). Manual of Environmental Microbiology. (4th Edition). Wiley.

Web Resources

1.	https://www.molbiotools.com/usefullinks.html
2.	https://geneticgenie.org3.
3.	https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5
4.	https://vlab.amrita.edu/index.php?sub=3&brch=272

5.	https://nptel.ac.in/courses/102105087	
Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	40 Marks
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	60 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1				S	M	S	S	M	S	M	S			
CO2				S	M	S	S	M	M	S	S			
CO3	M			S	S		S	M						
CO4	M			S	S		S	S						
CO5					M					M				

Subject	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst.**	**Marks**

Code								Hours	CIA	External	Total
23UPM BC1C07	**Fermentation technology and Pharmaceutical Microbiology**	**Core Course X Industry Module**	**3**	**1**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

Course Objectives	
CO1	Discuss about fermentation and its types, sensitize on methods of strain development for improved yield.
CO2	Impart knowledge on the fermenter design and types.
CO3	Acquire knowledge on the effective recovery and purification of the products.
CO4	Explain the importance of pharmaceutical microbiology.
CO5	Illustrate methods for production products using microorganisms and their quality control.

UNIT	Details	No. of Hours	Course Objectives
I	Bioprocesses - concepts and design. Industrially important microorganisms – Isolation, primary and secondary screening, preservation and improvement of industrially important strains. Upstream processing - Development of inoculums for fermentation process. Media for industrial fermentation - Formulation, optimization. Sterilization. Stages of upstream - Growth of inoculums, fermenter pre-culture and production fermentation. Types of fermentation - Batch, continuous, dual or multiple, surface, submerged, aerobic and anaerobic.	12	CO1
II	Fermenter – Design, types and construction, Instrumentation and control. Productivity. Yield coefficients. Heat production. Aeration and agitation. Gas exchange and mass transfer. Computer Applications in fermentation technology. Fermentation Economics.	12	CO2
III	Downstream Processing - Recovery and purification of intracellular and extracellular products. Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration - Physical, chemical and enzymatic methods. Extraction - Solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction. Purification by different methods. Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization.	12	CO3
IV	Overview of pharmaceutical microbiology - Ecology of microorganisms - Atmosphere, water, skin, respiratory flora of workers, raw materials, packaging, building equipment and their control measures. Design and layout of	12	CO4

	sterile manufacturing unit. Contamination and Spoilage of Pharmaceutical products - sterile injectable and non-injectable, ophthalmologic preparation, implants.		
V	Production of pharmaceutical products and quality assurance – Vaccines, immunodiagnostics, immuno-sera, immunoglobulin. Antibiotics - Penicillin, Griseofulvin, Metronidazole. Enzymes - Streptokinase, Streptodornase. Quality assurance and quality management in pharmaceuticals – In-Process, Final-Product Control and sterility tests. Regulatory aspects - BIS (IS), ISI, ISO, WHO and US certification.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Develop microbial strains, carry out fermentation and recover the products of the process.	PO6, PO7, PO8, PO9
CO2	Design fermenters according to needs for various products.	PO6, PO7, PO8, PO9
CO3	Recover the end products of the fermentation process economically.	PO4, PO6, PO7, PO8, PO9
CO4	Utilize the knowledge on pharmaceutical microbiology for industrial production of products.	PO6, PO7, PO8
CO5	Produce therapeutic products from microbes employing technology and analyze the quality the products.	PO6, PO7, PO8

Text Books

1.	Patel A. H. (2016). Industrial Microbiology. (2nd Edition). Laxmi Publications, New Delhi.
2.	Casida L. E. J. R. (2019). Industrial Microbiology. New Age International Publishers.
3.	Sathyanarayana U. (2005). Biotechnology. (1st Edition). Books and Allied (P) Ltd.
4.	Reed G. (2004). Prescott and Dunn's Industrial Microbiology. (4th Edition). CBS Publishers & Distributors.
5.	Waites M. J., Morgan N. L., Rockey J. S. and Higton G. (2013). Industrial Microbiology: An Introduction. Wiley Blackwell Publishers.

References Books

1.	Stanbury P. T. and Whitaker. (2016). Principles of Fermentation Technology. (3rd Edition). Pergamon Press. NY.
2.	Handa S. S. and Kapoor V. K. (2022). Pharamcognosy, (4th Edition). Vallabh Prakashan Publishers, New Delhi.
3.	Kokate C. K., Durohit A. P. and Gokhale S. R. Pharmacognosy. (2002). (12th Edition). Nirali Prakasham Publishers, Pune.

4.	Hugo W. B. and Russell A. D. (2004). Pharmaceutical Microbiology. (7th Edition). Blackwell Scientific Publication, Oxford.
5.	Wallis, T.E. (2005). Text book of Pharmacognosy. (5th Edition). CBS publishers and distributors, New Delhi.
Web Resources	
1.	https://ib.bioninja.com.au/options/untitled/b1-microbiology organisms/fermenters.html
2.	https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/penicillin.html
3.	https://www.sciencedirect.com/topics/biochemistry-genetics-andmolecular-biology/ethanol-fermentation
4.	https://www.usp.org/sites/default/files/usp/document/harmonization/genmethod/q05b_pf_ira_34_6_2008.pdf
5.	http://www.simbhq.org/

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Test	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
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Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1						L	L	M	L					

CO2						L	M	L	S					
CO3				M		L	M	M	L					
CO4						L	L	M						
CO5						L	M	L						

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1E13	**Biosafety, Bioethics and IPR**	**Elective Course V (Choice 1)**	**Y**	**Y**	**-**	**-**	**3**	**3**	**25**	**75**	**100**

Course Objectives	
CO1	Create a research environment. Encourage investigation, analysis and study the bioethical principles, values, concepts, and social and juridical implications in the areas of science, biotechnology and medicine.
CO2	Discuss about various aspects of biosafety regulations, IPR and bioethics concerns arising from the commercialization of biotechnological products.
CO3	Familiarize fundamental aspects of Intellectual property Rights in the development and management of innovative projects in industries.
CO4	Acquire knowledge about bioethics, biodiversity and Genetically modified foods and food crops
CO5	Provide students with an understanding of bioethics in research associated with medicine

UNIT	Details	No.of Hours	Course Objectives
I	Intellectual Property Rights: Different forms of Intellectual Property Rights – their relevance, importance to industry, Academia. Role of IPR's in Biotechnology, Patent Terminology - Patents, trademarks, copyrights, industrial designs, geographical indications, trade secrets, non-disclosure agreements. Patent life and geographical boundaries. International organizations and IPR - Overview of WTO, TRIPS, WIPO, GATT, International conventions, Trade agreements, Implication of TRIPS for developing countries.	12	CO1
II	Process involved in patenting. Patent Search - Procedural steps in patenting,process of filing, PCT application, pre-	12	CO2

	grant &post-grant opposition, PCT and patent harmonization including Sui-generis system, patent search methods, patent databases and libraries, online tools, Country-wise patent searches (USPTO, EPO, India etc.), patent mapping.		
III	Patentability of biotechnology inventions - Patentability of biotechnology inventions in India, statutory provisions regarding biotechnological inventions under the current Patent Act 1970 (as Amended 2005). Biotechnological inventions as patentable subject matter, territorial nature of patents - from territorial to global patent regime, interpreting trips in the light of biotechnology inventions, feasibility of a uniform global patent system, merits and demerits of uniform patent law, relevance of the existing international patent, tentative harmonisation efforts, implications of setting up a uniform world patent system.	12	CO3
IV	Introduction to bioethics - need of bioethics, applications and issues related to bioethics, social and cultural issues. Bioethics and biodiversity - conserving natural biodiversity, convention on protecting biodiversity, protocols in exchanging biological material across borders. Bioethics & GMO's - issues and concerns pertaining to genetically modified foods and food crops, organisms and their possible health implications and mixing up with the gene-pool.	12	CO4
V	Bioethics in medicine - Protocols of ethical concerns related to prenatal diagnosis, gene therapy, organ transplantation, xeno transplantation, ethics in patient care, informed consent. bioethics and cloning - permissions and procedures in animal cloning, human cloning, risks and hopes. Bioethics in research: stem cell research, human genome project, use of animals in research, human volunteers for clinical research, studies on ethnic races. he Nuremberg code.	12	CO5
	Total	60	

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Execute the role of IPR, Patent, Trademarks and its importance.	PO1, PO2, PO3, PO5, PO6
CO2	Develop patent procedure, patent filling and its mapping.	PO3, PO4, PO13

CO3	Become Patent attorneys and Patent officers.	PO2, PO3, PO4, PO7, PO9
CO4	Applybioethics in GMO, food crops and its biodiversity.	PO2, PO3, PO5, PO9
CO5	Analyze the importance of bioethics in research associated with HGP, clinical research, stem cell therapy.	PO1, PO3, PO5, PO6, PO9, PO10

Text Books	
1.	Usharani B., Anbazhagi S. and Vidya C. K. (2019). Biosafety in Microbiological Laboratories. (1st Edition). Notion Press. ISBN-101645878856
2.	Satheesh M. K. (2009). Bioethics and Biosafety. (1st Edition). J. K International Publishing House Pvt. Ltd: Delhi. ISBN: 9788190675703
3.	Goel D. and Parashar S. (2013). IPR, Biosaftey and Bioethics. (1st Edition). Pearson education: Chennai. ISBN-13: 978-8131774700
4.	Raj Mohan joshi. Biosafety and Bioethics. Wiley Publications.
5.	Sibi. GIntellectual, Property Rights, Bioethics, Biosafety and Entreepreneurship in biotechnology. (2021). Wiley Publications.
References Books	
1.	Nithyananda K. V. (2019). Intellectual Property Rights: Protection and Management, India, IN: Cengage Learning India Private Limited.
2.	Neeraj, P. and Khusdeep, D. (2014). Intellectual Property Rights, India, IN: PHI learning Private Limited,
3.	Ahuja, V K. (2017). Law relating to Intellectual Property Rights, India, IN: Lexis Nexis.
4.	Tony Hope (2004). Medical Ethics: A very Short introduction,. Oxford Publication.
5.	Goel Parashar. IPR, Biosafety and Bioethics (2013). Pearson Publications.

Web Resources	
1.	http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf.
2.	https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub _489.pdf.
3.	https://www.cdc.gov/training/quicklearns/biosafety/
4.	https://bioethics.msu.edu/what-is-bioethics
5.	https://www.wto.org/english/tratop_e/trips_e/intel1_e.htm

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or Overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S	S	S		S	S								
CO2			S	S									M	

CO3		S	S	S			S		S					
CO4		S	S		S				S					
CO5	S		S		S	S			S	M				

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1E14	**Toxicology**	**Elective Course V (Choice 2)**	**3**	**1**	**-**	**-**	**3**	**3**	**25**	**75**	**100**

Course Objectives

CO1	Recognize the various categories of environmental toxins and their hazardous consequence
CO2	Enhance the knowledge of underlying etiology of diseases
CO3	Strengthen the evidence for a causal link between the exposure of hazardous agent and the development of diseases
CO4	Illustrate various techniques to isolate and characterize the toxin
CO5	Examine, interpret and discuss the certainty of toxic substances, proposing the deep understanding of medicinal and industrial applications

UNIT	Details	No. of Hours	Course Objectives
I	General Introduction - Definition of toxins, different categories of toxins and venoms, recent trends in venom and toxin research.	12	CO1
II	Bacterial toxins - Bacterial toxins Bacterial toxinogenesis, endotoxins, exotoxins, exotoxins, bacterial protein toxins with special reference to cholera, diphtheria and tetanus toxins, molecular mechanism of action of endotoxins, exotoxins, enterotoxins, neurotoxins and mycotoxins.	12	CO2
III	Plant toxins & Toxins from snake venom - Natural toxins in plants, Plant toxic proteins, impact of plant toxin on human, natural toxins in food, plants, allelopathy. Toxins from snake venom Snakes and Biological significance of their venoms, composition of snake venom, evolution of venom, 3D structure of some important venom constituents and their mechanism of action (phospholipase A2, cardiotoxin, neurotoxin) three-finger toxins, anti-venom and medicinal plants in treatment of snakebite patients.	12	CO3

IV	Tools for isolation and characterization of toxins - Multidimensional chromatographic techniques (gel-filtration, ion-exchange reverse-phase HPLC, SDS-PAGE, 2-dimensional gel electrophoresis), toxin mass fingerprinting, N-terminal peptide sequencing, analysis of protein data by using proteomics software.	12	CO4
V	Medicinal and industrial applications of venoms and toxins. Use of toxin in neurobiology and muscular research, anticancer drug, diagnosis of haemostatic disorders, antibacterial agents, bioinsecticides and other industrial applications.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Perceive the adverse effects of toxin and its potential role in research.	PO1, PO2, PO9
CO2	Assess the toxicity, properties and mode of actions of microbial toxins.	PO2, PO4, PO6, PO10
CO3	Explicate the mode of actions and their biological significance.	PO1, PO2, PO4
CO4	Evaluate the toxicity level with the help of advanced techniques.	PO6, PO7. PO9.PO11
CO5	Elucidate the various natures of application of toxic substances.	PO4, PO5, PO6, PO8, PO9

Text Books

1.	Holst O. (2008). Bacterial Toxin –Methods & Protocols. Humana Press.ISBN 9781592590520.
2.	Shier W. T. (1990). Handbook of Toxinology. CRC Press. ISBN 9780824783747.
3.	Wilson K. and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. (7thEdition). Cambridge University Press India Pvt.Ltd. ISBN 1-4051-3544-1.
4.	Pholtan Rajeev S.R. (2021Pictorial handbookfortoxinology. Rudra Publications.
5.	Cora Lancester. (2015). Molecular Toxinology Handbook. Callisto Reference

References Books

1.	Reilly M.J. (2018). Bioinstrumentation. CBS Publishers and Distributors Pvt Ltd. ISBN 13 978-8123928395.

2.	Greenberg M., Hamilton R., Phillips S. and McCluskey G. J. (2003). Occupational, Industrial and Environmental Toxicology. St Louis: C.V. Mosby.
3.	Wiley-Vch. (2005). Ullmann's Industrial Toxicology. New York: John Wiley & Sons.
4.	Winder C. and Stacey N.H. and Boca Raton F. L.(2004). Occupational Toxicology. (2^{nd}Edition). CRC Press.
5.	Gopalakrishnakone(2015). Biological Toxins and Bioterrorism. Springer.

Web Resources	
1.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5869414/
2.	https://www.reseachgate.net/publication/269037373_TOXIN_AS_A_MEDICINE
3.	https://www.toxinology.org/
4.	https://www.mdpi.com/journal/toxins/special_issues/snakebite_clinical_toxinology
5.	https://pubmed.ncbi.nlm.nih.gov/12807310

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S	S							S					
CO2		S		S		S				S				
CO3	S	S		S										
CO4						S	S		S		S			
CO5				S	S	S		S	S					

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
23UPMBC1E15	**Water Conservation and Water Treatment Technologies**	**Elective Course V (Choice 3)**	**Y**	**Y**	**-**	**-**	**3**	**3**	**25**	**75**	**100**

Course Objectives

CO1	Explain how societal and climatic changes will distress water supply and water demand in future
CO2	Ascertain promising elucidations to the global water crisis and assess the pros and cons
CO3	Acquire knowledge to identify the quality of water by standard method
CO4	Illustrate the methods of water treatment technologies and assessing the impact of HWTS
CO5	Describe the application and uses of various emerging water treatment technologies

UNIT	**Details**	**No.of Hours**	**Course Objectives**
I	Water Scarcity; Major Causes of Water Scarcity, Types of Water Scarcity, Water Footprint- Effects of Water Scarcity Across the Globe-, Water Scarcity in India; Effects of Water Scarcity in India-Social and Political Effects and Economic Risks of Water Scarcity in India.	12	CO1
II	Multi-pronged approach to Prevent Water Scarcity; Aquifer Recharging, Water reuse and Zero-Liquid Discharge Technology, Coastal Reservoir, Desalination Plants- Measures for Preventing Water Scarcity in India - Jal Shakti Abhiyan Campaign, Atal Bhujal Yojana, Adoption of Composite Water Management Index (CWMI), Water conservation resource management, Rain Water Harvesting.	12	CO2

III	Water Quality and Pollution; Impurities in the water, Characteristics of different water sources Vulnerability of the water sources to contamination, Water quality criteria - Quality of surface waters, flowing waters, impounded waters, Groundwater, Water quality standards, Microbiological quality of drinking Water, Chemical quality of drinking water.	12	CO3
IV	Water Treatment Technologies; Sedimentation, Filtration, Coagulation and flocculation, Water softening and adsorption processes, Membrane filtration, Microfiltration, Ultrafiltration and Nanofiltration,Water disinfection, Activated carbon filtration, Household Water Treatment and Safe Storage (HWTS). Methods for household water treatment Safe water storage, Household water treatment and safe storage decision tree, Assessing the impact of HWTS, Government policies for HWTS.	12	CO4
V	New and Emerging Drinking Water Treatment Technologies; Nanotechnology, Acoustic nanotube technology, Photocatalytic water purification technology, Aquaporin Inside™ technology, Automatic Variable Filtration (AVF) technology, Sun Spring System, Desalination.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Appraise issues of water scarcity, stress, and conflict on global population.	PO1, PO2, PO4, PO5, PO10
CO2	Apprehend the multiple approaches against water scarcity and to understand various government schemes for water conservation.	PO1, PO2, PO5, PO10, PO14
CO3	Relate the connection between water quality and public health.	PO4, PO6, PO10
CO4	Design and execute standard strategy for successful HWTS implementation.	PO4, PO5, PO6, PO9
CO5	Cogitate the purpose, principles, operation, and limitation of various modern water treatment technologies.	PO5, PO7, PO8, PO9, PO10, PO11

Text Books

1.	Vasileios A., TzanakakisN.Paranychianakis V. and Angelakis A. N. (2020). Water Supply and Water Scarcity. MDPI, ISBN 978-3-03943-306-3 (Hbk). ISBN 978-3-

	03943-3070.
2.	Pannirselvam M., ShuLi.,Griffin G., Philip L., Natarajan A. and Hussain S. (2019). Water Scarcity and Ways to Reduce the Impact. ISBN: 978-3-319-75199-3.
3.	Tiwari A., Kumar A., Singh A., Singh T.N., Suozzi E., Matta G. and Russo S. (2022). Water Scarcity, Contamination and Management. Elsevier. ISBN: 9780323853781.
4.	Daniel, C.J. (1996). Environmental Aspects of Microbiology, 1st edn. Bright Sun Publications.
5.	Maier RM, Pepper IL, Gerba CP (2008). Environmental Microbiology, 2nd edn. Academic Press
References Books	
1.	Fujita K. and Mizushima T. (2021). Sustainable Development in India-Groundwater Irrigation, Energy Use, and Food Production. ISBN 9780367460976.
2.	Gupta R. (2008). Water Crisis in India. Atlantic Publishers. ISBN: 9788126909582, 9788126909582.
3.	AhujaS. (2013). Monitoring Water Quality-Pollution Assessment, Analysis, and Remediation. Elsevier. Book ISBN: 9780444594044. Hardcover ISBN: 9780444593955.
4.	Saeid Eslamian ., Faezeh Eslamian ., (2021) Water harvesting and conservation – Basic Concepts and fundamentals, Wiley Publications.
5.	Buckley RG. (2016) Environmental Microbiology 1st edn. CBS Publishing.
Web Resources	
1.	https://link.springer.com/book/10.1007/978-1-59745-278-6
2.	https://apps.who.int/iris/handle/10665/206916?show=full
3.	https://www.acs.org/content/acs/en/policy/publicpolicies/sustainability/water-statement.html
4.	https://www.toftigers.org/best-practice/water-conservation-and-treatment/
5.	https://doh.wa.gov/community-and-environment/wastewater-management/site-sewage-systems-oss

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S	S		S	S					S				
CO2	S	S			S					S				S
CO3				S		S				S				
CO4				S	S	S			S					
CO5					S		M	S	S	S	S			

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1N02	**Organic Farming and Bio fertilizer Technology**	**NME- II**	2	-	-	-	2	3	25	75	100

Course Objectives	
CO1	Impart knowledge on the importance, types and advantages of organic farming thereby creating awareness on conserving environment and natural resources, encouraging sustainable agriculture.
CO2	Familiarize with the basic concepts of farm development and relate the development of organic farming in their countries to meet global trends.

CO3	Explain the various types of biofertilizer and the scope in its production.
CO4	Discuss about biofertilizer production and its field application, promoting economy.
CO5	Develop the skill to analyze the quality of packaging, storage, assess the shelf life and bioefficacy of biofertilizers

UNIT	Details	No. of Hours	Course Objectives
I	Organic farming – Definition, relevance. Biological nutrient management- Organic manures, vermicompost, green manure, organic residue, biofertilizer soil amendments. Integrated pest and weed management - Use of biocontrol agents, bio pesticides etc. Organic and Conventional farming. Organic and Chemical farming – Comparison.	6	CO1
II	Certification and Schemes - Certification and Schemes. Organic certification in brief. Integrated farming system-definition, goal, components. Factors affecting ecological balance. Land degradation. Soil health management. Models of IFS for rainfed and irrigated conditions and different categories of farmers. Government schemes - NPOF, NPOF, NHM, HMNEH, NPMSH&F and RKVY.	6	CO2
III	Biofertilizers - Introduction, types, advantages and future perspective. Introduction, status and scope. Structure and characteristic features of bacterial biofertilizers- *Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium* and *Frankia*.	6	CO3
IV	Cyanobacterial biofertilizers- Anabaena, Nostoc, *Hapalosiphon*and fungal biofertilizers- AM mycorrhiza and ectomycorhiza. Nitrogen fixation -Free living and symbiotic nitrogen fixation. Mechanism of phosphate solubilization and phosphate mobilization, potassium solubilization.	6	CO4
V	Production technology - Strain selection, sterilization, growth and fermentation, mass production of carrier based and liquid bio-fertilizers. FCO specifications and quality control of biofertilizers. Application technology for seeds, seedlings, tubers. Biofertilizers -Storage, shelf life, quality control and marketing. Factors influencing the efficacy of biofertilizers.	6	CO5
	Total	**30**	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Produce biofertilizers and distinguish between organic and conventional farming.	PO1, PO3, PO4, PO5, PO6, PO7, P08,

		PO9, PO10, PO11, PO12, PO14
CO2	Plan a Complete Farm Business including marketing, operation and financial outline.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8
CO3	Practice the application of microbial bio-fertilizers in large scales, thereby increasing soil fertility.	PO4, PO5, PO6
CO4	Develop integrated farming for sustainable agriculture.	PO6, PO9, PO10
CO5	Promote the quality of packaging, storage, increase shelf life, accelerate the bio efficacy of bio fertilizers as per BIS standards	PO5, PO7, PO8, PO11, PO13, PO14

Text Books	
1.	Sharma A. K. (2001). Hand book of Organic Farming.Agrobios.
2.	Gaur A. C. (2006). Hand book of Organic Farming and Biofertilizers. Ambika Book Agency.
3.	Subba Rao N.S. (2017). Bio-fertilizers in Agriculture and Forestry. (4th Edition). Med Tech publisher.
4.	Subba Rao N. S. (2002). Soil Microbiology. Soil Microorganisms and Plant Growth. (4th Edition). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
5.	Sathe T.V. (2004). Vermiculture and Organic Farming. Daya Publishers.
References Books	
1.	Rakshit A. and Singh H. B. (2015). ABC of Organic Farming. (1st Edition). Jain Brothers.
2.	Dubey R. C. (2008). A Textbook of Biotechnology. S. Chand & Co., New Delhi.
3.	Bansal M. (2019). Basics of Organic Farming. CBS Publisher.
4.	Bhoopander G., Ram Prasad., (2019) Biofertilizer for sustainable agriculture and Environment, Springer
5.	Niir Board., (2012) (1st Edition) Biofertiliser and organic farming
Web Resources	
1.	https://agritech.tnau.ac.in/org_farm/orgfarm_introduction.html
2.	https://www.fao.org/organicag/oa-faq/oa-faq6/en/
3.	https://www.india.gov.in/topics/agriculture/organic-farming
4.	https://agriculture.nagaland.gov.in/bio-fertilizer/
5.	https://www.ccd.ngo/sustainable-agriculture.html?gclid=EAIaIQobChMI5a-KndCo-wIV2ZZLBR1ozQj9EAAYAiAAEgJW2_D_BwE

Methods of Evaluation		
Internal	Continuous Internal Assessment Test	25 Marks

Evaluation	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (K1)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand/ Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyze (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S		S	S	S	S	S	S	S	S	S	S		S
CO2	S	S	S	M	M	M	S	M						
CO3				S	S	S								
CO4						M			S	S				
CO5					M		S	S			S		M	S

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
23UPMBC1C08	**Food and Dairy Microbiology**	**Core Course XITheory**	**Y**	**Y**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

Course Objectives			
CO1	Discuss microorganisms involved in food spoilage.		
CO2	Illustrate bacterial and nonbacterial food borne infections important in public health.		
CO3	Familiarize various national and international aspects of food safety and quality assurance.		
CO4	Elaborate on microbiology of milk, preservation techniques and production of dairy products.		
CO5	Explain Dairy plant hygiene, quality control and waste disposal.		
UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Microorganisms of food- Scope of food Microbiology. Contamination and spoilage of food –vegetables, fruits, poultry, fish, eggs, meat, meat products and canned foods. Food Preservation - Temperature (low and high), drying, radiation and chemicals.	18	CO1
II	Food microbiology and public health. Food hazards. Food infections -*Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli*, *Salmonella*, *Shigella*, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*. Nonbacterial food borne illness - Helminthes, nematodes, protozoa, toxigenic fungi and food borne virus.	18	CO2
III	Quality assurance of food - International aspects of Quality and safety assessment of foods. Microbiological quality standards for food. Government regulatory practices and policies - FDA, HACCP, BIS (IS), FSSAI-2014. Food adulteration and common food additives.	18	CO3
IV	Introduction to Dairy microbiology – Milk production and hygiene. Microorganisms associated with milk. Microbial metabolites and their role in spoilages- souring, curdling, gassiness, ropiness, proteolysis, lipolysis, abnormal flavour and colour. Antimicrobial systems in raw milk. Microbiological grading of raw milk. Milk borne diseases and their control. Bacteriological aspects of milk processing – Thermization, pasteurization, boiling, sterilization, UHT, bactofugation, and membrane filtration.	18	CO4

V	Composition and chemistry of cream, butter, ghee, ice-cream, cheese, kefir, koumiss, rennin, condensed and dried milks, infant food. Spoilage of ghee and use of antioxidants. Chemistry of milk fermentation. Chemistry of rennin coagulation of milk and changes occurring during ripening of cheese, physico-chemical changes in the manufacture and storage of milk powder, lactose, crystallization and its significance. Dairy plant hygiene and sanitation. Disposal of dairy waste. Microbiological standards for Milk and Milk products- PFA BIS, Codex/ ISO standards.	18	CO5
	Total	90	

Course Outcomes

Course Outcomes		
CO1	Utilize the knowledge on process of food contamination and spoilage to preserve food.	PO7, PO8, PO9
CO2	Use the knowledge on food borne disease to protect public health.	PO5, PO7, PO8, PO9
CO3	Familiarize various national and international aspects of food safety and quality assurance.	PO4, PO7, PO8
CO4	Prepare dairy products and perform quality checks.	PO7, PO8
CO5	Apply microbiological standards to milk and milk products.	PO7, PO8

Text Books

1.	Adams M. R. and Moss M. O. (1996). Food Microbiology, New Age International (P) Limited Publishers, New Delhi.
2.	Frazier W.C., Westhoff. D. C. and Vanitha K.N. (2013). Food Microbiology. (6th Edition). McGraw Hill Education.
3.	Jay J.M., Loessner M.J. and Golden D.A. (2006). Modern Food Microbiology. (7th Edition). Springer.
4.	Doyle M. P., Buchanan R. L. (2012). Food Microbiology: Fundamentals and Frontiers. (4th Edition). American Society for Microbiology Press.
5.	Ray B. and Bhunia A. (2013). Fundamentals of Food Microbiology. (5th Edition). CRC Press.

References Books

1.	Robinson R. K. (2000). Dairy Microbiology3rdedn, Elsevier Applied Science, London.

2.	2. Adams M.R, and Moss M.D, (2005). Food Microbiology 4th edn, New Age International Pvt. Ltd., Publishers.First edition.
3.	3. Banwarst. G.J. (2003). Basic Food Microbiology 2nd edn, CBS Publishers and distributors.
4.	4. Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7th edn. Edward Arnold: London.
5.	5. Vijaya R K, (2004). Food Microbiology 1st edn. MJP Publishers, Chennai.
Web Resources	
1.	https://www.fssai.gov.in
2.	https://www.who.int/news-room/fact-sheets/detail/food-safety
3.	https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14

CO1							S	M	M					
CO2					S		M	M	M					
CO3				S			M	M						
CO4							M	M						
CO5							M	M						

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1C09	**Research Methodology and Biostatistics**	**Core Course XIITheory**	**Y**	**Y**	**-**	**-**	**5**	**6**	**25**	**75**	**100**

Course Objectives

CO1	Discuss the methods and techniques of data collection.
CO2	Explain sampling methods, write research reports and articles.
CO3	Discuss the basic concepts of Biostatistics.
CO4	Describe statistical software for analysis.
CO5	Explain the tests of significance.

UNIT	Details	No.of Hours	Course Objectives
I	Introduction to Research Methodology - Meaning and importance. Statement, Constraints. Review of literature - Review and synopsis presentation. Types of research, Research tools. Methods and techniques of data collection - types of data, methods of primary data collection (observation/ experimentation/ questionnaire/ interviewing/ case/pilot study, methods), methods of secondary data collection.	20	CO1
II	Sampling and sampling distributions. Sampling frame, importance of probability sampling, sampling - simple random, systematic, stratified random and cluster. Variables - nominal, ordinal, discontinuous, continuous, derived. Research process, designs and Report writing - types of research reports, guidelines for writing an article and report, report format, appendices, Ethical issues related to publishing, Plagiarism and Self-Plagiarism.	20	CO2
III	Introduction to Biostatistics - Basic concepts, Measurement and measurement scales, Sampling and data collection, Data presentation. Measures of central tendency: Mean, Median, Mode. Measures of variability - Standard deviation, standard	15	CO3

	error, range, mean deviation and coefficient of variation. Frequency table of single discrete variable, bubble spot, computation of mean, variance and standard Deviations, t test, correlation coefficient.		
IV	Correlation and regression - Positive, negative, calculation of Karl-Pearsons co-efficient of correlation. Linear regression and multiple linear regression, ANOVA, one and two way classification. Calculation of an unknown variable using regression equation. Tests of significance - Tests of significance: Small sample test (Chi-square t test, F test), large sample test (Z test) and standard error.	20	CO4
V	Probability and distributions - Introduction to probability theory and distributions, (concept without deviation) binomial, poison and normal (only definitions and problems) Computer oriented statistical techniques. RSM: methods for process optimization set up CCD, Box Behnken, optimal RSM design, regression models FDS curves, surface contours, multi linear constraints and categoric factors to optimal design.	15	CO5
	Total	90	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Collect and present data suitable to the research design.	PO1, PO4, PO9, PO10
CO2	Write research manuscripts and articles for journals.	PO1, PO2, PO3, PO4, PO5, PO6, PO9, PO10, PO13
CO3	Recommend the utilization of biostatistics tools for analysis of biological data.	PO5, PO6, PO9, PO10, PO13
CO4	Prove and justify hypothesis for a particular research.	PO3, PO4, PO9, PO10
CO5	Apply software tools for interpretation of biological data.	PO4, PO9, PO10, PO13

Text Books

1.	Sharma K.R. (2002) Research methodology. National Publishing House, New Delhi.
2.	Daniel W.W. (2005). Biostatistics; A foundation for analysis in the health sciences. (7^{th} Edition). Jhon Wiley & sons Inc, New York.
3.	Rao P. S. S. and Richard J. (2006). Introductionto Biostatistics & Research methods. Prentice-Hall, New Delhi.
4.	Veerakumari L. (2015) Bioinstrumentation 1^{st}edn. MJP Publishers.
5.	Ahuja V.K. (2017) Laws Relating to Intellectual Property Rights. Lexis Nexis.

References Books	
1.	Zar J. H. (2006). Biostatistical Analysis. (4th Edition). Pearson Education Inc. New Jersey.
2.	Beins B. C. and McCarthy M.A. (2011). Research Methods and Statistics.Pearson Education Inc. New Jersey.
3.	Adams K. A. and Lawrence E. M. K. (2014). Research Methods, Statistics, and Applications.SAGE Publications, Inc., New Delhi.
4.	Anderson J.B. and Poole M. (2011). Assignment and Thesis Writing. 4thedn. Wiley India Private Limited.
5.	Kothari C.R. and Garg G (2004) Research Methodology: Methods and Techniques. 2nd Edition. New Age International Publishers
Web Resources	
1.	https://www.studocu.com/en-ca/document/mount-royal-university/quantitative-research-methods-and-data-analysis/lecture-notes-all-lectures/344093
2.	https://www.khanacademy.org/math/statistics-probability/sampling-distributions-library
3.	https://testbook.com/learn/maths-mean-median-mode/
4.	https://rcub.ac.in/econtent/ug/bcom/sem4/Business%20Statistics%20Unit%204%20Correlation%20and%20Regression.pdf
5.	https://www.cse.iitk.ac.in/users/piyush/courses/pml_fall17/material/probabilty_tutorial.pdf

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment	
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	L			L					L	L				
CO2	M	M	M	M	M	M			M	M			M	
CO3					S	S			S	S			S	
CO4			S	S					S	S				
CO5				M					M	M			M	

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
23UPMBC1E16	**Bioenergy**	**Elective Course VI (Choice 1)**	**Y**	**Y**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives

CO1	Acquire knowledge on bioenergy utilizing organic wastes for energy recovery.
CO2	Discuss methods and strategies of exploiting microbes for the production technology of biodiesel.
CO3	Describe resources and techniques for the production and estimation of eco-friendly biofuels and the extent of their use potentially.
CO4	Gain knowledge for executing biogas plant in communities.
CO5	Explain possibility of using microbes for the production of bio-hydrogen as a source of future fuel.

UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Bioenergy– Biomass Energy Resources. Biomass conversion methods. Microbes as bioresources for bioenergy products (Bacteria, fungi, yeast and microalgae) -Bioprospecting of microbial strains for biofuel production.	12	CO1

II	Biodiesel − Microbes and Biodiesel. Production and feed stock. Techniques of lipid extraction and conversion to biodiesel. Biodiesel quality and its assessment. Strategies of genetic engineering of organisms for biodiesel production. Biodiesel production from single cell organisms (*Cryptococcus, Cunninghamella, Mortierella*).	12	CO2
III	Alcoholic Fuels from microorganisms: Biochemical conversion to ethanol: Biomass pre-treatment, Starch to sucrose conversion and Sucrose to ethanol fermentation. Role of enzymes and their applications in ethanol production. Distillation and Quantification of ethanol. Production and Estimation of biobutanol, biomethanol, biopropanol and bioglycerol.	12	CO3
IV	Biogas - Microbes and Biogas production, Biogas plants – types – design – construction– Biogas Bottling Technology and Development in India, Biogas appliances – burner, luminaries and power generation – effect on engine performance. Application of Biogas slurry in agriculture**.**	12	CO4
V	Biohydrogen– Production from bacteria and algae. Commercialized microalgae (*Spirulina, Dunaliella, Hematococcus*and *Chlorella*) and their production. Economics of microalgae production. Cultivation of seaweeds. Microbial fuel cells.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Evaluate the various aspects of biomass production and their implementation.	PO1, PO5, PO6
CO2	Design and construct a biodiesel plant.	PO5, PO7, PO8, PO11,
CO3	Carry out the process of fermentation for bio – alcohol fuels.	PO1, PO4, PO5, PO7,
CO4	Identify the nature of biogas as a biofuel and their technologies and applications.	PO5, PO7, PO8, PO11.
CO5	Design, execute and extract biohydrogen from algae.	PO4, PO5, PO7, PO8.

Text Books

1.	Dahiya A. (2014). Bioenergy- Biomass to Biofuel. (1st Edition). Academic Press Editor.
2.	Brown R. C. (2003). Biorenewable Resources: Engineering New Products from Agriculture. (1st Edition). Wiley Blackwell Publishing.

3.	Jawaid M., Hakeem K. R. and Rashid U. (2014). Biomass and Bioenergy: Processing and Properties. (1st Edition). Springer Cham.
4.	Caye M. Drapcho, Tery H. Walker (Biofuels EngineeringProcess Technology. McGraw Hill.
5.	Teri. Bio energy Powering the Future. Pearson Longman Publications.
References Books	
1.	Konur O. (2018). Bioenergy and Biofuels. (1st Edition). CRC Press.
2.	LeeJ. W.(2012). Advanced Biofuels and Bioproducts. (13th Edition), Springer.
3.	Khanal S. (2008). Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. (8th Edition). Wiley-Blackwell Publishing.
4.	Pradeep Chaturvedi.(1995). Bioenergy Resources. Concept Publishing Company.
5.	Lee S. (2018).Biofuel and Bioenergy. Taylor and Francis
Web Resources	
1.	https://www.elsevier.com Biofuels and Bioenergy
2.	https://www.sciencedirect.com › book › bioenergy
3.	https://www.un.org/en/climatechange/what-is-renewable-energy?gclid=EAIaIQobChMIqriN2Nao-wIV2HwrCh2pfA5mEAAYASAAEgI-p_D_BwE
4.	https://www.energy.gov/eere/bioenergy/bioenergy-basics
5.	https://www.iea.org/fuels-and-technologies/bioenergy

Methods of Evaluation		
Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks
Methods of Assessment		
Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions	
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview	
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain	
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge	
Evaluate (K5)	Longer essay/ Evaluation essay, Critique or justify with pros and cons	
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations	

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M				S	S								
CO2					S		S	S			S			
CO3	M			S	S		S							
CO4					S		S	S			S			
CO5				S	S		S	S						

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**S**	**Credits**	**Inst. Hours**	**Marks**		
									CIA	**External**	**Total**
23UPMBC1E17	**Marine Microbiology**	**Elective Course VI (Choice 2)**	**3**	**1**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives

CO1	Gain fundamental knowledge of marine environment and the microbial communities inhabiting the oceans.
CO2	Discuss the metabolic diversity of marine microorganisms and their interrelationships.
CO3	Explain the survival of microorganisms in extreme environments.
CO4	Illustrate pathogens and contaminants in sea foods.
CO5	Describe the applications of marine biotechnological products and their future role in a rapidly changing planet.

UNIT	**Details**	**No. of Hours**	**Course Objectives**
I	Marine microbial environment - Benthic & littoral zone, salt pan, mangroves and estuarine microbes, microbial loop. Marine microbial communities – Bacteria, fungi, protozoa. Microbial interactions – Endosymbionts and Ectosymbionts.	12	CO1
II	Dynamics of Marine Microbes - Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming – Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization – phosphorus cycle. Decomposition of organic matter. Bioleaching and biodeterioration of natural and synthetic materials.	12	CO2
III	Marine extremophiles: Mechanism of survival at extreme environments – Adaptive mechanisms in thermophilic,	12	CO3

	alkalophilic, osmophilic, barophilic, psychrophilic hyperthermophilic and halophilic microorganisms – Importance in biotechnology.		
IV	Marine Microbial Diseases:Aqua culture pathogens & Water borne pathogens -*Aeromonas, Vibrio,Salmonella, Pseudomonas, Leptospira, Corynebacteria* and viral diseases.Rapid diagnosis of contamination in sea foods and aquaculture products.	12	CO4
V	Applications of Marine Microbial Biotechnology: Production and applications of marine microbial products – Enzymes, Antibiotics, Organic acids, Toxins, Biosurfactants and Pigments. Sea food preservation methods. Probiotic bacteria and their importance in aquaculture.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Apply the knowledge on marine microbial communities and their interactions.	PO1, PO9
CO2	Illustrate the role of marine microorganisms in biogeochemical cycles.	PO5, PO7
CO3	Categorize the extreme environments in the oceans and the survival mechanisms adapted by the microorganisms living in these environments.	PO7, PO9
CO4	Identify the diseases affecting marine organisms and its diagnosis.	PO5, PO7
CO5	Evaluate the marine microorganisms as a resource for novel microbial products.	PO7, PO8, PO9

Text Books

1.	Munn C. B. (2019). Marine Microbiology: Ecology and Applications. (3rd Edition). CRC Press. ISBN:9780367183561.
2.	Bhakuni, D.S. and Rawat D.S. (2005). Bioactive Marine Natural Products. Anamaya Publishers, New Delhi. ISBN:1-4020-3472-5.
3.	Brock T. D. (2011). Thermophilic Microorganisms and Life at High Temperatures. Springer. ISBN-13:978-1461262862 / ISBN-10:1461262860.
4.	Nybakken, J.W. (2001). Marine Biology. (5th Edition). Benjamin Cummings. ISBN:0321030761 9780321030764.
5.	Veena. (Understanding marine biology. Discovery Publishing.

References Books

1.	Maier R.M., Pepper I.L. and Gerba C.P. (2006). Environmental Microbiology. (2nd Edition). Academic Press. ISBN:978-0-12-370519-8.
2.	Belkin S. and Colwell R.R. (2005). Oceans and Health: Pathogens in the Marine

	Environment. Springer. ISBN:978-0-387-23708-4.
3.	Scheper T. (2009). Advances in Biochemical Engineering/Biotechnology-Marine Biotechnology. Springer. ISBN:978-3-540-69356-7. E-ISBN:978-3-540-69357-4.
4.	Gasol J. M. and Kirchman D. L. (Eds.). (2018). Microbial Ecology of the Oceans. (3rd Edition). Wiley-Blackwell. ISBN:978-1-119-10718-7.
5.	Kim S. K. (2019). Essentials of Marine Biotechnology. Springer.
Web Resources	
1.	https://link.springer.com/content/pdf/bfm%3A978-0-387-23709-1%2F1
2.	https://www.researchgate.net/publication/285931262_Bioactive_Marine_Natural_Products
3.	http://link.springer.com/content/pdf/bfm%3A978-3-642-03470-1%2F1.pdf
4.	https://link.springer.com/book/10.1007/b102184
5.	https://www.wiley.com/en-bs/Microbial+Ecology+of+the+Oceans%2C+3rd+Edition-p-9781119107187

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participitation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, Short summary or overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
Analyse (K4)	Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge
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Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14

CO1	M								M					
CO2					M		S							
CO3							M		S					
CO4					M		S							
CO5							S	S	M					

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1E18	**Life Sciences for Competitive Examinations**	**Elective Course VI (Choice 3)**	**3**	**1**	**-**	**-**	**3**	**4**	**25**	**75**	**100**

Course Objectives

CO1	Impart knowledge on structure, metabolism and function of biomolecules.
CO2	Understand the importance of inheritance biology.
CO3	Discuss in-depth about the different types of ecosystems and their importance.
CO4	Outline the major drivers in biodiversity and various conservation approaches.
CO5	Introduce basic concepts of evolution and biological clock.

UNIT	Details	No. of Hours	Course Objectives
I	Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Metabolism of carbohydrates, lipids, amino acids, nucleotides and vitamins. Structure of atoms, molecules and chemical bonds.Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.).Bioenergetics.	12	CO1
II	Cellular Organisation,Cell division and cell cycle,Membrane structure and function,Organization of genes and chromosomes,Structural organization and function of intracellular organelles,DNA replication, repair and recombination,Protein synthesis and processing.	12	CO2
III	Inheritance Biology,Mendelian principles- Dominance,	12	CO3

	segregation, independent assortment,Linkage and Gene mapping, Karyotyping,Extrachromosomal inheritance - Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. Human genetics-Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.		
IV	Ecology-Habitat and Niche,biotic and abiotic interactions, Biome- biogeographical zones of India.Ecological Succession,Population Ecology- Characteristics of a population; population growth curves,Environmental pollution-global environmental change, Biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.Biodiversity Management approaches. Indian case studies on Conservation/Management strategy (Project Tiger, Biosphere Reserves).	12	CO4
V	Evolution and Behaviour- Evolution - Theories- Darwin's, Lamarck's, Oparin Haldane. Paleontological, Embryological and Molecular evidences. Hardy Weinberg's Law. Speciation; Allopatricity and Sympatricity. Adaptive radiation and Convergent evolution; Sexual selection; Co-evolution. Altruism, Biological clocks, Migration and Parental care. Molecular Evolution- Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny.	12	CO5
	Total	60	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Define, classify and assess the structure, biological functions and interactions of Biomolecules.	PO4, PO6, PO9
CO2	Validate the knowledge of collective and progressive notions of cellular organization.	PO4, PO6, PO9
CO3	Assess and describe the importance of inheritance biology.	PO4, PO6, PO9
CO4	Establish acquaintance and understanding of ecology & Biodiversity in a broader sense.	PO4, PO6, PO9
CO5	Understand the processes of evolution, relate with natural selection, adaptation and speciation.	PO4, PO6, PO9

Text Books

1.	Nelson D. L. and Cox M. M. (2008). Lehningers Principles of Biochemistry. (5^{th} Edition). W.H. Freeman and Company.
2.	Chapman J.L. (1998).Ecology: Principles and Applications. (2^{nd} Edition). Cambridge University Press.

3.	Krishnamurthy V.K. (2003). Textbook of Biodiversity. Science Publishers.
4.	Rogers A.L. (2011). Evidence of Evolution. University of Chicago Press. Chicago.
5.	Stites D.P.,AbbaI.Terr, Parslow T.G.(1997). Medical Immunology. 9thEdn, Prentice-Hall Inc.
References Books	
1.	Pontarotti P. (2018). Origin and Evolution of biodiversity. (1st Edition). Springer.
2.	Verma P.S. and Agarwal V.K. (2004). Cell biology, Genetics, Molecular Biology, Evolution and Ecology. (2nd Edition). S Chand publication.
3.	Lewin R. and Foley R. (2004). Principles of Human Evolution. (2nd Edition). Black well Publishing Company.
4.	Boyer R.F. (2002) Modern Experimental Biochemistry 3rd Edition. Pearson Education.
5.	Wilson K., Walker J., Clokie S and Hofmann A. (2018) Wilson and Walker' Principles and Techniques of Biochemistry and Molecular Biology 8th Edition Cambridge University Press.
Web Resources	
1.	https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_
2.	https://www.livescience.com/474-controversy-evolution-works.html.
3.	https://www.examrace.com/Study-Material/Life-Sciences/
4.	https://www.kopykitab.com/Methods-In-Biology-Life-Science-Study-Material-For-CSIR-NET-Exam-by-Panel-Of-Experts
5	https://www.erforum.net/2017/01/life-science-biology-handwritten-notes-for-competitive-exams.html

Methods of Evaluation

Internal Evaluation	Continuous Internal Assessment Tests	25 Marks
	Assignments	
	Seminars	
	Attendance and Class Participation	
External Evaluation	End Semester Examination	75 Marks
	Total	100 Marks

Methods of Assessment

Recall (KI)	Simple definitions, MCQ, Recall steps, Concept definitions
Understand /	MCQ, True/False, Short essays, Concept explanations, Short summary or

Comprehend (K2)	overview
Application (K3)	Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain
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Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	L			S	L	S			S	M				
CO2	L			S	L	S			S	M				
CO3	L			S	L	S			S	M				
CO4	L			S	L	S			S	M				
CO5	L			S	L	S			S	M				

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23PGMBPRO	**Project with Viva voce**		**-**	**-**	**4**	**-**	**7**	**10**	**40**	**60**	**100**

Subject Code	Subject Name	Category	L	T	P	S	Credits	Inst. Hours	Marks		
									CIA	External	Total
23UPMBC1S01	**Microbial Quality Control and Testing**	**Skill Enhancement Course III**	**Y**	**-**	**-**	**-**	**2**	**4**	**25**	**75**	**100**

Course Objectives	
CO1	Explain various microbiological quality standards for food, water and air regulatory practices and policies.
CO2	Discuss collection, processing and preservation ofwater samples from industries in different areas.
CO3	Enumeration and isolation of microorganism from the water samples.
CO4	Enumeration and isolation of microorganism from the air samples.
CO5	Gain knowledge on sterility testing of different components in industries and quality control techniques.

UNIT	Details	No. of Hours	Course Objectives
I	Concepts of quality control techniques - quality assurance, Total Quality Management (TQM) Continuous Quality Improvement (CQI) Quality Assurance (QA) pre analytical and post analytical techniques, ATCC, MTCC, microbial based assay.	6	CO1
II	Waste water microbiology – types and sources of contamination, prevention of water borne diseases. Water management, water harvesting, water recycling. Characteristics of waste water from industries - Sugar factory, Pulp & Paper mill, Distillery, Textile, Engineering, Food Industry, Domestic waste. Waste water treatment plant types and quality control. Water pollution causes and remedies.	6	CO2
III	Microflora of water. Microbiological analysis of water sample. Microbiological analysis of water sample collection, drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests Control of microbes in water: Water borne pathogens, water borne diseases. Control of water borne pathogens- Precipitation, chemical disinfection, filtration, high temperature, UV light.	6	CO3
IV	Microflora of air - Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres. Collection of air samples and analysis. Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, isolation and Identification. Control Measures of	6	CO4

	Bioaerosols - UV light, HEPA filters, desiccation, Incineration.		
V	Quality control in food - Food X ray inspection, PPE Equipment, IoT sensors, preventive quality control and reality quality control. Quality control of pharma products. Quality assurance framework, assessment of pharmaceutical quality, determinants of pharmaceutical quality, practical approaches to quality assurance.	6	CO5
	Total	30	

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Apply knowledge in quality analysis techniques suitable for industries.	PO4, PO5, PO7, PO8
CO2	Perform water managements, water harvestingand treat sewage, water pollutions and remedies.	PO4, PO5, PO7, PO8
CO3	Detect portability of water. Test water quality.	PO4, PO5, PO7, PO8
CO4	Impart knowledge on bioaerosols, impact and prevention	PO4, PO5, PO7, PO8
CO5	Apply quality control techniques for food and pharma products	PO4, PO5, PO7, PO8

Text Books

1.	Aneja R.P., Mathur B.N., Chandan R.C. and Banerjee, A.K. (2002). Experiments in Microbiology.
2.	Adams M. R. and Moss M. O. (2006). Food Microbiology. (2^{nd} Edition). Royal Society of Chemistry.
3.	Dubey R.C. and Maheshwari D. K. (2010). Practical Microbiology. S. Chand.
4.	Cappuccimo, J. and Sherman, N. (2002). Microbiology: A Laboratory Manual, (6^{th} Edition). Pearson Education, Publication, New Delhi.
5.	Rosamund M. Baird., Norman A. (2019). Handbook of Microbiologicalquality control in Pharmaceuticals and Medical Devices. CRC Press.

References Books

1.	Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2^{nd} Edition). - Taylor &Francis.
2.	Sundararaj T. (2003). Microbiology Laboratory Manual. (2^{nd} Edition). Published by A. Sundararaj
3.	Hoges N. A., Denyer S P. and Baird R.M. (2003). Handbook of microbiological quality control. Microbial Quality Assurance in Pharmaceutcals, cosmetics &

	Toiletries. by Sally F. Bloomfield
4.	Amitava Mitra. Fundamentals of Quality control and Improvement. (3rd Edition). Wiley Publications
5.	David Roesti, Marcel Goverde (2019). Pharmaceutical Microbiological Quality Assurance and control: Practical guide for non- sterile Manufacturing. Wiley Publishers.
Web Resources	
1.	https://www.researchgate.net › publication › 320730681
2.	https://www.fssai.gov.in
3.	https://mofpi.nic.in/Schemes/implementation-haccp-iso-22000-iso-9000-ghp-gmp-etc
4.	https://www.who.int/news-room/fact-sheets/detail/food-safety
5.	https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

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Mapping with Programme Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14

CO1				M	L		S	S						
CO2				M	L		M	M						
CO3				S	L		S	S						
CO4				S	L		S	S						
CO5				S	L		M	M						

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