PERIYAR UNIVERSITY, SALEM

M.SC.,

MICROBIOLOGY

SYLLABUS

FROM THE ACADMIC

YEAR 2026-2027

Programme Outcomes (POs)

PO1 – Problem Solving Skill

Apply microbiological knowledge, analytical thinking, and scientific approaches to identify, analyze, and solve problems related to health, environment, industry, and research.

PO2–DecisionMakingSkills
Develop the ability to make appropriate scientific, technical, and professional decisions through critical evaluation of experimental data and laboratory findings.

PO3–EthicalValues
Demonstrate professional ethics, integrity, biosafety awareness, and social responsibility while handling biological materials, research activities, and community-related issues.

PO4–Communication Skill
Communicate scientific concepts, research findings, and technical information effectively through oral presentations, written reports, and interpersonal interactions.

PO5–IndividualandTeamLeadership Skill
Exhibit leadership qualities, independent learning abilities, and teamwork skills for successful execution of academic, research, and professional responsibilities.

PO6–Employability Skill
Acquire practical knowledge, technical competency, and professional skills required for employment in healthcare, pharmaceutical, industrial, food, and research sectors.

PO7–Entrepreneurial Skill
Develop entrepreneurial abilities and managerial skills to establish and manage microbiology-based enterprises and biotechnological ventures.

PO8–Contribution to Society
Apply microbiological knowledge for community welfare through promotion of public health, environmental sustainability, hygiene, and disease prevention.

PO9–Multicultural Competence
Demonstrate respect for cultural diversity, social inclusiveness, and collaborative professional practices in national and global scientific environments.

PO10–Moral and Ethical Awareness Reasoning
Recognize moral, ethical, and legal responsibilities in scientific practices and apply ethical reasoning in research, healthcare, and societal applications.

Programme Specific Outcomes (PSOs) PSO1 –

Placement

Gain theoretical knowledge and laboratory expertise necessary for employment in academic institutions, hospitals, diagnostic laboratories, pharmaceutical industries, food industries, and research organizations.

PSO2– Entrepreneur

Develop skills in innovation, laboratory management, and bio-business to become successful entrepreneurs in microbiology-related fields.

PSO3–Research and Development

Acquire competence in advanced microbiological techniques, research methodologies, and analytical skills for higher studies and research activities.

PSO4–Contribution to Business World

Apply microbiological and managerial knowledge in industrial production, quality control, biotechnology, healthcare, and commercial microbiology sectors.

PSO5–Contribution to Society

Utilize microbiological knowledge for improving public health, environmental protection, sanitation, food safety, and overall societal well-being.

Understand the importance of artificial intelligence in microbiology and allied applications.

Microbiology programme Structure, Coursework, Contact Hours, Credits and Maximum Internal and External Marks for the Student Admitted in 2026-2027 Onwards

Semester	Course group	Title of Course work	Contact Hr/Week	Credits	Int.Mark	Ext. Mark	Total Mark	Page Number
I	**Core I**:	General Microbiology and Microbial Diversity	6	6	25	75	100	17
	Core II:	Immunology and Immunotechnology	6	6	25	75	100	21
	Core III: Practical-**I**	General Microbiology and Microbial Diversity	6	4	40	60	100	24
	Core-IV: Practical -**II**	Immunology and Immunotechnology	6	4	40	60	100	28
	Elective –I	**Choice-1** Forensic Science **Choice-2** Human Physiology and Micro biome (Among the two choices **anyone** can be chosen by the student)	4	3	25	75	100	32 34
	Skill Enhancement Course I (SEC I)	Essentials of Laboratory Management and Biosafety	2	2	25	75	100	37
Total			**30**	**25**			**600**	

Semester	Course group	Title of Course work	Contact Hr/Week	Credits	Int.Mark	Ext. Mark	Total Mark	Page Number
II	**Core V**	Medical Microbiology	6	6	25	75	100	40
	Core VI	Food, Dairy and Probiotic Microbiology	6	6	25	75	100	44
	CORE VII Practical III-	Medical Microbiology	6	4	40	60	100	49
	CORE VIII Practical IV	Food, Dairy and Probiotic Microbiology	6	4	40	60	100	52
	Elective –II	**Choice-1** Bioinstrumentation and Biological Techniques. **Choice-2** Extremophiles (Among the two choices **anyone** can be chosen by the student)	3	3	25	75	100	56 59
	NME- I	**Choices** 1.Entrepreneurship in Microbiology 2.Health and Hygiene	2	2	25	75	100	62
	Compulsory Paper	**Human Rights**	1	1	25	75	100	-
	Internship	**Internship during summer vacation. The credits shall be awarded in Semester-III statement of marks	-	1	-	-	-	-
Total			**30**	**27**			**700**	

Semester	Course group	Title of Course work	Contact Hr/Week	Credits	Int.Mark	Ext. Mark	Total Mark	Page Number
III	**Core IX**	Soil, Agricultural and Environmental Microbiology	5	5	25	75	100	68
	Core X	Molecular Biology and Genetic Engineering	5	5	25	75	100	72
	Core XI	Fermentation Technology and Pharmaceutical Microbiology	5	5	25	75	100	75
	Core XII Practical -V	Soil, Agricultural and Environmental Microbiology	5	3	40	60	100	79
	Core XIII Practical -VI	Molecular Biology and Fermentation Technology	5	3	40	60	100	82
	Elective III	**Choice-1** Biosafety, Bioethics and IPR **Choice-2** AI Tools for Microbiology **Choice-3** Nanotechnology (Among the three choices **anyone** can be chosen by the student)	3	3	25	75	100	86 89 92
	NME-II	**Choices** 1..Biofertilizer and Biomanure Technology 2. Human Infectious Diseases and Diagnostics	2	2	25	75	100	94 97
Total			**30**	**26**			**700**	

Semester	Course group	Title of Course work	Contact Hr/Week	Credits	Int.Mark	Ext. Mark	Total Mark	Page Number
IV	**Core XIV**	Research Methodology and Biostatistics	6	6	25	75	100	100
	Elective IV	**Choice-1** Marine Microbiology **Choice-2** Microbial Quality Control and Testing (Among the two choices **anyone** can be chosen by the student)	4	3	25	75	100	103 108
	Project	**Project**: Project with Viva Voce	20	4	25	75	100	111
	Extension Activity	Extension Activity	-	1	-	-	-	-
Total			**30**	**14**			**300**	

M.Sc., Microbiology
Credit Distribution for PG Courses
First Year
Semester -I

Part	Course	Course Title	Credits	No. of Hours
	Core I	General Microbiology and Microbial Diversity	6	6
	Core II	Immunology and Immunotechnology	6	6
	Core III	Practical -I: General Microbiology and Microbial Diversity	4	6
	Core IV	Practical -II: Immunology and Immunotechnology	4	6
	Elective I	Forensic Science/ Human Physiology and Micro biome (Among the two choices anyone can be chosen by the student)	3	4
	Skill Enhancement Course I (SEC I)	Essentials of Laboratory Management and Biosafety	2	2
		Total	**25**	**30**

First Year
Semester-II

Part	Course	Course Title	Credits	No. of Hours
	Core V	Medical Microbiology	6	6
	Core VI	Food, Dairy and Probiotic Microbiology	6	6
	Core VII	Practical -III: Medical Microbiology	4	6
	Core VIII	Practical -IV: Food, Dairy and Probiotic Microbiology	4	6
	Elective II	Bioinstrumentation and Biological Techniques/ Extremophiles (Among the two choices anyone can be chosen by the student)	3	3
	NME I	1.Entrepreneurship in Microbiology 2.Health and Hygiene	2	2
		Human Rights Compulsory Paper	1	1
		Internship* *Internship during summer vacation. The credits shall be awarded in Semester-III statement of marks	1	-
		Total	**27**	**30**

Second Year
Semester-III

Part	Course	Course Title	Credits	No. of Hours
	Core IX	Soil, Agricultural and Environmental Microbiology	5	5
	Core X	Molecular Biology and Genetic Engineering	5	5
	Core XI	Fermentation Technology and Pharmaceutical Microbiology	5	5
	Core XII	Practical -V: Soil, Agricultural and Environmental Microbiology	3	5
	Core XIII	Practical -VI: Molecular Biology and Fermentation Technology	3	5
	Elective – III	Biosafety, Bioethics and IPR/ AI Tools for Microbiology/ Nanotechnology (Among the three choices anyone can be chosen by the student)	3	3
	NME-II	**Choices** 1..Biofertilizer and Biomanure Technology 2. Human Infectious Diseases and Diagnostics	2	2
		Total	**26**	**30**

Second Year
Semester-IV

Part	Course	Course Title	Credits	No. of Hours
	Core XIV	Research Methodology and Biostatistics	6	6
	Elective IV	Marine Microbiology/ Microbial Quality Control and Testing (Among the two choices **anyone** can be chosen by the student)	3	4
	Project	Project and Viva voce	4	20
	Extension Activity		1	-
		Total	**14**	**30**

Total 92 credits for PG courses

REGULATIONS

1. CONDITIONS FOR ADMISSION

A. ELIGIBILITY CONDITIONS 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 / Animal Science / Applied Animal Science and Animal Biotechnology / Biochemistry / Bioinformatics / Biology / Food Science& Nutrition/Nutrition and Dietetics/B.Sc. Medical Lab Technology / BSMS/BAMS/BUMS/BHMS / Chemistry with Botany / Zoology] as Allied Subjects of this University or an Examination of any other University accepted by the Syndicate as equivalent there to shall be eligible for admission to M.Sc. Degree Course in Microbiology.

Candidate shall be admitted to the examination only if he/she has taken the qualifying degree in Science / Medical subjects as mentioned after having completed the prescribed courses consisting of twelve years of study and has passed the qualifying examination.

B. ELIGIBILITY FOR THE AWARD OF DEGREE

A candidate shall be eligible for the award of the degree only if he / she has undergone the prescribed course of study in a college affiliated to the University for a period of not less than two academic years, passed the examination of all the four semesters prescribed earning 91credits(plus1creditsforHumanRights)and fulfilled such conditions as have been prescribed therefore.

2. DURATION OF THE COURSE

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

3. 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 the end of the second academic year, respectively.

4. SCHEME OF EXAMINATIONS

The scheme of examinations for different semesters shall be as follows:

THEORY:

Time – 3hrs. Maximum marks–75Marks

Part A .Answer **ALL** questions (a),(b),(c),(d) Multiple choice)	15Marks (15x1=15marks)
Part B (Answer any **TWO** questions out of FIVE)	10 Marks (2x5= 10 marks)
Part C(Answer **ALL** questions Either (or) type FIVE questions (one question from each unit)	50 Marks (5x10=50 marks)

Internal marks	25
External marks	75
Total marks	100

The following procedure will be followed for Internal Marks:

1. **Internal Marks- Theory Papers:**

- Best two tests out of 3

Test	10 marks
Attendance	5 marks
Seminar	5 marks
Assignment	5 marks
Total	**25 marks**

2. **Practical Internal 40 marks**

Practical Test Best2 out of 3	30 marks
Attendance	5 marks
Record	5 marks
Total	**40 arks**

3, External- Practical	Marks-60
Total	Marks -100

4, Project:- 100 Marks

Internal marks	**25**
External marks	**75**

Internship	**Commended /highly commended**

Break up details for attendance

Below 60%	No marks
60% to 75%	3 marks
76% to 90%	4 marks
91% to 100%	5 marks

5. IMPORTANT POINTS

1. The each practical examination should be conducted for 6hrs/day, 2 consecutive days. The fee for the practicals is double the amount of the normal 6 hours practicals (ie. If the practical fee is Rs. 210 for 6 hrs practical's, for these Microbiology students, the fee will be Rs. 420/- practical). Similarly, the practical examiners also should be paid with double the remuneration (i.e. Rs. 100/- practical)

2. Elective papers can be selected by the concerned College Departments based on the student's interest.

3. For EDC papers, students should choose the other department EDC papers.

4. For Internship Training Programme Fees should be decided.

6. REQUIREMENTSFORPROCEEDINGTOSUBSEQUENTSEMESTERS:

Candidates shall register their names for the First semester examination after the admission in the PG Courses. Candidates shall be permitted to proceed from the First Semester up to the Final Semester irrespective of their failure in any of the Semester Examination subject to the condition that the candidates should register for all the arrear subjects of earlier semesters along with current (subject) Semester subjects. Candidates shall be eligible to proceed to the subsequent semester, only if they earn sufficient attendance as prescribed therefore by the Syndicate from time to time. Provided in case of candidate earning less than 50% of attendance in any one of the semester due to any extraordinary circumstance such as medical grounds, such candidates who shall produce Medical Certificate issued by the Authorized Medical Attendant (AMA), duly certified by the Principal of the College, shall be permitted to proceed to the next semester and to complete the course of study. Such candidate shall have to repeat the missed semester by rejoining after completion of final semester of the course, after paying the fee for the break of study as prescribed by the University from time to time.

1. **PASSING MINIMUM**

a) There shall be no Passing Minimum for Internal.

b) For External Examination, Passing Minimum shall be of 50 %(Fifty Percentage) of the maximum marks prescribed for the paper.

c) In the aggregate (External, Internal) the passing minimum shall be of 50% for each Paper/Practical/Project and Viva-voce.

d) Grading shall be based on overall marks obtained (internal + external).

1. CLASSIFICATIONOFSUCCESSFULCANDIDATES:

Candidates who secured not less than 60% of aggregate marks (Internal + External) in the whole examination shall be declared to have passed the examination in the First Class. All other successful candidates shall be declared to have passed in Second Class. Candidates who obtain 75% of the marks in the aggregate (Internal +External) shall be deemed to have passed the examination in First Class with Distinction, provided they pass all the examinations (theory papers, practicals, project and viva-voce) prescribed for the course in the First appearance.

1. GRADING SYSTEM:

The term grading system indicates a Seven (7) Point Scale of evaluation of the performances of students in terms of marks obtained in the Internal and External Examination, grade points and letter grade.

SEVEN POINT SCALE (As per UGC notification1998)

GRADE	GRADE POINT	PERCENTAGEOF EQUIVALENT
'O'=Outstanding	5.50– 6.00	75– 100
'A'=Very Good	4.50– 5.49	65–74
'B'=Good	3.50– 4.49	55–64
'C'= Average	3.00– 3.49	50–54
„D'=Below Average	1.50– 2.99	35–49
'E'=Poor	0.50– 1.49	25–34
„F'= Fail	0.00– 0.49	0–24

RANKING

Candidates who pass all the examinations prescribed for the course in the first appearance itself alone are eligible for Ranking /Distinction. Provided in the case of candidates who pass all the examinations prescribed for the course with a break in the First Appearance due to the reasons as furnished in the Regulations under "Requirements for Proceeding to subsequent Semester" are only eligible for Classification.

APPEARANCE FOR IMPROVEMENT

Candidates who have passed in a theory paper / papers are allowed to appear again for theory paper / papers only once in order to improve his / her marks, by paying the fee prescribed from time to time. Such candidates are allowed to improve within a maximum period of 10 semesters counting from his / her first semester of his/her admission. If candidate improve his marks, then his improved marks will be taken into consideration for the award of Classification only. Such improved marks will not be counted for the award of Prizes / Medals, Rank and Distinction. If the candidate does not show improvement in the marks, his previous marks will be taken into consideration. Candidate will be allowed to improve marks in the Practical, Project, Viva-voce, Fieldwork.

SEMESTER-I
CORE-I
GENERAL MICROBIOLOGY AND MICROBIAL DIVERSITY

COURSE OBJECTIVES

COs	COURSE OBJECTIVES	KNOWLEDGE LEVEL
CO1	Understand the historical development, scope, principles and Applications of microbiology and microscopy.	**K1, K2**
CO2	Analyze microbial diversity, taxonomy and modern classification Systems used in microbiology.	**K3, K4**
CO3	Examine microbial cell structure, physiology, nutrition and growth characteristics.	**K4, K5**
CO4	Apply microbial cultivation, sterilization, staining and Antimicrobial susceptibility testing techniques in microbiology laboratories.	**K5, K6**
CO5	Comprehend emerging concept and advanced technologies in Modern microbiology and microbial research.	**K5, K6**
K1–Knowledge;K2–Understanding;K3–Practice;K4 –Analysis;K5– Evaluating ; K6–Creation		

UNIT-I

Foundations of Microbiology and Microbial Visualization

History, scope and development of microbiology. Principles and applications of microscopy. Types of microscopes: Light microscope, Bright field microscope, Dark field microscope, Phase contrast microscope, Fluorescence microscope, DIC/No marski microscope, Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Cryo-Electron Microscopy (Cryo-EM), Atomic Force Microscopy (AFM), Confocal Laser Scanning Microscopy (CLSM) and Super-resolution microscopy. Electron microscopy sample preparation. Micrometry: Stage and ocular micrometer and their applications.

UNIT-II

Microbial Diversity, Taxonomy and Systematic

Classification, nomenclature and taxonomy of microorganisms. Phenotypic, genotypic and phylogenetic approaches. Classical and modern classification systems including two-kingdom, five-kingdom and three-domain systems. Characteristics and significance of bacteria, archaea, actinomycetes, fungi, algae, protozoa, viruses and extremophiles. Bergey's classification, molecular phylogeny, bioinformatics, culture collections and microbial preservation techniques.

UNIT-III

Microbial Cell Structure, Function and Growth

Organization of prokaryotic and eukaryotic cells. Structure and functions of microbial cell components, appendages and survival structures. Quorum sensing, extracellular polymeric substances (EPS) and biofilm formation. Microbial nutrition, sporulation, growth kinetics and cultivation systems including batch, continuous and synchronous culture. Measurement of microbial growth and environmental factors influencing microbial growth.

UNIT-IV

Microbial Cultivation, Control and Preservation

Principles of sterilization, disinfection and sterility assurance. Physical and chemical methods of microbial control. Classification and applications of culture media. Aerobic and anaerobic cultivation techniques, pure culture methods and staining procedures. Enumeration techniques, antimicrobial agents, mechanisms of antimicrobial resistance and antimicrobial susceptibility testing (AST).

UNIT-V

Emerging Concepts in Microbiology

Micro biome science and uncultivable microorganisms. Culture-dependent and culture-independent approaches including metagenomics, Meta transcriptomics, pan genomics and epigenomics. Earth Micro biome and Sargasso Sea projects. Microbial phylogeography, micro fluidics, single-cell microbiology, culturomics and synthetic biology. Space microbiology, One Health approach, sustainable development goals (SDGs), microbial fuel cells, artificial intelligence applications in microbiology and digital microbiology.

Course Outcomes

Course Outcomes	On completion of this course, students will be able to	Programme Outcomes
CO1	Explain the principles, historical development and applications Of microbiology and microscopy.	PO1, PO2, PO6
CO2	Analyze microbial diversity, taxonomy and classification Systems using modern systematic approaches.	PO1, PO2, PO6
CO3	Describe microbial cell structure, physiology and growth Characteristics under different environmental conditions.	PO1, PO4, PO8
CO4	Apply microbial cultivation, sterilization, staining and Antimicrobial susceptibility testing techniques in laboratory practices.	PO1,PO5, PO6
CO5	Evaluate emerging concepts and advanced technologies in Modern microbiology and microbial research.	PO1, PO7, PO8, PO10

Text Books

1. BrockBiology of Microorganisms—MichaelT.Madigan,KellyS. Bender, DanielH. Buckley, W. Matthew Sattley and David A. Stahl. Pearson Education, 2021.
2. Prescott's Microbiology—JoanneM.Willey,Kathleen Sandman and Dorothy Wood. McGraw Hill Education, 2023.
3. Microbiology: An Introduction—Gerard J.Tortora, BerdellR. Funke and ChristineL. Case. Pearson Education, 2023.
4. Microbiology—Michael J. PelczarJr.,E.C.S. Chanand NoelR.Krieg.TataMcGraw Hill Education.
5. Fundamentals of Microbiology— Jeffrey C. Pommerville. Jones &Bartlett Learning.
6. MicrobialLife—JamesT.Staley,RobertGunsalus,StephenLoryandJeromeJ.Perry. Sinauer Associates.
7. General Microbiology — Roger Y. Stanier, John L. Ingraham, Mark L. Wheelis and Page R. Painter. Macmillan Education.
8. A Text book of Microbiology—R.C.Dubey and D.K.Maheshwari.S.Chand& Company Ltd.

Reference Books

1. Bergey's Manual of Systematic Bacteriology—William B. Whitman (Ed.).Springer Publications**.**
2. Microbiology: Principles and Explorations Jacquelyn G. Black. Wiley Publications.
3. Microbial Ecology: Fundamentals and Applications—Ronald M.Atlasand Richard Bartha. Benjamin Cummings.
4. Prescott'sPrinciplesofMicrobiology—JoanneM.WilleyandKathleenSandman. McGraw Hill Education.
5. Molecular Biology of the Cell—Bruce Albertsetal. Garland Science.
6. Principles of Virology— S.J. Flint, V.R. Racaniello, G.F. RallandA.M.Skalka. ASM Press.
7. Microbial Ecology—LarryL. Barton and Diana E.Northup. Wiley-Blackwell.
8. Manual of Clinical Microbiology—JamesH.Jorgensen etal.ASM Press.
9. Microbiology:ALaboratoryManual—JamesG.CappuccinoandNatalieSherman. Pearson Education.
10. Experiments in Microbiology, Plant Pathology and Biotechnology—K.R.Aneja. New Age International Publishers.

Web Resources

1. https://www.asm.org/
2. https://www.ncbi.nlm.nih.gov/
3. https://www.microbiologyresearch.org/
4. https://www.cdc.gov/
5. https://www.who.int/
6. https://www.nature.com/subjects/microbiology
7. https://nptel.ac.in/
8. https://swayam.gov.in/
9. https://microbiologyinfo.com/
10. https://www.sciencedirect.com/topics/immunology-and-microbiology

Mapping with Programme Outcomes

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

L-Low; M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-I
CORE -II
IMMUNOLOGY AND IMMUNO TECHNOLOGY

COURSE OBJECTIVES

COs	**COURSEOBJECTIVES**	**KNOWLEDGE LEVEL**
CO1	Understand the fundamental concepts of the immune system, Immune cells, organs and mechanisms of innate and adaptive immunity.	**K1, K2**
CO2	Gain knowledge of antigen–antibody interactions, immunological responses , hypersensitivity ,autoimmunity and transplantation immunology.	**K2, K3**
CO3	Analyze immune responses associated with infectious diseases, cancer, immuno deficiency and vaccine development.	**K3, K4**
CO4	Develop skills in immunological techniques and their applications In diagnosis, research and therapeutics.	**K4, K5**
CO5	Evaluate emerging trends in immunotechnology , immuno therapy, molecular immunology and artificial intelligence-driven applications.	**K5, K6**
K1–Knowledge;K2–Understanding;K3–Practice;K4– Analysis;K5–Evaluating ;K6 – Creation		

UNIT-I

Introduction to Immunology

History and scope of immunology. Cells and organs of the immune system. Hematopoiesis and lymphoid organs. Innate and adaptive immunity. Physical and chemical barriers. Phagocytosis, inflammation, complements system, cytokines and chemokines. Pattern recognition receptors (PRRs), Toll-like receptors and immune regulation.

UNIT-II

Antigens, Antibodies and Immune Responses

Properties and types of antigens. Immunogenicity and antigenicity. Structure, classes and functions of immunoglobulins. Antigen–antibody interactions. Major Histocompatibility Complex (MHC), antigen processing and presentation. Generation of antibody diversity. Humoral and cell-mediated immune responses.

UNIT-III

Immuno pathology and Immunity to Infectious Diseases

Hypersensitivity reactions (Type I–IV), autoimmune diseases, immunodeficiency disorders, immune tolerance, transplantation immunology and graft rejection. Tumour immunology and immune evasion mechanisms. Immunity against bacterial, viral, fungal and parasitic infections. Vaccine immunology and vaccination strategies. Types of vaccines. Development of vaccines and antibodies in plants.

UNIT-IV

Immunotechnology

Immunological assays: precipitation, agglutination, complement fixation test, ELISA, radioimmunoassay (RIA), Western blotting, immuno fluorescence and immunohisto chemistry. Flow cytometry and fluorescence activated cell sorting (FACS). Hybridoma technology and production of monoclonal antibodies. Molecular and diagnostic applications of immunological techniques.

UNIT-V

Advanced Immunology and Emerging Technologies

Immuno informatics and systems immunology. Immunomics: introduction and applications. Engineered vaccines and antigen engineering.Multi epitope vaccines and reverse vaccinology. Nanotechnology in immunology. Immunotherapy, CAR-T cell therapy, cytokine therapy and precision medicine. Artificial intelligence and machine learning in immunology: applications in vaccine design, epitope prediction, antibody engineering, immunodiagnostics, immune profiling and personalized immunotherapy. Future prospects in immunological research.

Course Outcomes

Course Outcomes	On completion of this course, students will be able to	Programme Outcomes
CO1	Explain the organization and functions of the immune system And mechanisms of innate and adaptive immunity.	PO1, PO3, PO4
CO2	Describe antigen–antibody interactions, immune responses and Immunological disorders.	PO1, PO3, PO4
CO3	Analyze immune responses associated with infectious diseases, Immunodeficiency, tumour immunity and vaccine development.	PO1,PO3, PO4, PO5
CO4	Perform and interpret immunological techniques used in Diagnosis, therapeutics and biomedical research.	PO1, PO3, PO4, PO5
CO5	Evaluate advanced immunotechnological applications, Immunotherapy and AI-driven approaches in modern immunology.	PO3,PO4, PO5

Text Books

1. Murphy,K.andWeaver,C.(2022).*Janeway'sImmunobiology*.10thEdition.Garl andScience.Abbas,A.K.,Lichtman,A.H.andPillai,S.(2024).*Cellular and Molecular Immunology*. 11th Edition. Elsevier.
2. Punt, J., Stran ford, S., Jones, P. and Owen, J. (2021). *KubyImmunology*.9th Edition. W.H. Freeman.
3. Delves,P.J.,Martin,S.J.,Burton,D.R.andRoitt,I.M.(2023).*Roitt'sEssential immunology*. 14th Edition. Wiley-Blackwell.
4. Male,D.,Brostoff,J.,Roth,D.B.andRoitt,I.(2021).*Immunology*.9thEdition.Elsevier
5. Peakman,M.andVergani,D.(2018).*BasicandClinicalImmunology*.2ndEdition. Churchill Livingstone.
6. Coico,R.andSunshine,G.(2015).*Immunology:AShortCourse*.7thEdition.Wiley-Blackwell.
7. Goldsby, R.A., Kindt, T. J., Osborne, B.A.and Kuby,J. (2003).*Kuby Immunology*. W.H. Freeman.

Reference Books

1. Parham,P.(2021).*TheImmuneSystem*.5thEdition.Garland Science.
2. Hay,F.C.andWestwood,O.M.R.(2002).*PracticalImmunology*.4thEdition.Wiley-Blackwell.
3.
4. Paul,W.E.(Ed.)(2013).*FundamentalImmunology*.7thEdition.LippincottWilliams& Wilkins.
5. Rich,R.R.(2019).*ClinicalImmunology:PrinciplesandPractice*.5thEdition.Elsevier.
6. Sompayrac,L.(2019).*HowtheImmuneSystemWorks*.6thEdition.Wiley-Blackwell.
7. Owen,J.A.,Punt,J.,Stranford,S.A.andJones,P.P.(2013).*KubyImmunology*.7th Edition. W. H. Freeman.
8. Abbas,A.K.,Lichtman,A.H.andPillai,S.(2023).*BasicImmunology:Functions and Disorders of the Immune System*. 7th Edition. Elsevier.
9. Roitt, .M.andDelves,P.J.(2023).*Roitt'sEssentialImmunology*.14thEdition.Wiley-Blackwell.

Web Resources

1. https://www.immunology.org
2. https://www.ncbi.nlm.nih.gov
3. https://www.nature.com/subjects/immunology
4. https://www.frontiersin.org/journals/immunology
5. https://www.who.int/health-topics/immunization
6. https://www.cdc.gov/vaccines
7. https://asm.org
8. https://www.sciencedirect.com/topics/immunology
9. https://www.nature.com/subjects/vaccines
10. https://www.ebi.ac.uk/training/online/courses/immunology/

Mapping with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
O1	S		M	S		S			S					
CO2	S		M	S		S			S					
CO3	S		M	S	S		S	M	S					
CO4	S		M	S	M	S	S	M	S					
CO5			S	S	M	S	S	M	S					

L-Low; M-Medium ;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-I
CORE PRACTICAL -I
GENERAL MICROBIOLOGY AND MICROBIAL DIVERSITY

COURSEOBJECTIVES

COs	COURSEOBJECTIVES	KNOWLEDGE LEVEL
CO1	Understand the basic microbiological laboratory practices, Microscopy techniques and microbial observation methods.	**K1, K2**
CO2	Apply sterilization,culturemedia preparation and pure culture Techniques used in microbiology laboratories.	**K3, K4**
CO3	Analyse microbial growth, enumeration methods and Environmental factors influencing microbial growth.	**K3, K4**
CO4	Demonstrate staining techniques and biochemical tests for Identification of microorganisms.	**K4, K6**
CO5	Comprehend microbial cultivation, anaerobic culture methods And antimicrobial susceptibility testing techniques.	**K1, K2**
K1–Knowledge;K2–Understanding;K3–Practice;K4 –Analysis;K5– Evaluating; K6–Creation		

PRACTICAL EXPERIMENTS

1. Introduction to microbiology laboratory instruments, equipment, laboratory safety practices and handling of glassware.
2. Cleaning, washing, sterilization and maintenance of microbiological laboratory glass wares.
3. Handling and operation of compound microscope.
4. Microscopic observation and identification of bacteria, fungi, algae and protozoa by wet mount preparation.
5. Measurement of microbial size using stage and ocular micrometers (Micrometry).
6. Determination of bacterial motility by hanging drop method and soft agar method.
7. Preparation and sterilization of microbiological media:
   a) Nutrient broth
   b) Nutrient agar
   c) Agar slants

8. Study of different types of culture media:
   a) Enriched media
   b) Selective media
   c) Differential media
   d) Enrichment media
9. Sterilization techniques using autoclave, hotairoven and membrane filtration method.
10. Pure culture techniques by streak plate spread plate and pour plate methods.
11. Enumeration of microorganisms by viable count and total count methods.
12. Determination of bacterial growth curve, growth rate and generation time by spectrophotometric/turbidimetric method.
13. Simple staining and Grams staining of bacteria.
14. Acid-fast staining and metachromatic granule staining.
15. Endospore staining, capsule staining and flagella staining.
16. Anaerobic cultivation of bacteria by anaerobic gas pack method (Demonstration).
17. Biochemical tests for identification of bacteria:
    a) Oxidase test
    b) Catalase test
    c) IMViC tests
    d) Carbohydrate fermentation test
18. Antibiotic sensitivity testing by Kirby–Bauer method and Stokes method.

COURSEOUTCOMES

Course Outcomes	**On completion of this course, students will be able to**	**Programme Outcomes**
CO1	Demonstrate basic microbiological laboratory practices, Microscopy techniques and microbial observation methods.	PO1, PO2, PO6
CO2	Apply sterilization procedures, media preparation and pure Culture techniques in microbiology laboratories.	PO1, PO3, PO6
CO3	Analyze microbial growth patterns and perform microbial Enumeration techniques.	PO1, PO4, PO6
CO4	Perform staining procedures and biochemical tests for Identification of microorganisms.	PO2, PO5, PO7
CO5	Demonstrate anaerobic cultivation and antimicrobial susceptibility testing methods used in microbiology laboratories.	PO3,PO6,PO10

TextBooks

1. Microbiology: A Laboratory Manual—Cappuccino, J.G. and Welsh, C.(2019). *Microbiology :A Laboratory Manual*(12thEdition).PearsonEducation.
2. Experiments in Microbiology, Plant Pathology and Biotechnology — Aneja, K. R. (2020). *Experiments in Microbiology, Plant Pathology and Biotechnology* (5th Edition). New Age International Publishers.
3. Practical Microbiology — Dubey, R. C. and Maheshwari, D. K. (2015). *Practical Microbiology*. S. Chand & Company Ltd.
4. LaboratoryExercisesinMicrobiology—Harley,J.P.(2016).*LaboratoryExercisesin Microbiology* (10th Edition). McGraw Hill Education.
5. Benson'sMicrobiologicalApplications:LaboratoryManualinGeneralMicrobiology — Brown, A. E. (2015). *Benson's Microbiological Applications: Laboratory Manual in General Microbiology* (13th Edition). McGraw Hill Education.
6. Microbiology—Pelczar,M.J.,Chan,E.C.S.andKrieg,N.R.(2010).*Microbiology*. Tata McGraw Hill Education.
7. Brock Biologyof Microorganisms — Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M. and Stahl, D. A. (2021). *Brock Biology of Microorganisms* (16th Edition). Pearson.
8. Foundations in Microbiology — Talaro, K. P. and Chess, B. (2018). *Foundations in Microbiology* (11th Edition). McGraw Hill Education.

Reference Books

1. Handbook of Microbiological Media — Atlas, R. M. (2010). *Handbook of Microbiological Media* (4th Edition). CRC Press.
2. GeneralMicrobiology—Stanier,R.Y.,Ingraham,J.L.,Wheelis,M.L.andPainter, P.R. (2005).*GeneralMicrobiology*(5th Edition). Macmillan.
3. FundamentalPrinciplesofBacteriology—Salle,A.J.(2011).*FundamentalPrinciples of Bacteriology*. Tata McGraw Hill.
4. Hand book of Media for Clinical Microbiology—Atlas,R.M.andSnyder,J.W. (2019). *Handbook of Media for Clinical Microbiology* (2nd Edition). CRC Press.
5. Manual of Clinical Microbiology — Jorgensen, J. H., Pfaller, M. A., Carroll, K. C., Funke,G.,Landry,M.L.,Richter,S.S.andWarnock,D.W.(2015).*ManualofClinical Microbiology* (11th Edition). ASM Press.
6. Prescott's Microbiology — Willey, J. M., Sherwood, L. M. and Woolverton, C. J. (2020). *Prescott's Microbiology* (11th Edition). McGraw Hill Education.

Web Resources.

1. https://asm.org/
2. https://microbiologyinfo.com/
3. https://www.ncbi.nlm.nih.gov/
4. https://nptel.ac.in/
5. https://swayam.gov.in/
6. http://vlab.amrita.edu/
7. https://www.jove.com/education/microbiology
8. https://www.britannica.com/science/microbiology
9. https://www.cdc.gov/
10. https://www.who.int/

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

L-Low; M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-I
CORE PRACTICAL-II
IMMUNOLOGY AND IMMUNO TECHNOLOGY

COURSE OBJECTIVES

COs	COURSEOBJECTIVES	KNOWLEDGE LEVEL
CO1	Develop practical skills in blood collection, hematological Investigations and immune cell identification.	**K1, K2**
CO2	Apply immuno hematological techniques for blood grouping, cell Separation and antibody titration.	**K3, K4**
CO3	Perform and interpret serological reactions including Agglutination and precipitation tests forimmuno diagnosis.	**K3, K4**
CO4	Demonstrate immuno electrophoretic and enzyme immunoassay Techniques used in clinical diagnosis and research.	**K4, K5**
CO5	Perform immunoglobulin purification and evaluate their Applications in immunology and biotechnology.	**K5, K6**
K1–Knowledge;K2–Understanding;K3–Practice;K4 –Analysis;K5– Evaluating; K6–Creation		

PRACTICAL EXPERIMENTS

1. Collection of human peripheral blood and separation of serum and plasma.
2. Determination of Total Blood Count (TBC/CBC) and Differential Leukocyte Count (DLC).
3. Determination of Erythrocyte Sedimentation Rate (ESR).
4. ABO blood grouping (forward and reverse grouping), Rh typing and cross-matching.
5. Identification of immune cells by Leishman stains and Giemsa staining.
6. Isolation of buffy coat and preparation of lymphocytes from peripheral blood by density gradient centrifugation.
7. Determination of viable and non-viable cells by Trypan blue dye exclusion method.
8. Antibody titration of human blood group antigens.
9. Agglutination reactions:
   a) Widal test
   b) Rheumatoid Factor (RF) test

c) Anti-streptolysin O (ASO)test

d) C-Reactive Protein (CRP) test

e) β-HCG test

f) TPHA test

10. Rapid Plasma Reagin (RPR)/Venereal Disease Research Laboratory (VDRL) test.
11. Ouchterlony double immunodiffusion test.
12. Single radial immuno diffusion (Mancini method) for quantification of immunoglobulins.
13. Counter-current immuno electrophoresis.
14. Rocketimmuno electrophoresis.
15. Enzyme Linked Immunosorbent Assay (ELISA) for detection of HBs Ag or HIV antibodies.

Course Outcomes

Course Outcomes	On completion of this course, students will be able to	Programme Outcomes
CO1	Perform blood collection, hematological investigations and Immune cell identification using analytical thinking and laboratory skills.	PO1,PO2, PO5
CO2	Apply immuno hematological techniques for blood grouping, Cell separation and antibody titration.	PO2, PO4, PO6
CO3	Perform and interpret serological tests and immuno diagnostic Reactions with bio safety awareness and professional ethics.	PO1, PO3, PO8, PO10
CO4	Demonstrate immuno electrophoretic and ELISA techniques for Diagnostic and research applications.	PO2, PO6, PO7
CO5	Purify immunoglobulins and evaluate their applications in Immunology, diagnostics and biotechnology.	PO6, PO7, PO8

Text Books

1. Hay,F.C.andWestwood,O.M.R.(2002).*PracticalImmunology*.4thEdition.Wiley-Blackwell.
2. Hudson, L.andHay,F.C.(1989).*PracticalImmunology*.3rdEdition.Blackwell Scientific Publications.
3. Turgeon,M.L.(2022).*ClinicalHematology:TheoryandProcedures*.7thEdition. Wolters Kluwer.
4. Abbas,A.K.,Lichtman,A.H.andPillai,S.(2024).*Cellular and Molecular Immunology*. 11th

Edition. Elsevier.

5. Murphy, K.andWeaver,C.(2022).*Janeway'sImmunobiology*.10thEdition.GarlandScience.
6. Punt,J.,Stranford, S.,Jones, P.andOwen,J. (2021). *KubyImmunology*.9th Edition. W.H.Freeman.
7. Peakman, M.andVergani,D.(2018).*BasicandClinicalImmunology*.ChurchillLivingstone.
8. Cheesbrough,M.(2006).*DistrictLaboratoryPracticeinTropicalCountries*. Cambridge University Press.

Reference Books

1. Delves,P.J.,Martin,S.J.,Burton,D.R.andRoitt,I.M.(2023).*Roitt'sEssential Immunology*. 14th Edition. Wiley-Blackwell.
2. Coico,R.andSunshine,G.(2015).*Immunology:AShortCourse*.7thEdition.Wiley-Blackwell.
3. Paul,W.E.(2013).*FundamentalImmunology*.7thEdition.LippincottWilliams&Wilkins.
4. Rich,R.R.(2019).*ClinicalImmunology:PrinciplesandPractice*.5thEdition.Elsevier.
5. Sompayrac,L.(2019). *HowtheImmuneSystemWorks*.6thEdition.Wiley-Blackwell.
6. Dacie,J.V.andLewis,S.M.(2017). *Practical Haematology*.12thEdition. Elsevier.
7. Tizard,I.R.(2018).*VeterinaryImmunology:AnIntroduction*.10thEdition.Elsevier.
8. Goldsby,R.A., Kindt,T. J., Osborne,B.A.andKuby,J. (2003).*KubyImmunology*. W.H.Freeman.

Web Resources

1. https://www.immunology.org
2. https://www.ncbi.nlm.nih.gov
3. https://asm.org
4. https://www.cdc.gov
5. https://www.who.int
6. https://www.frontiersin.org/journals/immunology
7. https://www.nature.com/subjects/immunology
8. https://www.sciencedirect.com/topics/immunology

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

L-Low; M-Medium; S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-I
ELECTIVE-I CHOICE-1
FORENSIC SCIENCE

COURSE OBJECTIVES

COs	**COURSE OBJECTIVES**	**KNOWLEDGE LEVEL**
CO1	Understand the Scope, Principles Applications of forensic science in criminal investigation.	**K1,K2**
CO2	Analyze the organizational setup and functioning of forensic science laboratories.	**K3,K4**
CO3	Examine and identify biological evidence collected from crime scenes.	**K3,K4**
CO4	Demonstrate extraction, profiling and analysis of DNA from biological samples using forensic techniques.	**K4,K6**
CO5	Comprehend the principles of forensics toxicology, prisons a medico-legal investigation	**K1,K2**
	K1–Knowledge; K2–Understanding; K3–Practice; K4–Analysis; K5–Synthesis; K6–Creation	

UNIT 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 off forensic science. Duties of a forensic scientist.

UNIT-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.

UNIT-III

Forensic serology - Definition, identification and examination of body fluids - Blood, semen, saliva, sweat and urine. Forensic examination and identification of hair and fiber.

UNIT-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.

UNIT-V

Forensic toxicology-Introduction and concept of forensic Toxicology. Medico legal postmortem and their examination. Poisons-Types of poisons and their mode of action.

Course Outcomes

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 set up 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. NandaB.B.andTewariR.K.(2001)ForensicScienceinIndia:AVisionfortheTwenty First Century. Select Publishers, New Delhi. ISBN- 10:819011352/ ISBN-13:9788190113526
2. James S. H. and Nordby, J. J. (2015) Forensic Science: An Introduction to Scientific and InvestigativeTechniques.(5th Edition).CRCPress.ISBN-10:9781439853832/ISBN- 13:978-1439853832

3. LiR. (2015)ForensicBiology. (2nd Edition). CRC Press, NewYork.ISBN-13:978-1-4398-8972-5.
4. Sharma B.R (2020) Forensic science in criminal investigation and trials. (6th Edition) Universal Press.
5. Richard Saferstein (2017).Criminalistics- an introduction to Forensic Science.(12th Edition).Pearson Press.

Reference books

1. NordbyJ.J.(2000).DeadReckoning.TheArtofForensicDetection-CRCPress,New York. ISBN:0-8493-8122-3.
2. SafersteinR.andHallA.B.(2020).ForensicScienceHandbook,Vol.I,(3rd Edition). CRC Press, New York. ISBN-10:1498720196.
3. Lincoln, P. J .and Thomson,J.(1998).(2nd Edition).Forensic DNA Profiling Protocols. Vol. 98.Humana Press. ISBN: 978-0-89603-443-3.
4. ValMcDermid (2014). Forensics.(2nd Edition).ISBN9780802125156.
5. Vincent J. DiMaio., Dominick DiMaio.(2001).Forensic Pathology(2nd Edition).CRCPress.

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/microbialforensic

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					

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-I
ELECTIVE-I CHOICE-2
HUMAN PHYSIOLOGY AND MICROBIOME

COURSE OBJECTIVES

COs	]COURSE OBJECTIVES	KNOWLEDGE LEVEL
CO1	Understand the fundamental organization and functions of human body systems relevant to microbiology and host health	K1,K2
CO2	Develop knowledge of the human micro biome, its composition, ecology, and host interactions	K2,K3
CO3	Analyze the role of micro biome in physiology, immunity, metabolism, and disease.	K2,K4
CO4	Apply modern methods for micro biome analysis, interpretation, and translational research	K5,
CO5	Evaluate recent advances and emerging applications of human physiology and micro biome research in human health and disease.	K4,K5
	K1–Knowledge;/Remember ;K2–Understanding;K3–Practice; K4–Analysis; K5–Evaluating ; K6–Creation	

UNIT I

Introduction to human physiology: scope, organization of the human body, homeostasis, feedback regulation, and physiological adaptation. Cardiovascular physiology: cardiac cycle, conduction system, ECG basics, blood pressure, and regulation of circulation. Digestive physiology: functions of the gastrointestinal tract, digestion, absorption, and regulation of gastrointestinal secretions.

UNIT-II

Endocrine physiology: major endocrine glands, hormones, mechanisms of action, and regulation of hormonal secretion. Renal physiology: nephron structure, urine formation, acid–base balance, and water–electrolyte regulation. Nervous system physiology: neuron structure, synaptic transmission, autonomic nervous system, and basic sensory and motor functions.

UNIT-III

Human micro biome: definition, and significance in human health. Micro biota of gut, oral cavity, skin, respiratory tract, urogenital tract, and neonatal micro biome acquisition. Factors shaping the micro biome: diet, age, geography, genetics, antibiotics, lifestyle, and environmental exposure. Methods for micro biome study: culture-based approaches, 16S rRNA gene analysis, and metabolomics.

UNIT-IV

Micro biome–gut–brain axis: Microbial signaling, neuroactive metabolites, and behavior-related implications. Micro biome in disease: dysbiosis in gastrointestinal disorders, autoimmune diseases, allergies, infections, cancer, and reproductive health.

UNIT-V

Micro biome engineering and synthetic biology: designer microbes, micro biome editing, and translational applications. Early-life micro biome personalized nutrition, one health connections, and future directions in micro biome research.

Course Outcomes

Course Outcomes	On completion of this course, students will be able to ;	
CO1	Explain the basic principles of human physiology, homeostasis, and organization of major body systems	PO1,PO3,PO4
CO2	Describe various systems functioning in human physiology in relation to human health.	PO1, PO3,PO4,
CO3	Understand Micro biota of human organs, and method used to study the micro biome	PO1, PO3,PO4, PO5
CO4	Analyze the role of micro biome in behavior, gastrointestinal disorders immunity, and cancer	PO1, PO3,PO4, PO5.
CO5	Evaluate recent advances and translational applications in human physiology and micro biome research.	PO3, PO4,PO5, PO8,PO9

Text Books

1. Hall, J. E. and Hall, M. E. (2025) Guyton and Hall Textbook of Medical Physiology. 15th Edition. Elsevier.
2 Tortora, G. J. and Derrickson, B. H. (2016) Principles of Anatomy and Physiology. 15th Edition. Wiley.
3. Douglas, A. E. (2018) Fundamentals of Micro biome Science: How Microbes Shape Animal Biology. Princeton University Press.
4. Bull, M. J. and Plummer, N. T. (2014) The Human Gut Micro biome in Health and Disease. Integrative Medicine.
5. Shehata, E., Parker, A., Suzuki, T., Swann, J. R., Suez, J., Kroon, P. A. and Day-Walsh, P. (2022) Micro biomes in Physiology: Insights into 21st-Century Global Medical Challenges. Experimental Physiology, 107, 257–264

Reference Books

1. Boron, W. F. and Boulpaep, E. L. (2022) Medical Physiology. 4th Edition. Elsevier.

2. Costanzo, L. S. (2022) Physiology. 7th Edition. Elsevier.

3. Widmaier, E. P., Raff, H. and Strang, K. T. (2019) Vander's Human Physiology: The Mechanisms of Body Function . 15th Edition. McGraw Hill.

4. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M. and Stahl, D. A. (2021) Brock Biology of Microorganisms. 16th Edition. Pearson.

5. Laudes, M.; Geisler, C.; Rohmann, N.; Bouwman, J.; Pischon, T.; Schlicht, K. Microbiota in Health and Disease—Potential Clinical Applications. Nutrients 2021, 13, 3866. https://doi.org/10.3390/nu13113866

Web resources

1. https://shop.elsevier.com/books/guyton-and-hall-textbook-of-medical-physiology/hall/978-0-443-11101-3

2. https://www.wiley.com/en-us/Principles+of+Anatomy+and+Physiology,+15th+Edition-p-x001105240

3. https://pmc.ncbi.nlm.nih.gov/articles/PMC9304168/

4. https://pmc.ncbi.nlm.nih.gov/articles/PMC4566439/

5. https://thsti.res.in/en/NewsDetails/194/book-human-microbiome-in-health-and-disease-edited-by-dr-bhabatosh-das

Mapping with ProgrammeOutcomes

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

L-Low; M-Medium; S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-I
SKILL ENHANCEMENT COURSE-I
ESSENTIALS OF LABORATORY MANAGEMENT AND BIO SAFETY

COURSE OBJECTIVES

COs	COURSE OBJECTIVES	KNOWLEDGE LEVEL
CO1	To utilize containment principles to ensure biosafety.	**K1,K2**
CO2	To enrich the student role and responsibilities of laboratory hazards and their control.	**K3,K4**
CO3	To know the importance of first aid technique for various common lab accidents.	**K3,K4**
CO4	To acquire knowledge of biosafety level, risk assessment and maintain proper hygiene in the laboratory.	**K4,K5**
CO5	To discuss the biosafety regulations and guidelines and implementation of safety programs.	**K5,K6**
	K1–Knowledge;/Remember ;K2–Understanding;K3–Practice; K4–Analysis; K5–Evaluating ; K6–Creation	

UNIT 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.

UNIT-II

Common hazards in laboratory: Chemical hazards- Safe handling of chemicals and gases, hazard labels and symbols. Material safety data sheet (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.

UNIT-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.

UNIT-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.

UNIT-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.

Course Outcomes

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. SateeshM.K.(2013).BioethicsandBiosafety,IKInternationalPvtLtd.ISBN:8190675702.
2. MuthurajM. and Usharani B. (2019). Biosafety in Microbiological Laboratories. (1sr Edition). Notion Press. ISBN 10: 1645878856
3. BiosafetyinMicrobiologicalandBiomedicalLaboratories-U.S.HealthDepartment andHumanServices. (2016).(5thEdition). Lulu.com.
4.Kanai.L. Mukherjee. (MedicalLaboratoryTechnology(4thEdition). CBS Publishers.
5. Ramakrishnan (2012).ManualofMedicalLaboratoryTechniques.JPbrothers.

1. Reference books

1.World Health Organization, Biosafety programme management.(2010).(4th Edition). WHO Publications.

2.RashidN.(2013).Manual of Laboratory Safety(Chemical, Radioactive, andBiosafety with Biocides) (1st Edition).

3.DayuanX.(2015).BiosafetyandRegulationforGeneticallyModifiedOrganisms, AlphaScienceInternationalLtd,ISBN-10: 1842657917

4.OcheiJ.Kolhatkar (2000).A.(Medica lLaboratory Science–Theory and Practice.ISBN;13:978-0074632239

5.LynneS.Garcia.ClinicalLaboratoryManagement (2nd Edition).ASMPress

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. ttps://www.cdc.gov/labs/pdf/CDC-BiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf
5. https://www.who.int/publications/i/item/9789240011311

Mapping with ProgrammeOutcomes

	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			

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-II
CORE-V
MEDICAL MICROBIOLOGY

COURSE OBJECTIVES

COs	COURSEOBJECTIVES	KNOWLEDGE LEVEL
CO1	Understand the principles of medical microbiology, host–microbe Interactions and clinical specimen processing.	**K1, K2**
CO2	Analyze the morphology,pathogenicity,laboratorydiagnosisand Antimicrobial resistance of medically important bacteria.	**K2, K4**
CO3	Examine medically important viruses, fungi and algae and their Role in infectious diseases.	**K3, K4**
CO4	Apply knowledge of medical parasitology and diagnostic Approaches for parasitic diseases.	**K4, K5**
CO5	Comprehend advanced molecular diagnostics, antimicrobial resistance, infection control and emerging technologies in medical microbiology.	**K5, K6**
K1–Knowledge;K2–Understanding;K3–Practice;K4 –Analysis;K5– Evaluating ; K6–Creation		

UNIT-I

Introduction to Medical Microbiology and Host–Microbe Interactions

Scope and significance of medical microbiology. Host–microbe interactions, normal micro biota, pathogenicity, virulence factors and transmission of infectious diseases. Immune responses to microbial infections. Biosafety and quality assurance in clinical microbiology laboratories. Collection, transport and processing of clinical specimens.

UNIT-II

Medical Bacteriology and Antimicrobial Resistance

Morphology, classification, pathogenesis, laboratory diagnosis, prevention and control of clinically important bacteria. Gram-positive cocci and bacilli: *Staphylococcus*, *Streptococcus*, *Bacillus*, *Mycobacterium*, *Pneumococci, Clostridium* and *Corynebacterium*. Gram-negative cocci and bacilli:

Neisseria, *Salmonella*, *Shigella*, *Vibrio* and *Pseudomonas*. *Helicobacter, Rickettsiae;Treponema* and anaerobic bacteria. Antimicrobial susceptibility testing and mechanisms of antimicrobial resistance.

UNIT-III
Medical Virology, Mycology and Phycology

Classification, structure, replication and laboratory diagnosis of medically important viruses including Herpes viruses, Hepatitis viruses, Papova and Parvo virus. Influenza, Polio, Rota, Rhabdo, Human Immuno deficiency Virus HIV, Dengue virus, Chikungunya virus, Severe Acute Respiratory Syndrome Coronavirus-2(SARS-CoV-2) and emerging and Re-emerging viruses. Cultivation of viruses -embryonated eggs, experimental animals and cell culture techniques. **Medical Mycology:** superficial, subcutaneous, cutaneous, systemic and opportunistic fungal infections and laboratory diagnosis of fungal diseases. **Medical Phycology**: medically important algae including *Prototheca*spp. and algal toxins of public health significance. Antiviral and antifungal agents

UNIT-IV
Medical Parasitology and Diagnostic Approaches

Protozoan and Helminthic parasites of medical importance. Epidemiology, life cycle, pathogenesis, clinical manifestations and laboratory diagnosis of *Entamoeba, Giardia, Plasmodium, Leishmania,Trypanosoma, Toxoplasma*, *Taenia*, *FasciolaAscaris*,*Ankylostoma* ,*Trichuris, Enterobius* and *Wuchereria*. Opportunistic parasitic infections in immuno compromised individuals. Serological and molecular diagnosis of parasitic infections. Anti protozoal drugs.

UNIT -V

Advanced Medical Microbiology and Emerging Technologies

Molecular diagnostics: PCR, real-time PCR, sequencing and metagenomics. Biosensors and rapid diagnostic methods. Artificial intelligence and machine learning in medical microbiology for disease diagnosis, antimicrobial resistance prediction, outbreak surveillance and digital microbiology. Antimicrobial resistance and multidrug-resistant pathogens. Hospital-acquired, Zoonotic and opportunistic infections and infection control practices. Vaccination strategies. Emerging and re-emerging infectious diseases. Micro biome and human health. Public health surveillance and future prospects in medical microbiology.

Course Outcomes

Course Outcomes	On completion of this course, students will be able to	Programme Outcomes
CO1	Explain host–microbe interactions, pathogenicity and clinical Specimen processing used in medical microbiology laboratories.	PO1, PO2, PO6
CO2	Analyze medically important bacteria and evaluate Antimicrobial susceptibility and resistance mechanisms.	PO1, PO3, PO6
CO3	Analyze viral, fungal and algal pathogens and interpret their Laboratory diagnosis and therapeutic approaches.	PO1, PO4, PO6, PO8
CO4	Apply diagnostic approaches for medically important protozoan And helminth parasites.	PO1, PO2, PO5, PO7
CO5	Evaluate advanced diagnostic technologies, infection control Strategies and emerging trends in medical microbiology.	PO3, PO6, PO10

Text Books

1. Ananthanarayan, R. and Paniker, C. K. J. (2022). *Textbook of Microbiology* (12th Edition). Universities Press.
2. Jawetz, E., Melnick, J. L. and Adelberg, E. A. (2019). *Medical Microbiology* (28th Edition). McGraw-Hill Education.
3. Murray, P. R., Rosenthal, K. S. and Pfaller, M. A. (2020). *Medical Microbiology* (9th Edition). Elsevier.
4. Forbes, B. A., Sahm, D. F. and Weissfeld, A. S. (2016). *Bailey and Scott's Diagnostic Microbiology* (14th Edition). Elsevier.
5. Brooks, G. F., Carroll, K. C., Butel, J. S., Morse, S. A. and Mietzner, T. A. (2019).*Jawetz, Melnick and Adelberg's Medical Microbiology* (28th Edition). McGraw-HillEducation.
6. Mahon, C. R., Lehman, D. C. and Manuselis, G. (2022). *Textbook of Diagnostic Microbiology* (7th Edition). Elsevier.
7. Chatterjee, K. D. (2019). *Parasitology: Protozoology and Helminthology* (14th Edition). CBS Publishers and Distributors.
8. Larone, D. H. (2018). *Medically Important Fungi: A Guide to Identification* (6th Edition). ASM Press.

Reference Books

1. Tille,P. (2021).*BaileyandScott'sDiagnosticMicrobiology*(15thEdition). Elsevier.
2. Ryan,K.J.andRay,C.G.(2022).*SherrisMedicalMicrobiology*(8thEdition). McGraw-Hill Education.
3. Carroll,K.C.,Pfaller,M.A.andLandry,M.L.(2019).*ManualofClinical Microbiology* (12th Edition). ASM Press.
4. Versalovic,J.,Carroll,K.C.,Funke,G.,Jorgensen,J.H.,Landry,M.L.andWarnock, D.W. (2016).*ManualofClinicalMicrobiology*(11th Edition).ASM Press.
5. Koneman,E.W., Allen,S.D.,Janda, W.M.,Schreckenberger,P. C. andWinn,W.C. (2017).*Koneman'sColorAtlasandTextbookofDiagnosticMicrobiology*(7thEdition). Lippincott Williams & Wilkins.
6. Garcia,L.S.(2016).*DiagnosticMedicalParasitology*(6thEdition).ASMPress.
7. Warren Levinson (2020). *Review of Medical Microbiology and Immunology* (16th Edition). McGraw-Hill Education.
8. Patrick R. Murray and Ken S. Rosenthal (2021). *Cases in Medical Microbiology and Infectious Diseases* (5th Edition). Elsevier.

Web Resources

1. https://www.cdc.gov/
2. https://www.who.int/
3. https://asm.org/
4. https://www.ncbi.nlm.nih.gov/
5. https://www.cdc.gov/labquality/
6. https://www.ecdc.europa.eu/
7. https://www.idsociety.org/
8. https://www.fda.gov/
9. https://nptel.ac.in/

Mapping with ProgrammeOutcomes

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-II
CORE-VI
FOOD DAIRY AND PROBIOTIC MICROBIOLOGY

COURSE OBJECTIVES

COs	COURSE OBJECTIVES	KNOWLEDGE LEVEL
CO1	To understand the classification, microbial ecology, and contamination dynamics of food matrices	**K1,K2**
CO2	To acquire knowledge on food preservation principles, thermal destruction kinetics, and advanced preservation technologies	**K3,K3**
CO3	To analyse food borne pathogens ,sanitation practices, and food safety regulations for public health protection .	**K3,K4**
CO4	To develop understanding on dairy microbiology ,fermented foods, and starter culture technologies	**K4,K5**
CO5	To evaluate probiotics, probiotics, functional foods, and their therapeutic applications inhuman health.	**K2,K5**
	K1–Knowledge;/Remember;K2–Understanding;K3–Practice; K4–Analysis; K5–Evaluating ; K6–Creation	

UNIT-I

Introduction to Food Microbiology: Scope and classification of foods based on stability (perishable, semi-perishable, stable) and function (organic, functional, GM foods).

Food as a Substrate: Nutritional parameters supporting the colonization of molds, yeasts, and bacteria.

Factors Influencing Growth: Intrinsic: pH, water activity (aw), redox potential and natural antimicrobial barriers. **Extrinsic:** Temperature, relative humidity, and gaseous atmosphere.

Contamination&Ecology: Primary sources of food contamination. Introduction to biofilm formation in food ecosystems and microbial stress adaptation.

UNIT-II

Thermal Destruction Kinetics: Concepts of heat in activation— Thermal Death Time (TDT), *D*, *Z*, and *F* values. **Preservation Methods: Physical:** High temperature (boiling, pasteurization, sterilization, canning) and Low temperature (chilling, freezing). Dehydration, drying, and irradiation.

Chemical & Additives: Class I (natural) and Class II (chemical) preservatives as per food regulations; antioxidants, buffering agents, and emulsifiers. **Biological & Advanced:** Biopreservation using Lactic Acid Bacteria (LAB) metabolites and bacteriocins.Basicconcepts of Hurdle Technology and Modified Atmosphere Packaging (MAP).

UNIT-III

Food borne Diseases: Differentiation between food infections and food intoxications. **Causative Agents:** Symptoms, food vectors, and control of key pathogens **Bacterial:** *Salmonella*, *Shigella*, *E. coli*, *Listeria monocytogenes*,*Staphylococcus aureus*, *Clostridium botulinum*, *Campylobacter jejuni*,*Vibrio cholerae*, *Vibrio parahaemolyticus*, *Bacillus cereus*, and *Yersinia enterocolitica*.**Non-Bacterial:** Mycotoxins, food borne viruses and protozoa, algal-borne poisonings (paralytic shellfish poisoning, ciguatera fish poisoning).

Epidemiology & Hygiene: Basic steps in food borne outbreak investigations. Food plant sanitation, sanitizers, and quality of water. **Food Laws and Agencies:** Core mandates of food regulatory systems: HACCP principles, FSSAI, FDA, BIS, and Codex Alimentarius.

UNIT-IV

Milk as a Matrix: Composition, physical-chemical properties, and natural antimicrobial systems (lactoperoxidase) of raw milk. **Dairy Spoilage & Processing:** Common micro flora, sources of contamination, and microbial defects (souring, curdling, gassiness, ropiness). Microbiology of pasteurization (HTST, UHT) and grading using dye reduction tests (MBRT, resazurin).**Starter Cultures & Fermentation:** Classification and roles of starter cultures. Biochemistry of milk fermentation, rennin coagulation, and cheese ripening. **Fermented Products:** Production of dairy matrices (yogurt, cheese, buttermilk, kefir, and koumiss) and traditional non-dairy foods (sauerkraut, pickles, kimchi).

UNIT-V

ProbioticPrinciples: Definition, history, taxonomy, safety evaluation, and legal status of probiotic strains.

Selection Criteria: Essential traits for probiotics—acid and bile tolerance, gastrointestinal survival, mucosal adhesion, and viability/stability during storage.**Prebiotics:** Definition, classification, dietary

sources, and their structural interaction with host gut microflora.**Functional Foods:** Concept of functional dairy products and synbiotics. Therapeutic applications and health benefits of probiotic/prebiotic-enriched foods (e.g., dahi, yogurt, Yakult, and soy-based probiotic alternatives).

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Explain food classifications ,contamination routes, and microbial ecology in food matrices	PO1, PO3,PO8
CO2	Apply food preservation principles and evaluate modern preservation technologies	PO4, PO5,PO8
CO3	Identify food borne pathogens and assess food safety regulations and sanitation practices.	PO1, PO6,PO13,
CO4	Describe dairy microbiology, starter cultures, and fermented food production processes.	PO1, PO2,PO7
CO5	Evaluate probiotics ,probiotics ,and functional foods for health and industrial applications	PO8, PO12,PO9

Text Books

1. Frazier, W.C.andWesthoff, D.C.(2008).*FoodMicrobiology*.TataMcGrawHillEducation,NewDelhi.

2. Adams, M.R.andMoss,M.O.(2016).*FoodMicrobiology*.RoyalSocietyofChemistry, Cambridge.

3.Robinson,R.K.(2002).*DairyMicrobiologyHandbook*.Wiley-InterscienceePublications.

4.Salminen,S.andvonWright,A.(2004).*LacticAcidBacteria:MicrobiologicalandFunctionalAspects*. CRC Press

5. K.VijayaRamesh (2021).*FoodMicrobiology*.MJPPublishers,Chennai.

Reference Books

1. Doyle,M.P.,Beuchat, L.R.andMontville,T.J.(2012).*FoodMicrobiology:Fundamentalsand Frontiers*.ASM Press
2. Hui,Y.H. (2006).*HandbookofFoodScience, Technology and Engineering*. CRC Press.

3.Desai,S.R.(2015).*FundamentalsofDairyMicrobiology*. Himalaya PublishingHouse, Mumbai.

4Banwart,G.J.(2012).*BasicFoodMicrobiology*.SpringerPublications..

5. FSSAI(LatestEdition).*ManualofMethodsofAnalysisofFoods*. FoodSafetyandStandardsAuthority ofIndia,NewDelhi.

Web Resources

1. https://www.fssai.gov.in/
2. https://www.who.int/health-topics/food-safety
3. https://asm.org/
4. https://nptel.ac.in/
5. https://www.coursera.org/search?query=food%20microbiology

Mapping with ProgrammeOutcomes

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-II
CORE PRACTICAL -III
MEDICAL MICROBIOLOGY

COURSE OBJECTIVES

COs	COURSEOBJECTIVES	KNOWLEDGE LEVEL
CO1	Develop practical skills in microscopic examination and Identification of clinically important pathogens.	**K1, K2**
CO2	Apply cultural, staining and biochemical techniques for isolation And identification of microorganisms.	**K3, K4**
CO3	Perform and interpret antimicrobial susceptibility testing and Parasitological diagnostic methods.	**K3, K4**
CO4	Demonstrate virological techniques including cell culture, Embryonated egg inoculation and serological assays.	**K4, K6**
CO5	Understand advanced diagnostic methods used in clinical Microbiology laboratories.	**K2, K4**
K1–Knowledge;K2–Understanding;K3–Practice;K4 –Analysis;K5– Evaluating; K6–Creation		

PRACTICAL EXPERIMENTS

A. MEDICAL BACTERIOLOGY

1. Direct microscopic examination of clinical specimens by wet mount and smear techniques for presumptive diagnosis of infectious agents.
2. Isolation and identification of clinically important bacterial pathogens from clinical specimens by cultural and biochemical characteristics:
   a) *Staphylococcus aureus*
   b) *Escherichia coli*
   c) *Klebsiella pneumoniae*
   d) *Pseudomonas aeruginosa*
   e) *Salmonella typhi*
   f) *Shigella dysenteriae*
   g) *Vibrio cholerae*
3. Antimicrobial susceptibility testing by Kirby–Bauer method including interpretation and quality control.
4. Determination of Minimum Inhibitory Concentration (MIC) by broth dilution method.

B. MEDICAL MYCOLOGY

5. Microscopic examination of fungi:
   a) KOH mount and KOH– DMSO mount for detection of fungal elements in clinical specimens
   b) Indian ink preparation for demonstration o*f Cryptococcus neoformans* capsule in CSF
   c) LPCB(Lacto phenol Cotton Blue)mount for microscopic examination of fungal morphology from culture
6. Isolation and identification of moulds by culture characteristics:
   a) *Aspergillus*
   b) *Penicillium*
   c) *Mucor*
   d) *Rhizopus*
   e) *Fusarium*
   f) *Trichophyton sp*
   g) *Microsporumsp*
   h) *Epidermophyton sp*

7. Germtubetest for identification of *Candida albicans*.
8. Slide culture technique for detailed study of fungal morphology.

C. MEDICAL PARASITOLOGY

9. Examination of stool samples for ova and cysts using saline and iodine wet mount methods.
10. Concentration techniques for parasitic examination:
    a) Formal ether concentration method
    b) Zinc sulphate flotationmethod
    c) Saturated salt flotation method
11. Blood smear examination for malarial parasites using Leishman staining.
12. Identification of common arthropods of medical importance - spotters of *Anopheles, Glossina, Phlebotomus, Aedes,* Ticks and mites.

D. MEDICAL VIROLOGY

13. Isolation and titration of Bacteriophage from environmental sources.
14. Demonstration of chick embryo inoculation and cell culture techniques.
15. Observation of viral cytopathic effects (CPE) and inclusion bodies.
16. Viral serological techniques:
    a. Haemagglutination inhibition (HAI)test
    b. ELISA (demonstration)
    c. Western blotting(demonstration)

Course Outcomes

Course Outcomes	On completion of this course, students will be able to	Programme Outcomes
CO1	Perform microscopic examination and identify clinically important pathogens.	PO1, PO2, PO5
CO2	Apply culture, staining and biochemical methods for microbial identification.	PO2, PO4, PO6
CO3	Perform and interpret antimicrobial susceptibility and parasitological tests.	PO1,PO2, PO3, PO4, PO8
CO4	Demonstrate virological diagnostic techniques including CPE, Embryonated egg and serology.	PO2, PO6, PO7, PO8
CO5	Understand advanced diagnostic tools in medical microbiology.	PO2, PO6, PO7, PO8

Text Books

1. Prescott, L.M., Harley, J.P.andKlein, D.A.(2020).*Microbiology*.McGraw-Hill.
2. Cheesbrough, M.(2006).*DistrictLaboratoryPracticeinTropicalCountries*. Cambridge University Press.
3. Collee, J.G., Fraser, A.G., Marmion, B.P.andSimmons, A.(2016).*Mackie& McCartney Practical Medical Microbiology*. Elsevier.
4. Ananthanarayan, R.and Paniker, C.K.J.(2021).*Text book of Microbiology*. Universities Press.
5. Bailey Scott's Diagnostic Microbiology (2022). Elsevier.
6. Jawetz, Melnick&Adelberg'sMedicalMicrobiology (2020). McGraw-Hill.

Reference Books

1. Koneman, E.W.etal.(2017).*DiagnosticMicrobiology*.LippincottWilliams&Wilkins.
2. Forbes, B.A. et al.(2016).*Diagnostic Microbiology*. Mosby.
3. Tille,P.(2018).*Bailey&Scott'sDiagnosticMicrobiology*.Elsevier.
4. Ryan, K.J.andRay,C.G.(2020). *Sherris Medical Microbiology*. McGraw-Hill.
5. Larone, D. H.(2018).*MedicallyImportantFungi*. ASMPress.

Website Resources

1. https://www.cdc.gov
2. https://www.who.int
3. https://www.ncbi.nlm.nih.gov
4. https://asm.org
5. https://www.sciencedirect.com
6. https://www.nature.com/subjects/microbiology
7. https://www.frontiersin.org/journals/microbiology
8. https://www.microbiologyinfo.com

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-II
CORE PRACTICAL-IV
FOOD DAIRY AND PROBIOTIC MICROBIOLOGY

COURSEOBJECTIVES

COs	**COURSEOBJECTIVES**	**KNOWLEDGE LEVEL**
CO1	Develop practical skills in the isolation, enumeration and Characterization of food spoilage microorganisms.	**K1, K2**
CO2	Apply microbiological techniques in food preservation and Quality assessment.	**K3, K4**
CO3	Identify food borne pathogens and evaluate antimicrobial Resistance patterns using standard microbiological methods.	**K3, K4**
CO4	Perform microbiological analysis and quality grading of milk and fermented dairy products.	**K4, K6**
CO5	Prepare and evaluate probiotic fermented foods and analyzetheir Functional properties.	**K1, K2**
K1–Knowledge;K2–Understanding;K3–Practice;K4 –Analysis;K5– Evaluating ; K6–Creation		

PRACTICAL EXPERIMENTS

1. Microbiological examination and isolation of spoilage bacteria, yeasts and molds from spoiled vegetables, fruits and bread.
2. Determination of total microbial load from high-fat or low-moisture foods and isolation of fungi from spoiled nuts and kernels.

3. Alkaline Phosphatase Test for determination of pasteurization efficiency in milk.
4. Production and extraction of bacteriocins by Lactic Acid Bacteria (LAB) for bio preservation.
5. Estimation of microbial load in processed and preserved foods such asfruitpulp, carbonated beverages and ice creams using Total Plate Count (TPC) method.
6. Isolation of food borne bacterial pathogens from contaminated food samples using selective and differential media.
7. Determination of antibiotic resistance profiles of food borne pathogens using Kirby–Bauer disk diffusion method.
8. Rapid platform testing and grading of raw milk samples using Methylene Blue Reduction Test (MBRT) and Resazurin test.
9. Enumeration of milk micro flora using Standard Plate Count (SPC)and Breed's Direct Microscopic Count.
10. Biochemical characterization and differentiation of dairy micro flora using Litmus Milk Test.
11. Bench-scalepreparationofprobioticfermentedmilkproductssuchasdahi, yogurt, lassi and whey drink, followed by evaluation of probiotic survivability, prebiotic growth stimulation and antimicrobial activity against target indicators.

Course Outcomes

Course Outcomes	On completion of this course, students will be able to	Programme Outcomes
CO1	Isolate and characterize spoilage micro organisms from various food matrices using analytical thinking and collaborative team efforts.	PO1,PO2, PO5
CO2	Apply microbiological techniques for food preservation, quality Assessment and generate standard technical data reports.	PO2, PO4, PO6
CO3	Identify food borne pathogens and evaluate antimicrobial resistance profiles securely while enforcing biosafety awareness And public hygiene values.	PO1, PO3, PO8, PO10
CO4	Perform professional microbiological examinations, platform Testing and quality grading of raw milk and dairy commodities.	PO2, PO6, PO7

CO5	Formulate bench-scale probiotic functional foods and critique their active viability ,bio-preservative strength and industrial Enterprise value.	PO6,PO7, PO8

Text Books

1. Harrigan,W.F.(1998).*LaboratoryMethodsinFoodandDairyMicrobiology*.Academic Press.
2. Garg,N.,Garg,K.L.,andMukerji,K.G.(2010).*LaboratoryManualofFoodMicrobiology*. I.K. International Publishing House.
3. Salminen,S.,vonWright,A.,andOuwehand,A.(2011).*LacticAcidBacteria:Microbiological and Functional Aspects*. CRC Press.
4. Aneja,K.R.(2018).*ExperimentsinMicrobiology,PlantPathologyandBiotechnology*. New Age International.
5. Goldman,E.,andGreen,L.H.(2015).*PracticalHandbookofMicrobiology*.CRCPress.

Reference Books

1. FSSAI(LatestEdition).*ManualofMethodsofAnalysisofFoods:FoodMicrobiology*. Food Safety and Standards Authority of India, New Delhi.
2. Weisburg,S.(2022).*StandardMethodsfortheExaminationofDairyProducts*.American Public Health Association.
3. Ray, B., and Bhunia,A.(2013).*Fundamental FoodMicrobiology*.CRCPress.
4. Gunasekaran, P. (2012). *Laboratory Manual in Microbiology*. New Age International Publishers.
5. Tamime, A.Y.,and Robinson,R.K.(2007).*Yoghurt: cienceand Technology*. Wood head Publishing Ltd.

Web Recourses

1. https://www.scribd.com/document/612913942/MBRT-of-Millk
2. https://fssai.gov.in/cms/manuals-of-methods-of-analysis-for-various-food-products.php
3. https://fssai.gov.in/upload/uploadfiles/files/Microbiological_Testing_Foods_Draft_Manual_06_09_2016.pdf
4. https://www.fssai.gov.in/upload/uploadfiles/files/Manual_Fruits_Veg_25_05_2016(1) pdf
5. https://asm.org/protocols/kirby-bauer-disk-diffusion-susceptibility-test-pro

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-II
ELECTIVE—II CHOICE-1
BIOINSTRUMENTATION AND BIOLOGICAL TECHNIQUES

COURSE OBJECTIVES

COs	COURSE OBJECTIVES	KNOWLEDGE LEVEL
CO 1	Provide knowledge on basic laboratory instruments, preparation of solutions and maintenance of controlled laboratory conditions.	K1,K2
CO 2	Explain the principles and applications of centrifugation and chromatographic techniques used in biological analysis	K3,K4
CO 3	Develop understanding of electrophoretic separation methods and blotting techniques for biomolecular studies.	K3,K4
CO 4	Introduce spectroscopic, biophysical and imaging techniques employed in analysis of biomolecules and living cells.	K4,K6
CO 5	Familiarize students with radio isotopic techniques, detection systems and safety procedures in biological research.	K1,K2
	K1–Knowledge; K2–Understanding; K3–Practice; K4–Analysis; K5–Synthesis; K6–Creation	

UNIT -I Buffers, molars and normal solutions, pH meter, pH electrodes –calomel and glass electrodes. Incubator, water bath shaker, laminar airflow. Lyophilizer, Flow cytometry.

UNIT-II. Centrifugation and chromatography:

Centrifugation-Basicprinciplesofsedimentation,typesofcentrifugesand rotors. Preparative ultra-centrifugation differential and density gradient.
ChromatographyPrinciples,definitions&Applications;Rfvalue.Typesof chromatography: Methods based on polarity (Partition chromatography, adsorption chromatography,TLC,HPTLC,gasliquidchromatography,and reverse phase liquid chromatography); Methods based on partition (Gel filtration and Affinity chromatography). HPLC, Nano-LC, FPLC and Ion-exchange chromatography.

UNIT-III Electrophoresis and its applications:
Electrophoresis: General principles - moving boundary electrophoresis -electrophoretic mobility – supportive materials – electro endosmosis – types (horizontal, vertical and two dimension alelectrophoresis)- 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.

UNIT-IV Spectroscopic and Biophysical techniques: Principle of spectroscopy, absorption of light by molecules and electromagnetic spectrum. Instrumentation, principle and application of UV- visible spectroscopy, Raman, FTIR spectroscopy, spectrofluorimetry, Atomic Absorption Spectrophotometry, Flame photometry, Emission spectroscopy, NMR, ESR and GC-MS. Detection of molecules in living cells - FISH and GISH. Biophysical analysis of biomolecules using UV-Visible spectroscopy.

UNIT-V

Radio isotopic 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.

Course Outcomes

Course Outcomes		
Course Outcomes	On completion of this course, students will;	
CO1	Explain the principles and applications of common laboratory instruments, buffer systems and pH measurement techniques	PO4,PO6,PO7, PO8, P11
CO2	Demonstrate knowledge of centrifugation and chromatographic methods for separation and purification of biological molecules.	PO4,PO6,PO7, PO8, P11
CO3	Describe electrophoretic and blotting techniques used in molecular and clinical biology.	PO4,PO6,PO7, PO8, P11
CO4	Interpret the principles and applications of spectroscopic and biophysical techniques in biomolecular analysis	PO4, PO6,PO7, PO8,P11
CO5	Understand radio isotopic methods, detection of radioactivity and their applications in biological sciences with appropriate safety measures.	PO4,PO6,PO7, PO8, P11

Text Books

1. SharmaB.K.(2014).InstrumentalMethodofChemicalAnalysis.KrishnaPrakashan Media(P)Ltd.

2. ChatwalG.RandAnandS.K.(2014.)InstrumentalMethodsofChemicalAnalysis. Himalaya Publishing House.

3. MitchellG.H.(2017).GelElectrophoresis:Types,ApplicationsandResearch.Nova Science Publishers Inc.

4.HolmeD.PeckH.(1998).AnalyticalBiochemistry.(3rdEdition).PrenticeHall

5.JayaramanJ.(2011).LaboratoryManualinBiochemistry.(2ndEdition).WileyEastrn Ltd., NewDelhi.

References Books

1. PaviaD.L. (2012)Spectroscopy(4thEdition). Cengage.

2. SkoogA.andWestM.(2014).PrinciplesofInstrumentalAnalysis.(14thEdition). W.B.SaundersCo.,Philadephia.

3. MillerJ.M.(2007).Chromatography:ConceptsandContrasts(2ndEdition)Wiley-Blackwell.

4.GurumaniN.(2006).ResearchMethodologyforBiologicalSciences.(1stEdition) 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.

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			

L-Low; M-Medium; S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-II
ELECTIVE—II CHOICE-2
EXTREMOPHILES

EXTREMOPHILES: BIOLOGY AND ADAPTATION IN EXTREME ENVIRONMENTS

COURSE OBJECTIVES

COs	COURSE OBJECTIVES	KNOWLEDGE LEVEL
CO1	Understand the diversity, distribution, and ecological significance of extremophiles inhabiting a wide range of extreme environments.	K1,K2
CO2	Classify and characterize major groups of extremophiles based on their environmental adaptations and physiological features.	K2,K3,K4
CO3	Explain the cellular, molecular, genetic and metabolic mechanisms that enable extremophiles to survive and thrive under extreme conditions.	K3,K4
CO4	Evaluatethe industrial, environmental, agricultural,medical, and biotechnological applications of extremophiles and their biomolecules.	K4,K5
CO5	Examine the role of extremophiles in astrobiology, origin-of-life studies and future scientific innovations, including their potential for space exploration and sustainable technologies	K4,K5
	K1–Knowledge; K2–Understanding; K3–Practice; K4–Analysis; K5–Synthesis; K6–Creation	

Unit I– Introduction to Extremophiles

Definition and concept of extremophiles and extremotolerant microorganisms. Characteristics of extremophiles. History and discovery of extremophiles. Major extreme environments: hot springs, glaciers, saline habitats, acidic and alkaline environments, deep sea, deserts, and radioactive regions. Ecological and evolutionary significance of extremophiles.

Unit II–Types of Extremophiles

Thermophiles and hyperthermophiles: characteristics, habitats, and applications. Psychrophiles: cold adaptations and examples. Halophiles: salt tolerance and osmoregulation. Acidophiles and alkaliphiles: pH adaptation mechanisms. Barophiles and xerophiles: adaptations to pressure and dryness. Methanogens and radio resistant microorganisms: characteristics and significance.

Unit III–Physiology and Molecular Adaptations of Extremophiles

Cell membrane and cell wall adaptations. Protein and enzyme adaptations under extreme conditions. Stress response mechanisms including heat shock, cold shock, and DNA repair systems. Genetic and molecular adaptations. Metabolic pathways and energy generation in extreme environments.

Unit IV– Applications of Extremophiles

Industrial applications of extremozymes in detergents, textiles, food, and paper industries. Biotechnology applications including PCR and bioactive compound production. Environmental applications in bioremediation and wastewater treatment. Agricultural and medical applications. Bioenergy production and nanotechnology applications.

Unit V– Extremophiles and Astrobiology

Role of extremophiles in understanding the origin of life. Extremophiles as models for extraterrestrial life. Survival under space conditions. Recent advances in extremophile research including genomics and synthetic biology. Future prospects, challenges, and commercial applications.

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Explain concepts, diversity, and significance of extremophiles	PO1,PO2,PO6, PO10,PO12
CO2	Classify extremophiles and describe adaptation mechanisms	PO1, PO2,PO3, PO6,PO10
CO3	Analyze molecular and physiological adaptations	PO1, PO2,PO3, PO5.PO10
CO4	Evaluate applications of extremophiles in various sectors	PO1, PO2,PO3, PO4,PO12
CO5	Assess future prospects and astrobiological significance	PO1, PO2,PO5, PO6,PO7

Text Books

1. Willey, Joanne M., Sherwood, Linda M., & Woolverton, Christopher J. (2020). **Prescott's Microbiology** (11th Edition). New York: McGraw-Hill Education. ISBN: 978-1260258998.
2. White, David, Drummond, James, & Fuqua, Clay (2011). **The Physiology and Biochemistry of Prokaryotes** (4th Edition). New York: Oxford University Press. ISBN: 978-0195393040.
3.Cavicchioli, Ricardo (Ed.) (2007). **Archaea: Molecular and Cellular Biology**. Washington, DC: American Society for Microbiology Press. ISBN: 978-1555813567.
4. Catling, David C. (2013). **Astrobiology: A Very Short Introduction**. Oxford, UK: Oxford University Press. ISBN: 978-0199586455.
5. Dubey, D.P. & Maheshwari, D.K. (2005). **Microbial Diversity: Exploration and Bioprospecting**. New Delhi: Narosa Publishing House. ISBN: 978-8173196478

Reference Books

1. Wharton, David A. (2002). **Life at the Limits: Organisms in Extreme Environments**. Cambridge, UK: Cambridge University Press. ISBN: 978-0521782128.

2. Horikoshi, Koki & Grant, William D. (Eds.) (1998). **Extremophiles: Microbial Life in Extreme Environments**. New York: Wiley-Liss. ISBN: 978-0471186083.

3. Robb, Frank T., Antranikian, Garabed, Grogan, Dennis W., & Oren, Aharon (Eds.) (2008). **Thermophiles: Biology and Technology at High Temperatures**. Boca Raton, Florida: CRC Press. ISBN: 978-0849390784.

4. Maier, Raina M., Pepper, Ian L., & Gerba, Charles P. (2015). **Environmental Microbiology** (3rd Edition). Amsterdam: Academic Press. ISBN: 978-0123946263.

5. Madigan, Michael T., Bender, Kelly S., Buckley, Daniel H., Sattley, W. Matthew, & Stahl, David A. (2021). **Brock Biology of Microorganisms** (16th Edition). New York: Pearson Education. ISBN: 978-0134874401.

Web resources

1. https://study.com/academy/lesson/extremophiles-definition-examples.html
2. https://www.mooc-list.com/course/extremes-life-microbes-and-theirdiversity-edx
3. https://www.coursera.org/learn/life-on-other-planets
4. http://hdl.handle.net/10754/575661

5 Cavicchioli,R.,Amils,R.,Wagner,D.,McGenity,T.(2011).Lifeandapplicationsof extremophiles. Environmental Microbiology. 10.1111/j.1462- 2920.2011.02512.x

Mapping with ProgrammeOutcomes

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-II
NON MAJOR ELECTIVE—I CHOICE-1
ENTREPRENEURSHIP IN BIOBUSINESS

COURSE OBJECTIVES

COs	Course Objectives	Knowledge Level
CO 1	Understanding the Entrepreneurial spirit and resourcefulness	**K1, K2**
CO2	Discovering business ideas and their implementation	**K1, K2, K3**
CO3	Analyse the entrepreneurship opportunity in Agricultural technology	**K3, K4**
CO4	Analyse the entrepreneurship opportunity in Industrial Biotechnology	**K3, K4, K5**
CO5	Role of Information Technology and Government schemes for Entrepreneurship	**K4, K6**
	K1–Knowledge; K2–Understanding; K3–Practice; K4–Analysis; K5–Evaluating; K6–Creation	

UNIT-I INTRODUCTION TO ENTREPRENEURSHIP AND STARTUPS

Introduction to bio-business, SWOT analysis of bio-business, Traits of an entrepreneur, Development of Entrepreneurship, Stages in entrepreneurial process, Government schemes and funding, Small scale industries - Definition, characteristics, need and rationale, Barriers to entrepreneurship

UNIT-II BUSINESS IDEAS AND THEIR IMPLEMENTATION

Discovering ideas, Business Plan, Business Ethics, Components of an Effective Business Model-Market Analysis -Identifying the target market -Competition evaluation -Strategy Development, Collaborations and Partnerships, Marketing-4 P's of Marketing-product, price, place and promotion. Accounting, Risk analysis.

UNIT-III ENTREPRENEURSHIP OPPORTUNITY IN AGRICULTURALTECHNOLOGY

Business opportunity, Lab to market strategies, schemes, challenges and scope. Case study on Plant cell and tissue culture technique, Polyhouse culture, nutraceuticals, value added herbal products. Bioethanol production using agricultural waste, algal source. Integration of system biology for agricultural applications.Method of manufacture of dairy products -Ice-cream, Cheese, Paneer, Yoghurt, Integrated compost production - microbe enriched compost, Bio Fertilizers, Bio pesticide/ insecticide production,Agriculture waste valorisation, Mushroom(Agaricus and Oyster) and products from higher fungi (Ganoderma lucidum), Biosensor development in agri management.

UNIT-IV ENTREPRENEURSHIP OPPORTUNITY IN INDUSTRIAL BIOTECHNOLOGY

Business opportunity, Essential requirement, Lab to market strategies, schemes, challenges, and scope. Pollution monitoring and Bioremediation for Industrial pollutants.BioPlastics, Industrial Enzymes, Single cell protein- Choice of Microorganisms for SCP production, Commercial production of SCP. Stem cell production, stem cell bank, production of monoclonal/polyclonal antibodies, secondary metabolite production – antibiotics, probiotic and prebiotics.

UNIT-V INFORMATION TECHNOLOGY AND GOVERNMENT SCHEMES TO BIO ENTREPRENEURSHIP

Information technology in Bio business, Assessment, development and upgradation of Technology,Technology Transfer, Quality Control, Regulatory compliances and procedures (ISO,GMP) , Building Biotech business challenges in Indian context, biotech partners (BIRAC, DBT, Incubation centers, operational biotech parks in India,Funding agencies etc). Indian Company act for Biobusiness, Successful start-ups-case study.

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Will understand the Entrepreneurial spirit in Bio business	PO1, PO2, PO6,PO7, PO10,
CO2	How to analyze business ideas and their implementation	PO1, PO2,PO4, PO6,PO7, PO10
CO3	To analyses the entrepreneurship opportunity in Agricultural technology	PO1, PO2, PO3, PO6, PO7, PO8, PO10
CO4	To analyses the entrepreneurship opportunity in Industrial Biotechnology	PO1, PO2, PO3, PO6, PO7, PO8, PO10
CO5	To role of Information Technology and Government schemes for Entrepreneurship	PO1, PO2, PO3, PO9, PO10

Text Books

1. Steve. B., and Bob D. (2012). *The Startup Owner's Manual: The Step by- Step Guide for Building a Great Company*. K & S Ranch ISBN – 978-0984999392.
2. Shimasaki C. (2014). *Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies*- Academic Press. ISBN: 978-0-12-404730-3
3. Stanbury P. F. and Whitekar. A. *Principles of Fermentation Technology*, (3rd Edition). Butterworth-Heinemann. ISBN 10: 0080999530
4. Anil Kumar (2020). *Small Business and Entrepreneurship*, Willey Distributions, Dream Tech Press.
5. Crueger, W, and Crueger. A. (2017). *Biotechnology: A Text Book of Industrial Microbiology*. (2nd Edition). Medtech. ISBN-10 : 9385998633

Reference books

1."Building Backwards to Biotech *The power of Entrepreneurship to drive cutting edge science to Market*, Stephanie A.Wisner, March 2022.

2. Skala, A., Skala, & Barlow. (2019). *Digital Startups in transition economies*. Springer International Publishing.

3. Siler, Stephen. *Biotechnology: A Guide to Scientific Approach and Technological Innovation*. Phil Dawson, 2022

4. Singh, S. (2016). *Mythbreaker: Kiran Mazumdar-Shaw and the story of Indian biotech*. Collins Business India

5. Chelladurai, G., Sr. S. IruthayaKalai Selvam, and Priya Sundarrajan. *Bio Entrepreneurship*. Authors Click Publishing, 2024

Web resources

1. https://www.profitableventure.com/biotech-business-ideas/
2. https://www.bio-rad.com/webroot/web/pdf/lse/literature/Biobusiness.pdf
3. https://www.nature.com/articles/s41587-021-01110-3
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3003900/
5. https://springhouse.in/government-schemes-every-entrepreneur/

Mapping with ProgrammeOutcomes

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-II
NON MAJOR ELECTIVE—I CHOICE-2
HEALTH AND HYGIENE

COURSE OBJECTIVES

COs	**COURSE OBJECTIVES**	**KNOWLEDGE LEVEL**
CO1	Understand the principles of personal, community and environmental hygiene.	**K1,K2**
CO2	Gain knowledge about nutrition, food safety and public health laws	**K3,K4**
CO3	Recognize the importance of physical and mental health in disease prevention.	**K3,K4**

CO4	Understand national and international health programmes and their implementation.	**K4,K6**
CO5	Develop awareness regarding lifestyle disorders, addictions and preventive healthcare practices.	**K1,K4**
	K1–Knowledge; K2–Understanding; K3–Practice; K4–Analysis; K5–Synthesis; K6–Creation	

Unit I

Introduction to hygiene and healthy living – Dimensions of health – Factorsaffectinghealth–Personalandcommunityhygiene–Healthhabitsand practices – Positive and negative community practices – Scientific principles related to health – Preventive healthcare – Hand hygiene and sanitation – Role of microbiology in public health.

UNIT II

Nutrition, Food Safety and Environmental Hygiene: Nutrition and health- Balanced diet – Malnutrition and deficiency disorders – Food surveillance–Foodfortification– Foodadulterationandpreventivemeasures– Food safety laws and standards – Environmental and housing hygiene – Safe drinking water – Waste disposal and biomedical waste management – Ventilation and lighting.

Unit III

Physical health and Lifestyle: Physical health and fitness - Importance of physical exercise – Walking, jogging, yoga and meditation – Stress management – Sleep hygiene – Lifestyle disorders – Importance of immunity and fitness – Role of WHO in global health – Personal hygiene – Importance of sunlight and Vitamin D – Digestive health and gut hygiene – Healthdestroyinghabitsandaddictions–Smoking,alcohol,tobacco,substance abuse and rehabilitation awareness – Digital addiction and sedentary lifestyle.

Unit IV

Mental hygiene and Occupational Health: Mental hygiene and **mentalhealth**– Factorsinfluencingmentalhealth–Developmentaltasksand basic needs – Emotional stability and psychological well-being – Mental hygiene during infancy, childhood, adolescence, adulthood and old age – Anxiety, depression and stress-related disorders – Counseling and emotional support – Occupational health hazards – Workplace stress management.

Unit V

Healthprogrammes and health education: National and internationalhealthprogrammes– Malaria,TuberculosisandHIV/AIDScontrol programmes – Immunization and vaccination awareness – National Health Mission (NHM) – Reproductive and Child Health (RCH) programmes – Family planning – Emerging infectious diseases and pandemic preparedness – Role of microbiologists in public health surveillance.

Course Outcomes	On completion of this course, students will;	
CO1	Explain the principles of personal,community,environmental and occupational hygiene for maintaining public health	PO1, PO2,PO5,PO10
	.Understand the importance of nutrition, food safety, sanitation and waste management in disease prevention.	PO1,PO5,PO10
CO3	Analyze the role of physical fitness, mental health and healthy lifestyle practices in improving quality of life.	PO1,PO5,PO10
CO4	. Recognize the impact of addictions, stress and lifestyle disorders on human health and well being.	PO1,PO5,PO10
CO5	Demonstrate awareness of national and international health programmes, immunization strategies and public health initiatives.	PO1, PO5,PO10

Text Books

1. BamjiM.S.,KrishnaswamyK.andBrahmamG.N.V.(2019).TextbookofHuman Nutrition. (4thEdition). OxfordandIBHPublishingCo.Pvt.Ltd.,NewDelhi.

2. Swaminathan(1995)Food&Nutrition(VolI)(2ndEdition).TheBangalorePrinting &PublishingCoLtd., Bangalore.

3. PanikerJ.C.K.andAnanthanarayanR.(2017).TextbookofMicrobiology.(10th Edition).UniversitiesPress(India)Pvt. Ltd.

4.LindsayDingwall.(2010).**PersonalHygieneCare** PrintISBN:9781405163071|OnlineISBN:9781444318708|DOI:10.1002/9781444318708.

5. Walter C. C. Pakes(1900).TheScienceofHygiene:aText-bookofLaboratoryPractice. (London: Methuen and Co.,).

]Reference books

1. KhaderV. (2000)Food,NutritionandHealth,KalyanPublishers,New Delhi.
2. Srilakshmi,B.(2010) FoodScience,(5thEdition)NewAgeInternationalLtd.,NewDelhi.
3. DubeyR.C. andMaheshwariD. K. (2010).PracticalMicrobiology.S.Chand.
4. Park K. 2007, Park's text book of Preventive and Social Medicine, BanarsidasBhanot publishers, India.
5. Srilakshmi,2002,Dietetics,NewAgePublications,India

Web resources

1. HealthandHygiene-PersonalHygiene, CommunityHygieneandDiseases (vedantu.com)
2. Chapter-32.pdf(nios.ac.in)
3. Menstrua health and HygieneGuide|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

Mapping with ProgrammeOutcomes.

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-III
CORE-IX
SOIL,AGRICULTURAL AND ENVIRONMENTAL MICROBIOLOGY

COURSE OBJECTIVES

COs	**COURSE OBJECTIVES**	**KNOWLEDGE LEVEL**
CO1	Understand the diversity, ecology and functions of soil Microorganisms and nutrient cycling processes.	**K1, K2**
CO2	Analyze microbial interactions and plant–microbe relationships involved in plant health and disease.	**K3, K4**
CO3	Demonstrate the role of microorganisms in sustainable agriculture, biofertilizers and biological control methods.	**K3, K4**

CO4	Apply microbial principles in environmental management, waste treatment and resource recovery systems.	**K4, K5**
CO5	Comprehend microbial approaches in biodegradation, bioremediation and environmental pollution control.	**K5, K6**
K1–Knowledge;K2–Understanding;K3 –Practice;K4–Analysis;K5– Evaluating ; K6–Creation		

UNIT-I

Soil Microbiology and Soil Microbial Processes

History, scope and significance of soil microbiology. Soil as a microbial habitat: soil profile and physical, chemical and biological properties of soil. Diversity and distribution of soil microorganisms: bacteria, actinomycetes, fungi, algae, protozoa, archaea and viruses. Soil organic matter: humic substances, humic acid and fulvic acid. Microbial role in bio geo chemical cycles of carbon, nitrogen, phosphorus and sulphur. Ammonification, nitrification and denitrification. Biological nitrogen fixation: symbiotic, associative and free-living systems. Nitrogenase, hydrogenase, *nif*and *nod* genes.

UNIT-II

Microbial Interactions and Plant–Microbe Relationships

Microbial interactions: mutualism, synergism, commensalism, antagonism, competition, parasitism and predation. Plant–microbe interactions: rhizosphere, rhizoplane, spermosphere, phyllosphere and endophytes. Rhizosphere effect and R ratio. Plant pathology: host–pathogen interactions and disease cycle. Important plant diseases: citruscanker, bacterial leaf blight of rice, wheat rust, tikka leaf spot, wilt of cotton, red rot of sugarcane and yellow vein mosaic disease of okra.

UNIT-III

Sustainable Agriculture and Agricultural Microbiology

Biofertilizers: *Rhizobium*, *Azotobacter*, *Azospirillum*, *Frankia*, cyanobacteria, *Azolla* and mycorrhizae. Plant Growth Promoting Rhizobacteria (PGPR) and microbial biostimulants. Biological reclamation of saline and sodic soils. Microbial biocontrol agents and bio pesticides: *Trichoderma*, *Pseudomonas fluorescens*, *Bacillus thuringiensis*, *Beauveria* and *Metarhizium*. Bioleaching using *Acidithio bacillus*. Sustainable agricultural practices: organic

farming, regenerative agriculture, hydroponics, vertical farming and Integrated Pest Management. (IPM).Applications of artificial intelligence in precision agriculture and soil health monitoring

UNIT-IV

Environmental Microbiology and Waste Management

Components of environment: atmosphere, hydrosphere and lithosphere. Microbial management of municipal, agricultural, industrial, biomedical, plastic and electronic wastes. Landfill microbiology and methane cycling microorganisms. Wastewater and sewage treatment: primary, secondary and tertiary treatment, activated sludge process, tricklingfilters and oxidation ponds. Resource recovery and circular bio economy: biomanure, biogas, bio hydrogen and bioethanol.

UNIT-V

Environmental Pollution and Bioremediation

Microbial degradation of cellulose, lignin, petroleum hydrocarbons, pesticides, herbicides, heavy metals and xenobiotics. Principles and applications of bioremediation, bioaugmentation, biostimulation and phytoremediation. Applications of artificial intelligence in environmental monitoring and pollution assessment. Environmental pollution control measures, environmental legislation in India and Environmental Impact Assessment (EIA).

Course Outcomes

Course Outcomes	On completion of this course, students will be able to	Programme Outcomes
CO1	Explain the diversity and ecological significance of soil microorganisms and nutrient cycling processes.	PO1, PO2, PO6
CO2	Analyze microbial interactions and plant–microbe relationships Associated with plant health and diseases.	PO1, PO3, PO4
CO3	Apply microbial techniques in sustainable agriculture, Biofertilizer development and biological control methods.	PO1, PO5, PO7
CO4	Evaluate microbial approaches used in waste management, Waste water treatment and environmental sustainability.	PO1, PO6, PO8
CO5	Assess microbial biodegradation and bioremediation strategies for environmental pollution control.	PO3, PO6, PO10

Text Books

1. Alexander,M.(1997).IntroductiontoSoilMicrobiology(2ndEdition).WileyEasternLtd.
2. SubbaRao,N.S. (2017).Soil Microbiology(5thEdition).Med Tech Publishers.
3. Rang swami, G. and Bagyaraj, D. J. (2012). Agricultural Microbiology (3rd Edition). PHI Learning Pvt. Ltd.
4. Pepper, I. L., Gerba, C. P. and Gentry, T. J. (2015). Environmental Microbiology (3rd Edition). Academic Press.
5. Atlas,R.M.andBartha,R.(1998).MicrobialEcology:FundamentalsandApplications (4th Edition). Benjamin/Cummings Publishing.
6. Sharma,P.D.(2016).Environmental Microbiology. Rastogi Publications.
7. Dubey, R. C. and Maheshwari, D. K. (2014). A Textbook of Microbiology. S. Chand& Company Ltd.
8. Aneja,K.R.(2020).ExperimentsinMicrobiology,PlantPathologyandBiotechnology (5th Edition). New Age International Publishers.

Reference Books

1. Sylvia, D.M., Fuhrmann,J.J.,Hartel,P.G.andZuberer,D.A.(2005).Principlesand Applications of Soil Microbiology (2nd Edition). Pearson Education.
2. Madigan,M.T., Bender,K.S.,Buckley,D.H.,Sattley,W.M.andStahl,D.A.(2021). Brock Biology of Microorganisms (16th Edition). Pearson Education.
3. Prescott, L. M., Harley. P. and Klein, D. A. (2017). Microbiology (10th Edition).McGraw Hill Education.
4. Atlas, R. M. and Philip, J. (2005). Bioremediation: Applied Microbial Solutions for Real-World Environmental Cleanup. ASM Press.
5. Martin,A.(2014).EnvironmentalMicrobiology:MethodsandProtocols.HumanaPress.
6. Purohit,S.S.(2018).Agricultural Biotechnology. Agro bios India.
7. Raina, M. M. (2011). Practical Handbook of Environmental Biotechnology. Agro bios India.
8. Glick,B.R.(2012).MolecularBiotechnology:PrinciplesandApplicationsof Recombinant DNA. ASM Press.

Web Resources

1. https://academic.oup.com/femsec/article/93/5/fix044/3098413
2. http://www.fao.org/3/t0551e/t0551e05.htm
3. http://www.environmentshumail.blogspot.in/

4. https://www.frontiersin.org/articles/10.3389/fpls.2017.01617/full
5. https://serc.carleton.edu/microbelife/index.html

Mapping with ProgrammeOutcomes

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-III
CORE-X
MOLECULAR BIOLOGY AND GENETIC ENGINERING

COURE OBJECTIVES

COs	**Course Objectives**	**Knowledge Level**
CO 1	Understand the structure of DNA and mode of DNA replication and role DNA modifying Enzymes	**K1,K2**
CO2	Study the mechanism of transcription and translation and post transcriptional and translational modifications	**K1, K2,K3**
CO3	Gene regulation and expression and role of noncoding RNA's	**K3,K4**
CO4	Molecular basis of gene mutation. Detection and analysis of mutations and Molecular markers	**K4,K5**
CO5	Molecular genetics Tools and Application	**K4,K5**
	K1–Knowledge; K2–Understanding; K3–Practice; K4–Analysis; K5–Evaluating ; K6–Creation	

Unit I -Structure of Nucleic Acids and DNA replication

Molecular structure of genes and chromosomes, Different forms of DNA - A,B and Z - Super coiling of DNA - DNA synthesis: DNA polymerase I II & III; Topoisomerase I & II- Properties of DNA - Melting curve; Hyperchromicity - cot value - DNA Replication - Mechanism of DNA replication - 0mode, D-loop, Rolling circle model; Reverse transcriptase. DNA Degradation - DNase: exonucleases. Restrictions endonucleases: different types. I, II & III.

Unit II -Transcription, Translation

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 Transcriptional and Post translational modifications.

Unit III -Regulation of gene expression

Gene regulation and expression – Lac operon, arabinose and tryptophan operons. Induction and repression mechanism in operons. Gene regulation in eukaryotic systems - repetitive DNA, gene rearrangement, promoters, enhancer elements. Noncoding and micro RNA, RNA interference

Unit IV-Mutation and Molecular Markers

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). Molecular Markers, RFLP, RAPD, AFLP, CRISPR gene editing.

Unit V-Molecular genetics Tools and Applications

Forward Genetics, Reverse Genetics, Genome Wide Association studies-SNP, Karyotyping, Gene editing – CRISPR/CAS9, Personalised Medicines, Forensic genetics,Cancergenetics,Immunogenetics,Population genetics, Sanger Sequencing, Next generation sequencing -WS,WES, targeted panels, RNA-seq, DNA Microarrays.

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Analyze, demonstrate and appreciate DNA replication and DNA modifying enzymes	PO1,PO2,PO6, PO10
CO2	Analyze, demonstrate and appreciate transcription and translation	PO1, PO2,PO6, ,PO10
CO3	Analyze the Gene regulation mechanism and protein expression	PO1, PO2,PO3, PO6,PO10
CO4	Investigate the types of mutation, DNA repair mechanisms and about molecular markers	PO1, PO2,PO3, PO6,PO7, PO8,PO10
CO5	Illustratively assess the molecular techniques for DNA analysis.	PO1,PO2,PO3, PO6,PO7, PO8,PO10

Text Books

1. Alberts, Bruce, et al. *Molecular Biology of the Cell*. 7th ed., W. W. Norton & Company, 2022

2. Watson, J. D., Yashpal, M., & Chatterjee, D. (2025). *Molecular biology of the gene: An Indian adaptation* (9th ed.). CBS Publishers and Distributors.
3. Krebs, Jocelyn E., et al. *Lewin's Genes XII*. 12th ed., Jones & Bartlett Learning, 2018

4. Lodish, Harvey, et al. *Molecular Cell Biology*. 9th ed., W. H. Freeman, 2021
5. Snustad, D. Peter, and Michael J. Simmons. *Principles of Genetics*. 7th ed., John Wiley & Sons, 2015.

Reference Books

1. Pierce, Benjamin A. *Genetics: A Conceptual Approach*. 7th ed., Macmillan Learning, 2024.

2. BrownT.A.(2016).GeneCloningandDNAAnalysis-AnIntroduction.(7th Edition). John Wiley and Sons,Ltd.

3. RussellP.J.(2010).Genetics-AMolecularApproach.(3rd Edition).PearsonNew International Edition

4. SynderL.,PetersJ.E.,HenkinT.M.andChampnessW.(2013).MolecularGeneticsof Bacteria.(4thEdition).ASMPressWashington-D.C.ASMPress

5. GlickB.R.andPattenC.L.(2018).Molecular Biotechnology–Principles and Applications of Recombinant DNA.(5th Edition).ASMPress.

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/

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-III
CORE-X I
FERMENTATION TECHNOLOGY AND PHARAMACEUTICAL MICROBIOLOGY

COURSE OBJECTIVES

COs	**COURSE OBJECTIVES**	**KNOWLEDGE LEVEL**
CO1	Understand the principles, scope and industrial applications of Fermentation technology and industrial microbiology.	**K1, K2**
CO2	Analyze upstream processing, bioreactor systemsand fermentation process control techniques used in industrial microbiology.	**K3, K4**
CO3	Examine downstream processing methods and industrial Production of microbial metabolites and bio products.	**K3, K4**
CO4	Apply pharmaceutical microbiology principles related to contamination control, sterilization and sterility assurance systems.	**K4, K6**
CO5	Comprehend quality assurance systems, regulatory practices and Emerging biotechnological trends in pharmaceutical industries.	**K1, K2**
K1–Knowledge;K2–Understanding;K3–Practice;K4 –Analysis;K5– Evaluating; K6–Creation		

UNIT-I

Introduction to Fermentation Technology

History, scope and development of fermentation technology and industrial microbiology. Componentsandeconomicsoffermentationprocesses.Industriallyimportantmicroorganisms including bacteria, fungi, yeasts and actinomycetes. Isolation, screening, selection, preservation and strain improvement. Types of fermentation processes: batch, fed-batch, continuous, submerged, solid-state, aerobic and anaerobic fermentation. Microbial growth kinetics and growth curve.

UNIT- II

Upstream Processing and Bioreactor Technology

Inoculum development, scale-up techniques, media formulation and optimization. Sterilization of media, air and fermenters. Fermenter design and construction. Types of bioreactors including stirred tank, airlift, bubble column, packed bed, fluidized bed and photo bioreactors.Aeration, agitation, oxygentransfer, heat transfer and instrumentation. Process monitoring and control of pH, temperature, dissolved oxygen and foam. Computer applications in fermentation technology.

UNIT-III

Downstream Processing and Industrial Microbial Products

Principles and stages of downstream processing. Biomass separation by filtration, centrifugation, sedimentation and flocculation. Cell disruption methods. Extraction and purification techniques including solvent extraction, liquid-liquid extraction, aqueous two-phase extraction, supercritical fluid extraction, precipitation, dialysis, ultra filtration, reverse osmosisandchromatography.Drying,crystallizationandformulation.Industrialproductionof organicacids(citricacid,lacticacid,aceticacid),aminoacids(glutamicacid,lysine),enzymes (amylase, protease, lipase), antibiotics (penicillin, streptomycin, tetracycline, griseofulvin), vitamins (vitamin B12, vitamin C) and alcoholic beverages (ethanol, wine and beer).

UNITIV

Pharmaceutical Microbiology

Scope of pharmaceutical microbiology. Microbial contamination and spoilage of pharmaceutical products. Sources of contamination including air, water, raw materials, personnel and equipment. Environmental monitoring and clean room practices. Sterilization methods: heat, filtration, radiation and gaseous sterilization. Antiseptics, disinfectants and preservatives. Sterility testing, microbial limit tests, bacterial endotoxin test and growth promotion test. Pharmaceutical water systems including purified water, DM water and water for injection.

UNIT-IV

Quality Assurance, Regulatory Practices and Emerging Trends

Production and standardization of vaccines, toxoids, antisera and recombinant products. Validation of instruments including autoclave, hot air oven and laminar airflow. SOP, GDP, GLP and GMP. Regulatory frameworks including WHO, FDA, ISO, IP, BP and USP. Immobilizationofcellsandenzymes.Biosensorsandprobiotics.Microbialbiotransformation.

Recombinant DNA technology, synthetic biology, bioethics, intellectual property rights, industrial sustainability and waste management.

Course Outcomes

Course Outcomes	On completion of this course, students; will be able to	Programme Outcomes
CO1	Explain the principles, industrial microorganisms and Fermentation systems used in industrial microbiology.	PO1, PO3, PO8
CO2	Apply upstream processing methods and evaluate bioreactor Operations and process control systems.	PO4, PO5, PO10
CO3	Analyze downstream processing techniques and industrial Production of microbial metabolites.	PO4, PO5, PO6
CO4	Assess pharmaceutical microbiology practices, contamination Control and sterilization systems.	PO1, PO8, PO10
CO5	Evaluate quality assurance systems, regulatory practices and Emerging biotechnological applications in pharmaceutical industries.	PO3,PO6, PO10

Text Books

1. Stanbury,P.F.,Whitaker,A.,andHall,S.J.(2016).*PrinciplesofFermentation Technology*. 3rd Edition. Butterworth-Heinemann.
2. Patel,A.H.(2022).*IndustrialMicrobiology*.2ndEdition.MacmillanPublishersIndia.
3. Denyer,S.P.,Hodges,N.A.,Gorman,S.P.,andGilmore,B.F.(Eds.).(2023). *Hugo and Russell's Pharmaceutical Microbiology*. 9th Edition. Wiley-Blackwell.
4. Kokare,C.R.(2017).*PharmaceuticalMicrobiology:PrinciplesandApplications*.6th Edition. Nirali Prakashan.
5. K.Vijaya Ramesh (2020). *Industrial Microbiology*.MJP Publishers.

Reference Books

1. Sandle,T.(2023).*PharmaceuticalMicrobiology:EssentialsforQualityAssurance and Quality Control*. 2nd Edition. Woodhead Publishing.
2. El-Mansi,E.M.T.,Bryce,C.F.A.,Dahhou,B., Sanchez,S.,Demain,A.L.,andAllman,A.R.(Eds.).(2019).*FermentationMicrobiology andBiotechnology*.4th Edition. CRC Press.
3. Vogel,H.C.andTodaro,C.M.(2014).*FermentationandBiochemicalEngineering Handbook: Principles, Process Design, and Equipment*. 3rd Edition.

WilliamAndrew.

4. Baird, R. M., Hodges, N. A., and Denyer, S. P. (Eds.). (2017). *Handbook of MicrobiologicalQualityControlinPharmaceuticalsandMedicalDevices*.CRCPress.
5. Joshi, V. K. and Pandey, A. (2010). *Biotechnology: Food Fermentation (Microbiology,BiochemistryandTechnology)*.EducationalPublishers&Distributors.

Website Resources

1. https://www.who.int/
2. https://www.fda.gov/
3. https://www.iso.org/
4. https://nptel.ac.in/
5. https://swayam.gov.in/

Mapping with ProgrammeOutcomes

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-III
CORE-PRACTICAL -V
SOIL,AGRICULTURAL AND ENVIRONMENTAL MICROBIOLOGY

COURSE OBJECTIVES

COs	**COURSE OBJECTIVES**	**KNOWLEDGE LEVEL**
CO1	To develop skills in the isolation, enumeration and characterization of agriculturally important soil microorganisms involved in nutrient cycling and soil fertility.	**K1, K2**
CO2	To examine plant–microbe interactions through the study of rhizosphere, phyllosphere, endophytes, plant growth-promoting microorganisms and plant pathogens.	**K3, K4**

CO3	To apply microbial technologies for sustainable crop production through biofertilizers, bioresources, composting and biological inputs used in agriculture.	**K3, K4**
CO4	To evaluate the microbiological quality of environmental samples and understand microbial approaches for waste management, resource recovery and environmental monitoring.	**K5, K6**
CO5	To perform biodegradation and bioremediation studies and gain practical exposure to environmental and industrial microbiological applications.	**K5, K6**
K1–Knowledge;K2–Understanding;K3–Practice;K4 –Analysis ;K5– Evaluating ; K6–Creation		

PRACTICAL EXPERIMENTS

A. Soil Microbiology

1. Enumeration of soil bacteria, fungi and actinomycetes by serial dilution and plate count methods.
2. Isolation of nitrogen-fixing microorganisms:
   a) *Azotobacter*
   b) *Azospirillum*
3. Isolation of *Rhizobium* from root nodules of leguminous plants.
4. Isolation of phosphate-solubilizing microorganisms from soil.
5. Isolation and characterization of rhizosphere microorganisms.
6. Isolation and observation of cyanobacteria from soil and paddy field samples.
7. Isolation of cellulolytic microorganisms from compost.
8. Isolation of VAM fungi from soil.

B. Agricultural Microbiology

9. Isolation and identification of plant pathogenic microorganisms from diseased plant samples:
   a) Tikka leaf spot
   b) Citrus canker
   c) Red rot of sugarcane
10. Cultivation of *Azolla*.
11. Cultivation of edible mushroom from solid waste.

9. Environmental Microbiology

12. Determination of microbial load in waste water by standard plate count method.
13. Microbiological analysis of water by Most Probable Number (MPN) method.

14. Water quality analysis by membrane filtration method.
15. Determination of Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) of water samples.
16. Quantification of airborne microorganisms by settle plate and air sampler methods.
17. Isolation of hydrocarbon-degrading microorganisms from contaminated soil.

COURSEOUTCOMES

Course Outcomes	On completion of this course, students will be able to	Programme Outcomes
CO1	Perform isolation and enumeration of soil microorganisms using standard microbiological techniques.	PO1, PO2, PO6
CO2	Analyze agriculturally important microorganisms and plant pathogenic microorganisms from environmental samples.	PO1, PO3, PO4
CO3	Apply microbiological techniques related to biofertilizers, rhizosphere microbiology and sustainable agriculture.	PO1, PO5, PO7
CO4	Perform microbiological and physico chemical analysis of water and waste water samples for environmental monitoring.	PO2,PO6, PO8
CO5	Evaluate microbial applications in environmental management, waste utilization and sustainable resource recovery.	PO3, PO6, PO10

Text Books

1. SubbaRao,N.S. (2017).SoilMicrobiology(5thEdition).MedTechPublishers.
2. Rangaswami, G. and Bagyaraj, D. J. (2012). Agricultural Microbiology(3rd Edition). PHI Learning Pvt. Ltd.
3. Pepper, I. L., Gerba, C. P. and Gentry, T. J. (2015). Environmental Microbiology(3rd Edition). Academic Press.
4. Aneja,K.R.(2020).ExperimentsinMicrobiology,PlantPathologyandBiotechnology (5th Edition). New Age International Publishers.
5. Dubey,R.C.andMaheshwari,D.K.(2015).PracticalMicrobiology.S.Chand& Company Ltd.
6. Cappuccino, J. G. and Welsh, C. (2019). Microbiology: A Laboratory Manual (12thEdition). Pearson Education.
7. Gunasekaran, P. (2012). Laboratory Manual in Microbiology. New Age InternationalPublishers.

8. Atlas,R.M.andBartha,R.(1998).MicrobialEcology:FundamentalsandApplications (4th Edition). Benjamin/Cummings Publishing.

Reference Books

1. Alexander,M.(1997).IntroductiontoSoilMicrobiology(2ndEdition).WileyEasternLtd.
2. Sylvia,D.M.,Fuhrmann,J.J.,Hartel,P.G.andZuberer,D.A.(2005).Principlesand Applications of Soil Microbiology (2nd Edition). Pearson Education.
3. Madigan,M.T.,Bender,K.S.,Buckley,D.H.,Sattley,W.M.andStahl,D.A.(2021). Brock Biology of Microorganisms (16th Edition). Pearson Education.
4. Prescott, L. M., Harley,J. P. and Klein, D. A. (2017). Microbiology (10th Edition).McGraw Hill Education.
5. Sharma,P.D.(2016).EnvironmentalMicrobiology. Rastogi Publications.
6. Purohit,S.S.(2018).AgriculturalBiotechnology. AgrobiosIndia.
7. Martin,A.(2014).EnvironmentalMicrobiology:MethodsandProtocols.HumanaPress.
8. Raina, M. M. (2011). Practical Handbook of Environmental Biotechnology. AgrobiosIndia.

Web Resources

1. https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5
2. https://vlab.amrita.edu/index.php?sub=3&brch=272
3. https://nptel.ac.in/courses/102105087
4. http://www.epa.gov
5. http://www.icar.gov,in

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-III
CORE-PRACTICAL -VI
MOLECULAR BIOLOGY AND FERMENTATION TECHNOLOGY

COURSE OBJECTIVES

COs	COURSE OBJECTIVES	KNOWLEDGE LEVEL
CO1	Understand the principles and applications of microbial genetics and molecular biology techniques used in microbiology laboratories.	K1, K2
CO2	Analyze microbial genetic materials and apply molecular Techniques such as transformation, PCR and electrophoresis.	K3, K4
CO3	Demonstrate fermentation technology processes involved in industrial production of enzymes, organic acids and microbial metabolites.	K3, K4
CO4	Apply industrial microbiology techniques for microbial screening, fermentation optimization and immobilization processes.	K4, K6
CO5	Comprehend pharmaceutical microbiology practices related to Antimicrobial susceptibility testing, sterility assurance and disinfectant evaluation.	K5, K6
K1–Knowledge; K2–Understanding; K3–Practice; K4– Analysis;K5– Evaluating ;K6–Creation		

Practical Experiments

A. Microbial Genetics

1. Isolation and quantification of chromosomal DNA from bacterial cells.
2. Isolation and agarose gel electrophoresis of plasmid DNA
3. Determination of molecular weight of DNA using agarose gel electrophoresis
4. Preparation of competent bacterial cells and bacterial transformation
5. Amplification of bacterial DNA by Polymerase Chain Reaction (PCR)
6. Estimation of protein by Lowry's method
7. Separation of proteins by SDS–PAGE
8. Separation of biomolecules by paper chromatography
9. Separation of biomolecules by Thin Layer Chromatography(TLC)
10. Separation of biomolecules by column chromatography

B. Fermentation Technology &Pharmaceutical Microbiology

1. Screening of antibiotic-producing microorganisms from soil samples
2. Screening for enzyme producers:
   a) Amylase
   b) Protease
   c) Lipase
3. Screening for organic acid producers:
   a) Acetic acid
   b) Lactic acid
4. Production of industrially important enzymes by submerged and solid-state fermentation (any one enzyme)
5. Optimization of parameters for amylase production
6. Wine production by yeast fermentation
7. Citric acid production using *Aspergillus niger*
8. Immobilization of microbial cells and enzymes
9. Antibiotic susceptibility testing by Kirby–Bauer method
10. Determination of Minimal Inhibitory Concentration(MIC)by:
    a) Broth dilution method
    b) Filter paper disc assay
11. Evaluation of disinfectants and determination of phenol coefficient
12. Sterility testing of pharmaceutical products by membrane filtration method(Demonstration)

COURSEOUTCOMES

Course Outcomes	**On completion of this course, students will be able to**	**Programme Outcomes**
CO1	Perform isolation, quantification and analysis of microbial genetic materials using standard molecular biology techniques.	PO1, PO2, PO6
CO2	Apply microbial genetic techniques such as transformation, PCR and electrophoresis in laboratory investigations.	PO1, PO4, PO6
CO3	Demonstrate fermentation techniques for microbialproduction Of enzymes, organic acids and industrial metabolites.	PO1, PO5, PO7

CO4	Apply industrial fermentation and immobilization techniques Used in bioprocess industries.	PO1, PO6, PO8
CO5	Perform pharmaceutical microbiology techniques related to Antimicrobial susceptibility, MIC determination and sterility testing.	PO3,PO6,PO10

Text Books

1. Bossi, L.,Camilli, A. andGründling,A. (2024). *Experiments in Bacterial Genetics:A Laboratory Manual*. Cold Spring Harbor Laboratory Press.
2. Sambrook,J.andGreen,M.R.(2012).*MolecularCloning:ALaboratoryManual*(4th Edition, 3-Volume Set). Cold Spring Harbor Laboratory Press.
3. Saxena, J., Baunthiyal, M. and Ravi, I. (2021). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Scientific Publishers.
4. McNeil,B.andHarvey,L.M.(Eds.).(2008).*PracticalFermentationTechnology*.John Wiley & Sons.
5. El-Mansi,E.M.T.,Bryce,C.F.A.,Dahhou,B.andSanchez,S.(2019).*Fermentation Microbiology and Biotechnology: Practical Manual*. CRC Press.

Reference Books

1. Ausubel, F. M., Brent, R., Kingston, R. E., Moore, D. D., Seidman, J. G., Smith, J. A. and Struhl, K. (2003). *Short Protocols in Molecular Biology* (5th Edition). Wiley.
2. Stanbury, P. F., Whitaker, A. and Hall, S. J. (2017). *Principles of Fermentation Technology* (3rd Edition). Butterworth-Heinemann. Denyer, S. P., Hodges, N., Gorman, S. P. and Gilmore, B. (Eds.). (2011). *Hugo and Russell's Pharmaceutical Microbiology* (8th Edition). Wiley-Blackwell.
3. Schmauder,H.P.(1997). *MethodsinBiotechnology*.Taylor&Francis/CRCPress.
4. Osborn, A. M. and Smith, C. J. (2005). *Molecular Microbial Ecology* (Advanced Methods Series). Taylor & Francis.
5. Cappuccino, J. G. and Welsh, C. (2019). *Microbiology: A Laboratory Manual* (12thEdition). Pearson Education.

Web Resources

1. https://experiments.springernature.com/
2. https://www.addgene.org/protocols/
3. https://blast.ncbi.nlm.nih.gov/
4. http://vlab.amrita.edu/
5. https://www.bio-rad.com/en-us/life-science-education/

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-III
ELECTIVE-III CHOICE-1
BIOSAFETY ,BIOETHICS AND IPR

COURSE OBJECTIVES

COs	**COURSE OBJECTIVES**	**KNOWLEDGE LEVEL**
CO1	Understand the fundamentals of Intellectual Property Rights (IPR), patents, trademarks, copyrights, and their significance in biotechnology.	**K1,K2**
CO2	Explain the procedures involved in patent filing, patent search, and international patent regulations	**K2,K3**
CO3	Analyze the patentability of biotechnological inventions and the legal framework governing biotechnology patents in India.	**K3,K4**
CO4	Understand the principles of bioethics and evaluate ethical issues related to biodiversity conservation and genetically modified organisms (GMOs).	**K2,K4**
CO5	Examine ethical concerns in medicine and biological research, including cloning, stem cell research, organ transplantation, and human subject research.	**K3,K4,K5**
	K1–Knowledge;/Remember ; K2–Understanding;K3–Practice;	

UNIT 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, tradesecrets, 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 .

UNIT-II

Process involved in patenting. Patent Search - Procedural steps in patenting, process of filing, PCT application, pre-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.

UNIT-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 harmonization efforts, implications of setting up a uniform world patent system.

UNIT-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.

UNIT-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.

Course Outcomes

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	Apply bioethics 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. UsharaniB., AnbazhagiS.andVidyaC.K.(2019).BiosafetyinMicrobiological Laboratories.(1st Edition).NotionPress.ISBN-101645878856,

2. SatheeshM.K.(2009).BioethicsandBiosafety.(1st Edition).J.KInternationalPublishing House Pvt.Ltd:Delhi.ISBN: 9788190675703

3. GoelD.andParasharS.(2013).IPR,BiosafteyandBioethics.(1st Edition). Pearson education: Chennai. ISBN-13: 978-8131774700

4. RajMohanjoshi.Biosafety an dBioethics.WileyPublications.

5. Sibi. GIntellectual, Property Rights, Bioethics, Biosafety and Entreepreneurship in biotechnology. (2021). Wiley Publications.

Reference books

1.Nithyananda K. V. (2019). Intellectual Property Rights: Protection and Management, India,IN: CengageLearning India Private Limited.

2.Neeraj,P.andKhusdeep,D.(2014).IntellectualPropertyRights,India,IN:PHIlearningPrivateLimited.

3.Ahuja, V K. (2017). Law relating to Intellectual Property Rights, India, IN: Lexis Nexis.

4.TonyHope(2004).MedicalEthics:AveryShortintroduction,.OxfordPublication

5. Goel Parashar.IPR,Biosafety and Bioethics(2013).PearsonPublications

Web resources

6. http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf.
7. https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf.
8. https://www.cdc.gov/training/quicklearns/biosafety/
9. https://www.wto.org/english/tratop_e/trips_e/intel1_e.htm
10. https://bioethics.msu.edu/what-is-bioethics\

Mapping with ProgrammeOutcomes

	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				

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-III
ELECTIVE-III CHOICE-2
AI TOOLS FOR MICROBIOLOGY

COURSE OBJECTIVES

COs	COURSE OBJECTIVES	KNOWLEDGE LEVEL
CO1	To establish a robust foundation in the GNU/Linux environment and the philosophy of Free and Open-Source Software (FOSS) in microbial research.	K1,K2
CO2	To develop multi-language literacy in Python, R, and Julia for automating complex biological data analysis	K3,K4
CO3	To facilitate a systematic transition from sequence-based bioinformatics to predictive Machine Learning methodologies.	K3,K4
CO4	To explore the frontiers of Generative AI and Autonomous Agents in protein engineering and microbial discovery.	K4,K5
CO5	To empower students to design and document open-source computational tools for the microbiology community.	K5,K6
	K1–Knowledge;/Remember ;K2–Understanding;K3–Practice; K4–Analysis; K5–Evaluating ; K6–Creation	

UNIT I: The Open-Source Scientific Computing Ecosystem

Philosophy of Free and Open-Source Software (FOSS) and its impact on reproducible research in Microbiology. Automation: Fundamentals of Bash scripting for high-throughput microbial data workflows. Version Control: Collaborative research using Git; documentation standards with Markdown; hosting biological repositories on GitHub/GitLab.

UNIT II: Multi-Paradigm Programming for Microbiologists

Python for Life Sciences: Core syntax, data structures, and functions; utilizing Biopython for sequence manipulation and NCBI Entrez database integration. Bioconductor for genomic analysis; high-dimensional visualization of microbial diversity and growth kinetics using ggplot2.

UNIT III: Heuristic Analysis and Machine Learning in Microbiology

Sequence alignment algorithms (Global vs. Local); Phylogenetic inference and molecular evolution. The Machine Learning Transition: Converting biological sequences into numerical descriptors (K-mer frequencies, codon bias, and physicochemical properties). Learning Paradigms: Supervised learning for pathogen classification and Antibiotic Resistance (AMR) prediction. Unsupervised learning for microbial community clustering using Principal Component Analysis (PCA).

UNIT IV: Generative AI and Autonomous Agents in Research

Principles of Large Language Models (LLMs) and Transformers in biological inquiry. Autonomous Agents: Introduction to AI Agents for automated literature synthesis and autonomous data retrieval from the Sequence Read Archive (SRA). Ethical AI: Addressing bias, reproducibility, and the "Black Box" challenge in microbial genomics.

UNIT V: Industrial Applications and Open-Source Development

Optimization of industrial fermentation processes; AI-driven discovery of novel antimicrobials and probiotics. Micro biome Analytics: AI applications in personalized nutrition and gut micro biome modeling. Capstone Project Concept: Identification of a microbial research problem to be solved using Python, R, or Julia.

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Operate independently within a Linux environment for high-end microbial research.	PO1,PO2,PO4, PO5,PO6
CO2	Develop custom, high-performance scripts in Python, R, and Julia to handle large-scale microbiological data	PO1,PO2,PO3,PO4, PO5,PO6
CO3	Apply Machine Learning workflows to predict microbial phenotypes and antibiotic resistance patterns.	PO1, PO2,PO3, PO5,PO6,PO10
CO4	Integrate Generative AI and Agents into the research lifecycle for accelerated scientific discovery.	PO1, PO2,PO3, PO4, PO5, PO6, PO10.
CO5	Contribute to the global scientific community by publishing licensed, open-source software tools on GitHub.	PO1,PO2,PO3,PO4,PO 5, PO6,PO7,PO10 PO8,PO9

Text Books

1. Bioinformatics and Functional Genomics – Jonathan Pevsner, Wiley.
2. Python for Bioinformatics – CRC Press.
3. Machine Learning with Python for Everyone – Pearson.
4. Introduction to Computational Biology and Bioinformatics – Narosa Publishing.
5. Artificial Intelligence in Healthcare and Biomedical Applications – Elsevier.

Reference Books:

6. Buffalo, V. (2015). *Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools*. O'Reilly Media.
7. Jones, M. (2015). *Python for Biologists: A Complete Programming Course for Beginners*. Create Space Independent Publishing.
8. Wickham, H., & Grolemund, G. (2017). *R for Data Science: Import, Tidy, Transform, Visualize, and Model Data*. O'Reilly Media.
9. Ramsundar, B., et al. (2019). *Deep Learning for the Life Sciences: Applying Deep Learning to Genomics, Microscopy, and Other Data*. O'Reilly Media.
10. Shotts, W. (2019). *The Linux Command Line: A Complete Introduction*. No Starch Press.

Web Resources

1 . ncbi.nlm.nih.gov
2. biopython.org
3.bioconductor.org
4. skills.github.com
5. ncbi.nlm.nih.gov

Mapping with ProgrammeOutcomes

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-III
ELECTIVE-III CHOICE-3
NANOTECHNOLOGY

COURSE OBJECTIVES

COs	COURSE OBJECTIVES	KNOWLEDGE LEVEL
CO1	Understand the fundamental concepts, classification, properties, and scope of nanotechnology, with special emphasis on microbial nanotechnology	K1,K3
CO2	Explain various methods of nanoparticles synthesis, including physical, chemical, and biological approaches, and evaluate the role of microorganisms in nanoparticles production	K2 K3,K4
CO3	Understand the principles and applications of major nanomaterial characterization techniques used to analyze nanoparticles properties and structures	K2,K4
CO4	Explore the diverse applications of nanotechnology in microbiology, including antimicrobial agents, drug delivery, diagnostics, biosensors, food technology, agriculture, and environmental management.	K3,K5
CO5	Evaluate the safety, toxicological, ethical, and regulatory aspects of nanotechnology and examine future prospects of nano biotechnology and sustainable nano material development.	K4,K5
	K1–Knowledge; K2–Understanding; K3–Practice; K4–Analysis; K5–Evaluating ; K6–Creation	

UNIT I – Introduction to Nanotechnology -Definition, scope, and historical development of nanotechnology - Classification of nanomaterial: nanoparticles, nanotubes, nanocomposites, quantum dots - Physical and chemical properties of nanomaterials-Concepts of nanoscale dimensions and surface area-Principles of top-down and bottom-up approaches - Role of microorganisms in nanotechnology

UNIT II– Synthesis of Nanoparticles -Physicalmethods of nanoparticle synthesis - Chemical synthesis methods - Biological synthesis (green synthesis) - Microbial synthesis using bacteria, fungi, algae, and actinomycetes - Intracellular and extracellular synthesis mechanisms - Factors affecting nanoparticle synthesis.

UNIT III – Characterization of Nanomaterials -Principles and applications of characterization techniques: UV–Visible Spectroscopy, Dynamic Light Scattering (DLS), X-Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Size, shape, stability, and surface charge analysis

UNIT IV – Applications of Nanotechnology in Microbiology -Antimicrobial nanoparticles and mechanisms - Nanotechnology in drug delivery systems -Nano-biosensors for pathogen detection – Nanotechnology in diagnostics and therapeutics-Nanoparticles in vaccine development - Food microbiology and nano-packaging-Agricultural and environmental applications

UNIT V – Nanotoxicology, Biosafety and Future Perspectives - Nanotoxicology and health impacts – Cytotoxicity and environmental toxicity of nanoparticles - Biosafety regulations and risk assessment - Ethical and social issues in nanotechnology - Regulatory guidelines for nanomaterials - Future prospects of nanobiotechnology .

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Explain nanotechnology concepts and properties	PO1,PO2,PO3, PO5,PO7
CO2	Describe synthesis methods and microbial roles	PO1, PO2,PO3, PO4,PO5
CO3	Analyze characterization techniques and data	PO1, PO2,PO4, PO5,PO10
CO4	Assess applications of nanotechnology	PO1, PO2,PO6, PO10,PO12
CO5	Evaluate biosafety, ethics, and future prospects	PO1, PO2,PO6, PO7,PO12

Text Books

1. Rai, Mahendra, Yadav, Alka & Gade, Aniket (Eds.) (2021). **Biological Synthesis of Nanoparticles and Their Applications**. Cham, Switzerland: Springer Nature. ISBN: 978-3030712655.
2. Soloviev, Mikhail (Ed.) (2012). **Nanoparticles in Biology and Medicine: Methods and Protocols**. New York: Humana Press. ISBN: 978-1617799525.
3. Wiesner, Mark R. &Bottero, Jean-Yves (Eds.) (2007). **Environmental Nanotechnology: Applications and Impacts of Nanomaterials**. New York: McGraw-Hill Professional. ISBN: 978-0071477505.
4. Pradeep, T. (2017). **Nano: The Essentials – Understanding Nanoscience and Nanotechnology**. New Delhi: McGraw-Hill Education India. ISBN: 978-9352604975.
5. Sahu, Saura C. & Casciano, Daniel A. (Eds.) (2009). **Nanotoxicity: From In Vivo and In Vitro Models to Health Risks**. Chichester, UK: John Wiley & Sons. ISBN: 978-0470747780.

Reference books

1. Kulkarni, Sulabha K. (2015). **Nanotechnology: Principles and Practices** (4th Edition). New Delhi: Springer India. ISBN: 978-3319091822.
2. Niemeyer, C.M. & Mirkin, C.A. (Eds.) (2004). **Nanobiotechnology: Concepts, Applications and Perspectives**. Weinheim, Germany: Wiley-VCH. ISBN: 978-3527306589.
3. Rai, Mahendra & Duran, Nelson (Eds.) (2011). **Microbial Nanotechnology: Green Synthesis and Applications**. Wallingford, UK: CABI Publishing. ISBN: 978-1845937676.
4. Poole Jr., Charles P. & Owens, Frank J. (2003). **Introduction to Nanotechnology**. Hoboken, New Jersey: John Wiley & Sons. ISBN: 978-0471079354.
5. Vo-Dinh, Tuan (Ed.) (2007). **Nanotechnology in Biology and Medicine: Methods, Devices and Applications**. Boca Raton, Florida: CRC Press. ISBN: 978-0849391347.

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

Mapping with programme out come

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-III
NON MAJOR ELECTIVE-II CHOICE-1
BIOFERTILIZERS AND BIOMANURE TECHNOLOGY

COURSE OBJECTIVES

COs	**COURSE OBJECTIVES**	**KNOWLEDGE LEVEL**
CO1	Understand the concepts, importance, and role of biofertilizers and biomanures in sustainable agriculture, soil fertility and nutrient cycling.	**K1,K3**
CO2	Acquire knowledge of beneficial microorganisms used as biofertilizers, their mechanisms of plant growth promotion, and their agricultural significance.	**K1,K2 ,K4**
CO3	Understand the production technologies of biofertilizers, including mass cultivation, formulation, quality control, and storage and application methods.	**K3,K4**
CO4	Gain practical knowledge of biomanure production technologies, such as composting, vermicomposting, green manuring, and agricultural waste recycling for soil health improvement.	**K4,K5**

CO5	Evaluate the applications, recent advances, commercial potential and future prospects of biofertilizers and biomanures in environmentally sustainable crop production systems.	**K4,K5**
	K1–Knowledge; K2–Understanding; K3–Practice; K4–Analysis; K5–Evaluting ; K6–Creation	

Unit I – Introduction to Biofertilizers and Biomanures - Concept, scope, and importance of biofertilizers and biomanures in sustainable agriculture -Classification and types of biofertilizers –History and development of biofertilizer technology -Role of microorganisms in soil fertility and nutrient cycling-Organic farming and eco-friendly agricultural practices

Unit II – Microbial Biofertilizers -Nitrogen-fixing microorganisms: Rhizobium, Azotobacter, Azospirillum, cyanobacteria. Phosphate-solubilizing microorganisms and potassium-mobilizing bacteria-Mycorrhizae: types and significance - Mechanisms of plant growth promotion by microbes - Isolation, screening, and identification of beneficial microorganisms

Unit III – Production Technology of Biofertilizers - Mass cultivation of biofertilizer microorganisms - Carrier materials and formulation methods - Sterilization, packaging, storage, and shelf life - Quality control standards and BIS specifications- Methods of application: seed treatment, soil application, root dipping, foliar spray

Unit IV – Biomanure Technology -Composting: principles and methods. - Vermicomposting and vermiculture technology -Green manure and farmyard manure preparation - Production and utilization of biogas slurry and agricultural waste recycling - Role of biomanures in soil health improvement and crop productivity

Unit V – Applications, Advances, and Future Prospects -Biofertilizers in integrated nutrient management (INM)-Commercial production and marketing of biofertilizers Environmental impact and sustainability aspects -Recent advances in biofertilizer research: microbial consortia, nano-biofertilizers, liquid biofertilizers -Constraints, challenges, and future prospects of biofertilizer and biomanure technology

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Explain concepts and significance of biofertilizers and biomanures	PO1,PO2,PO6,PO7, PO12
CO2	Describe microbial biofertilizers and growth promotion mechanisms	PO1,PO2,PO3, PO4,PO6
CO3	Analyze production technology and quality control measures	PO1,PO2,PO4, PO6,PO11
CO4	Evaluate biomanure production methods and applications	PO1,PO2,PO5, PO6,PO11
CO5	Assess recent advances and sustainability aspects	PO1,PO2,PO7, PO8,PO10

Text Bo
oks

1. Subba Rao, N.S. (2017). **Biofertilizers in Agriculture and Forestry** (4th Edition). New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.. ISBN: 978-8120417397.
2. Sylvia, David M., Fuhrmann, Jeffry J., Hartel, Peter G., &Zuberer, David A. (2005). **Principles and Applications of Soil Microbiology** (2nd Edition). Upper Saddle River, New Jersey: Pearson Prentice Hall. ISBN: 978-0130941176.
3. Rangaswami, G. & Bagyaraj, D.J. (2013). **Agricultural Microbiology** (2nd Edition). New Delhi: PHI Learning Private Limited. ISBN: 978-8120348769.
4. Thangarajan, T., Saranraj, P., & Annapoorani, P. (2017). **Biofertilizers and Organic Farming**. New Delhi: Astral International Pvt. Ltd.. ISBN: 978-9386057484.
5. Palaniappan, S.P. & Annadurai, K. (2018). **Organic Farming: Theory and Practice**. Jodhpur, India: Scientific Publishers. ISBN: 978-9388172796

Reference books

1. Paul, Eldor A. (2015). **Soil Microbiology, Ecology and Biochemistry** (4th Edition). Amsterdam: Academic Press. ISBN: 978-0124159556..
2. Rai, Mahendra K. (Ed.) (2006). **Handbook of Biofertilizers and Microbial Pesticides**. New York: The Haworth Press. ISBN: 978-1560222705.
3. Maier, Raina M., Pepper, Ian L., & Gerba, Charles P. (2015). **Environmental Microbiology** (3rd Edition). Amsterdam: Academic Press. ISBN: 978-0123946263.
4. Ismail, Sultan Ahmed (2005). **The Earthworm Book: Vermiculture and Vermicomposting**. Chennai, India: Orient Longman. ISBN: 978-8125028468.
5. Katyal, J.C. & Vyas, A. (2009). **Biofertilizers for Sustainable Agriculture**. New Delhi: Indian Council of Agricultural Research Publications.

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

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	L					MS		
CO2	S	M	M	L		M								
CO3	M	S		M										
S	M	M			L	L				L	M			
S	M	S				S	M	L		M	M			

L-Low; M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-III
NON MAJOR ELECTIVE-II CHOICE-2
HUMAN INFECTIOUS DISEASES AND DIGNOSTICS

COURSE OBJECTIVES

COs	COURSE OBJECTIVES	KNOWLEDGE LEVEL
CO1	To impart knowledge on common human infectious diseases and their causative agents	**K1,K2**
CO2	To understand the transmission and prevention of infectious diseases.	**K2,K3**
CO3	To familiarize students with major bacterial, viral, fungal, and parasitic diseases.	**K2,K3**
CO4	To introduce conventional and modern diagnostic techniques.	**K3,K4**
CO5	To create awareness on infection control and public health management.	**K5,K6**
	K1–Knowledge; K2–Understanding; K3–Practice; K4–Analysis; K5–Evaluating ; K6–Creation	

UNIT I
INTRODUCTION TO HUMANINFECTIOUS DISEASES:

Normal microbial flora and host–pathogen interaction. Classification of infectious diseases. Sources and modes of transmission of infections. Communicable and non-communicable diseases. Nosocomial infections and opportunistic infections. Principles of epidemiology. Vaccination and immunization programs.

UNIT II

BACTERIAL AND FUNGAL DISEASES:

Bacterial diseases–Tuberculosis, Typhoid, Cholera, Diphtheria and Pneumonia. Fungal diseases – Candidiosis, Aspergillosis and Dermatophytosis. Symptoms, causative agents, mode of transmission, laboratory diagnosis, prevention and control measures.

UNIT III
VIRAL AND PARASITIC DISEASES:

Viral diseases – Influenza, Dengue, Hepatitis, COVID-19 and HIV/AIDS. Parasitic diseases–Malaria, Amoebiasis and Filariasis.Clinicalmanifestations, transmission, diagnosis, prevention and control measures.

UNIT IV
DIAGNOSTIC TECHNIQUES INI NFECTIOUS DISEASES:

Collection, transport and processing of clinical specimens. General methods of laboratory diagnosis-Microscopy and stainingtechniques.Culture methods and biochemical tests. Serological techniques – ELISA and agglutination tests.Moleculardiagnostictechniques–PCRandrapiddiagnostictests.Biosensors and imaging techniques in disease diagnosis.

UNIT V
PREVENTION, CONTROL AND PUBLICHEALTH MANAGEMENT:

Antimicrobial agents and antibiotic resistance. Infection control measures and hospital hygiene. Biomedical waste management. Public health surveillance and outbreak investigation. Emerging and re-emerging infectious diseases. Role of WHO and national health programs in disease control.

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Explain the basic concepts of infectious diseases and host–pathogen interactions.	PO1,PO6,PO7, PO8,PO9
CO2	Identify major bacterial,fungal,vira land parasitic diseases affecting humans	PO1, PO6,PO7, PO8,PO9
CO3	Understand the modes of transmission, prevention and control of infectious diseases.	PO1, PO5,PO7, PO8,PO9
CO4	Demonstrate knowledge on conventional and modern diagnostic techniques used in disease identification	PO1, PO6,PO7, PO9,PO11
CO5	Recognize the significance of infection control, public health management and antimicrobial resistance.	PO5, PO6,PO7, PO8,PO9

Text Books

1. KanungaR.(2017).AnanthanarayananandPanicker'sTextbookofMicrobiology. (2017).Orient Longman, Hyderabad.

2. Greenwood,D.,Slack,R.B.andPeutherer,J.F.(2012)MedicalMicrobiology,(18th

Edition).ChurchillLivingstone, London.

3. Finegold,S.M.(2000)DiagnosticMicrobiology,(10th Edition).C.V.Mosby Company, St.Louis
4.PanikerJ.(2006).Text Book of Parasitology. JayPeeBrothers,NewDelhi.
5.ChanderJ.(2018).TextbookofMedicalMycology.(4th Edition).Jaypeebrothers Medical Publishers

Reference Books

1.SalleA. J.(2007).Fundamental Principles of Bacteriology.(4th Edition). Tata McGraw-HillPublications.
2.CarterJ. (2001).Virology:Principles and Applications(1st Edition).Wiley Publications.
3.WilleyJ.,SandmanK.andWoodD.Prescott'sMicrobiology.(11th Edition).McGrawHill Book.
4.Koneman E.W., Allen S. D., Schreckenberg P. C. and Winn W. C. (2020). Koneman's Color Atlas and Textbook of Diagnostic Microbiology.(7th Edition).Jones&Bartlett Learning.ISBN:1284322378 9781284322378.
5. FinegoldS.M.(2000).DiagnosticMicrobiology.(10th Edition).C.V.MosbyCompany,St.Louis.

Web resources

1. http://textbookofbacteriology.net/nd

2. https://en.wikipedia.org/wiki/Virology

3.https://www.healthline.com/health/viral-diseases#contagiousness

4. https://www.adelaide.edu.au/mycology/
5.https://www.msdmanuals.com/en-in/home/infections/diagnosis-of-Infectious3disease/diagnosis-of-infectious-disease

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-IV
CORE-XIV
RESEARCH METHODOLOGY AND BIOSTATISTICS

COURSE OBJECTIVES

COs	COURSE OBJECTIVES	KNOWLEDGE LEVEL
CO1	Understand the fundamentals of research methodology, research process, variables, data types and methods of data collection	K1,K2
CO2	Acquire knowledge on sampling techniques, research design, and scientific report writing and publication ethics.	K3,K4
CO3	Understand the basic concepts of biostatistics, data presentation and descriptive statistical measures	K3,K4
CO4	Apply correlation, regression, ANOVA and tests of significance in statistical analysis and interpretation	K3,K5
CO5	Understand probability distributions and apply Computer-oriented statistical techniques and RSM for process optimization and data	K5,K6
	K1–Knowledge; K2–Understanding; K3–Practice; K4–Analysis; K5–Evaluating ; K6–Creation	

UNIT I Introduction to Research Methodology and Research Planning : Meaning, importance and objectives of research; types of research; research processincludingidentificationofresearchproblem,formulationofstatements and constraints, and research planning; review of literature, sources and methods of literature survey, review and synopsis presentation; research variables including nominal, ordinal, discontinuous, continuous and derived variables; types of data – primary and secondary data; methods and techniques of data collection including observation, experimentation, questionnaire, interview, case study and pilot study methods; methods of secondary data collection; research tools and instruments.

UNIT II Sampling Techniques, Research Design and Scientific Reporting
:Concept of population, sample, sampling frame and sampling distribution; importance of probability sampling; sampling methods including simple random, systematic ,stratified random and cluster sampling; meaning and importanceofresearchdesignandtypesofresearchdesigns;researchreport
writing including types of reports, guidelines for writing research articles and reports,reportformat,appendicesandreferencing;ethicalissuesinpublication, plagiarism and self-plagiarism.

UNIT III Introduction to Biostatistics and Descriptive Statistics : Introduction to biostatistics and basic statistical concepts; measurement and measurement scales; sampling and data collection; methods of data presentation; frequency table for single discrete variables and bubble spot diagrams; measures of central tendency including mean, median

and mode; measures of variability including range, mean deviation, standard deviation, standarderrorandcoefficientofvariation;computationofmean,varianceand standard deviation; introduction to correlation coefficient and t-test.

UNIT IV Correlation, Regression and Tests of Significance: Correlation and regression analysis including positive and negative correlation, Karl Pearson's coefficient of correlation, linear regression and multiple linear regression; prediction and calculation of unknown variables using regression equations; analysis of variance (ANOVA) including one-way and two-way classification; tests of significance including small sample tests such as Chi-square test, t-test and F-test, and large sample tests such as Z-test and standard error.

UNIT V Probability Distributions and Computer-Oriented Statistical Techniques :Introduction to probability theory and probability distributions; basic concepts of binomial, Poisson and normal distributions with definitions and simple problems (without derivations); computer-oriented statistical techniques and introduction to Response Surface Methodology(RSM);methods for process optimization including Central Composite Design (CCD), Box-Behnken design and optimal RSM design; regression models, FDS curves and surface contour plots; multilinear constraints and categorical factors in optimal design.

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. DanielW.W.(2005).Biostatistics;Afoundationforanalysisinthehealthsciences. (7th Edition).Jhon Wiley&sonsInc,NewYork
3. RaoP.S.S.andRichardJ.(2006).IntroductiontoBiostatistics&Research methods. Prentice-Hall, New Delhi
4. Veerakumari L.(2015)Bioinstrumentation1st edn.MJPPublishers.
5. Ahuja V.K. (2017) Laws Relating to Intellectual PropertyRights. Lexis Nexis.

Reference books

1. ZarJ.H.(2006).BiostatisticalAnalysis.(4th Edition).PearsonEducationInc.New Jersey.
2. BeinsB.C.andMcCarthyM.A.(2011).ResearchMethodsandStatistics.Pearson Education Inc. New Jersey.
3. AdamsK.A.andLawrenceE.M.K.(2014).ResearchMethods,Statistics,and Applications. SAGE Publications, Inc., New Delhi.
4. AndersonJ.B.andPooleM.(2011).Assignment andThesisWriting.4th edn. 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.
4. 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

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	

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-IV
ELECTIVE –IV CHOICE -1
MARINE MICROBIOLOGY

COURSE OBJECTIVES

COs	**COURSE OBJECTIVES**	**KNOWLEDGE LEVEL**
CO1	Understand marine ecosystems, oceanographic principles and the diversity of marine microorganisms	**K1,K2**
CO2	Explain ecological functions, biogeochemical processes and adaptive mechanisms of marine microbes.	**K2,K3**
CO3	Analyze the role of marine microbes in aquaculture, seafood safety and microbial disease management	**K2,K4**
CO4	Examine environmental issues and emerging applications of marine microorganisms in ecosystem management	**K3,K4**
CO5	Evaluate the biotechnological and economic potential of marine microbial resources for sustainable development	**K4,K5**
	K1–Knowledge; K2–Understanding; K3–Practice; K4–Analysis;K5–Evaluating;K6–Creation	

UNIT I – Marine Ecosystems and Microbial Diversity

Introduction to Marine Microbiology and Microbial Oceanography. Marine ecosystems and habitats: coastal, littoral, pelagic, benthic, estuarine, mangrove, saltpan, deep-sea and hydrothermal vents ecosystems. Physicochemical characteristics of seawater. Diversity of marine microorganisms: bacteria, archaea, actinomycetes, cyanobacteria, microalgae, fungi, protozoa and viruses. Marine microbial communities and microbial loop.

Endosymbiotic and ectosymbiotic associations. Marine sampling and cultivation techniques.

UNIT- II – Marine Microbial Ecology and Adaptations

Role of marine microorganisms in ecosystem functioning. Primary productivity and phototrophic microorganisms. Carbon, nitrogen, phosphorus and sulfur cycles. Oceanic carbonate system, climate regulation and blue carbon sequestration. Iron limitation and anaerobic ammonium oxidation (Anammox). Organic matter decomposition and nutrient recycling. Marine extremophiles: halophiles, psychrophiles, thermophiles, barophiles, acidophiles and alkaliphiles. Adaptive mechanisms and ecological significance

UNIT III – Aquaculture Microbiology and Seafood Safety

Aquaculture microbiology and microbial health management. Pathogens associated with marine, freshwater and ornamental fisheries. Major bacterial pathogens: Vibrio, Aeromonas, Salmonella, Pseudomonas, Leptospira and Corynebacterium. Viral diseases of marine organisms. Aquaculture probiotics and biofloc technology. Microbial contamination of seafood and aquaculture products. Rapid detection and diagnostic methods. Seafood quality assurance, preservation techniques and public health concerns.

UNIT IV - Blue Microbiology and Environmental Applications

Micro plastic pollution and the Plastisphere Harmful algal blooms and red tides: causes, impacts and management. Marine biofouling and microbially influenced corrosion Bioleaching, biodegradation and biodeterioration of natural and synthetic materials. Microbial indicators and biomarkers of ocean health. Marine natural products: antimicrobial, antiviral, anticancer compounds, biopolymers, biosurfactants, pigments, Green Fluorescent Protein (GFP) and Red Fluorescent Protein (RFP).

UNIT V – Marine Biotechnology and Blue Economy

Marine microbial biotechnology: enzymes, extremozymes, antibiotics, organic acids, pigments, toxins and bioactive compounds. Applications in food, pharmaceutical, agriculture and environmental sectors. Seaweed farming and marine resource utilization. Blue Economy: concepts, opportunities and challenges. Marine Products Export Development Authority (MPEDA): role and functions. Remote sensing and GIS in marine research. National and international marine research initiatives: Deep Sea Mission, Blue Carbon Initiative and SDG-14 (Life below Water). Future prospects of sustainable marine biotechnology

Course Outcomes

Course Outcomes	On completion of this course, students will;	
CO1	Describe marine ecosystems, oceanographic parameters and microbial diversity.	PO1, PO8,PO9
CO2	Explain microbial interactions, ecological functions and biogeochemical cycles in marine environments	PO1, PO5,PO7,
CO3	Analyze adaptive mechanisms of marine extremophiles and their environmental significance.	PO7,PO9
CO4	Evaluate marine environmental issues and microbial approaches for ecosystem management.	PO5,PO7, PO8,
CO5	Assess the role of marine microorganisms in aquaculture, seafood safety and biotechnology for sustainable development	PO7,PO8,PO9

Text Books

1.MunnC.B.(2019).MarineMicrobiology:EcologyandApplications.(3rd Edition).CRCPress. ISBN:9780367183561.

2.Bhakuni,D.S.andRawatD.S.(2005).Bioactive Marine Natural Products.AnamayaPublishers, NewDelhi.ISBN:1-4020-3472-5.

3. BrockT. D.(2011).Thermophilic Microorganisms and Life at High Temperatures.Springer.ISBN-13:978-1461262862/ISBN-10:1461262860

4.Nybakken,J.W.(2001).MarineBiology.(5thEdition).BenjaminCummings. ISBN:0321030761978032103076 4.

5.Veena.(Understanding marine biology. Discovery Publishing.

6.Lederberg, H., 1992. Encyclopedia of Microbiology, Vol.1-4., Academic Press, NY. 1154 pp

7. Se-kwon Kim, (2015) Handbook of Marine Biotechnology, Springer,

8. Felix, S., (2010) Handbook of Marine and Aquaculture Biotechnology, Agrobios India.

9. Gautam, N.C., (2007) Aquaculture Biotechnology, Shree Publishers and Distributors.

10. Lakra, W.S. (2008) Fisheries Biotechnology, Narendra Publishing House.

11. Kuravamveli, S. J., 2002. The Aquarium Handbook. 1 st Edition, Amity Aquatechpvt. Ltd Cochin. 256 pp

Reference books

1. MaierR.M.,PepperI.L.andGerbaC.P.(2006).EnvironmentalMicrobiology. (2nd Edition).AcademicPress.ISBN:978-0-12-370519-8.

2.BelkinS.andColwellR.R. (2005).Oceans and Health: Pathogens in he Marine Environment.Springer.ISBN:978-0-387-23708-4.

3.ScheperT.(2009).Advances in Biochemical Engineering/Biotechnology-Marine Biotechnology. Springer. ISBN:978-3-540-69356-7.E-ISBN:978-3-540-69357-4.

4.GasolJ.M.andKirchmanD.L.(Eds.).(2018).Microbial Ecology of the Oceans.(3rd Edition).Wiley-Blackwell.ISBN:978-1-119-10718-7.

5.KimS. K.(2019).Essentials of Marine Bio technology. Springer.

6. Krichman, D.L., (2000) Microbial Ecology of the Oceans. Wiley-liss, New York.

7. Paul, J., (2001). Methods in Microbiology: Marine Microbiology, Academic Press

8. Gram, L., (2009) Microbial Spoilage of Fish and Seafood, Springer.

9. Ramachandran, S., 2000. Marine remote sensing applications. Institute for Ocean Management, Anna University.

10. Kreuzer, R., 1974. Fishery Products, FAO Fishing News (Books) Ltd., England, 280 pp.

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-

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

L-Low; M-Medium; S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-IV
ELECTIVE –IV CHOICE -2
MICROBIAL QUALITY CONTROL AND TESTING

COs	**COURSE OBJECTIVES**	**KNOWLEDGE LEVEL**
CO1	Understand the principles and importance of quality control and quality assurance systems in microbiology laboratories and industries.	**K1, K2**
CO2	Analyze microbiological quality assessment procedures involved in water and wastewater management systems.	**K3,K4**
CO3	Examine air microbiology ,bioaerosals monitoring and microbial Contamination control methods.	**K3, K4**
CO4	Apply food quality control systems and food safety management Practices in food industries.	**K4, K6**
CO5	Comprehend pharmaceutical quality assurance systems, sterility Assurance and regulatory practices in pharmaceutical industries.	**K1, K2**
K1–Knowledge;K2–Understanding;K3–Practice;K4 –Analysis;K5–Synthesis;K6 – Creation		

UNIT-I

Quality Control and Quality Assurance in Microbiology

Concepts and principles of Quality Control (QC), Quality Assurance (QA), Total Quality Management (TQM)and ContinuousQualityImprovement(CQI).Quality Risk Management (QRM) and ICH Q9 principles. Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP). Pre-analytical, analytical and post-analytical quality control procedures. Reference microbial cultures and repositories (ATCC, MTCC). Microbial assays, laboratory documentation practices, data integrity and ALCOA+ principles in microbiological laboratories.

UNIT-II

Water Microbiology and Wastewater Management

Micro flora of water and sources of water contamination. Waterborne pathogens and waterbornediseases.Microbiologicalanalysisofpotablewaterbypresumptive, confirmed and completed coli form tests, Most Probable Number (MPN) method, membrane filtration technique and presence/absence tests. Characteristics of domestic and industrial wastewater. Waste water treatment systems and quality control measures. Water conservation, recycling and rainwater harvesting. Methods for microbial control in water: sedimentation, filtration, chemical disinfection, heat treatment and UV irradiation.

UNIT-III

Air Microbiology and BioaerosalsControl

Micro flora of air and bioaerosals. Airborne bacteria, fungi and viruses and their significance in human health, hospitals, food and pharmaceutical industries. Collection and analysis of air samples. Air sampling devices and microbial enumeration techniques. Indoor air quality monitoringandcontaminationcontrolsystems.Controlmeasuresforairbornemicroorganisms including HEPA filtration Radiation, laminar airflow systems, incineration and desiccation

UNIT- IV

Food Quality Control and Safety Management

Principles of food quality control and food safety. Food contamination and spoilage microorganisms. Biofilms in food processing environments and their role in persistent contamination. HACCP principles, VACCP (Vulnerability Assessment and Critical Control Points) and TACCP (ThreatAssessmentandCriticalControlPoints).Foodqualityassessment methods including microbial standards and rapid detection techniques. Food X-ray inspection systems, preventive quality control and hygiene practices in food industries. Food safety

regulations including FSSAI and ISO standards.

UNIT-V

Pharmaceutical Quality Assurance and Regulatory Practices

Quality assurance in pharmaceutical industries. Pharmaceutical contamination and sterility assurance systems. Sterility testing, pyrogen testing and Bacterial EndotoxinTest (BET)using LimulusAmebocyteLysate(LAL)assay.Validationandcalibrationoflaboratoryinstruments and equipment. Biological indicators for sterilization validation including *Geobacillus stearothermophilus*. Standard Operating Procedures (SOP), Good Documentation Practices (GDP) and regulatory compliance. Assessment and determinants of pharmaceutical product quality. Regulatory guidelines of WHO, FDA and pharmacopeial standards. Environmental monitoring and practical approaches to pharmaceutical quality management systems.

Course outcomes

Course Outcomes	**On completion of this course ,students will be able to**	**Programme Outcomes**
CO1	Explain the concepts and applications of quality control and quality assurance systems in microbiology laboratories and industries.	PO1,PO3, PO6
CO2	Analyze microbiological quality assessment techniques used in water analysis and waste water management.	PO1, PO2, PO8
CO3	Evaluate air microbiology and bioaerosals control measures used in health care and industrial environments.	PO1, PO4, PO8
CO4	Apply food quality control systems and food safety management practices in food industries.	PO1, PO5, PO6, PO7
CO5	Assess pharmaceutical quality assurance systems, sterility assurance procedures and regulatory practices.	PO3, PO6, PO10

Text Books

1. Bisen, P. S. and Verma, K. (2021). *Handbook of Microbiology, Quality Control and Industrial Applications*. CBS Publishers and Distributors.
2. Pelczar, M. J., Chan, E. C. S. and Krieg, N. R. (2010). *Microbiology*. Tata McGrawHill Education.
3. Jay,J.M.,Loessner,M.J.andGolden,D.A.(2005).*ModernFoodMicrobiology*. Springer Publications.

4. Adams,M.R.andMoss,M.O.(2016).*FoodMicrobiology*.RoyalSocietyofChemistry.
5. Hugo and Russell's Pharmaceutical Microbiology by W. B. Hugo and A. D. Russell (2011). Wiley-Blackwell Publications.

Reference Books

1. Doyle,M.P.,Beuchat,L.R.andMontville,T.J.(2012).*FoodMicrobiology: Fundamentals and Frontiers*. ASM Press.
2. Baird, R. M., Hodges, N. A. and Denyer, S. P. (2000). *Handbook of Microbiological Quality Control in Pharmaceuticals and Medical Devices*. CRC Press.
3. Prescott,L.M.,Harley,J.P.andKlein,D.A.(2004).*Microbiology*.McGrawHillEducation.
4. FSSAI (LatestEdition).*ManualofMethodsofAnalysisofFoods*.FoodSafetyand Standards Authority of India, New Delhi.
5. WHOTechnicalReportSeriesonPharmaceuticalMicrobiologyandSterilityAssurance.

Web Resources

1. https://www.fssai.gov.in/
2. https://www.who.int/health-topics/food-safety
3. https://www.fao.org/food-safety
4. https://asm.org/
5. https://www.foodsafety.gov/

Mapping with ProgrammeOutcomes

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

L-Low;M-Medium;S-Strong
Rating:Low:0/60=**0%**;**Medium**:12/60=**20%**;**Strong**:48/60=**80%**

SEMESTER-IV
PROJECT
PROJECT VIVA VOCE

COURSE OBJECTIVES

This course is designed to provide advanced research training through the execution of an independent project in a specialized area of Microbiology. It enables students to develop competencies in research planning, experimental design, scientific literature retrieval, data collection, documentation, and statistical analysis. The course emphasizes the application of appropriate methodologies and analytical tools for generating, interpreting, and validating research findings while fostering critical thinking, problem-solving abilities, and ethical research practices.

The course further aims to strengthen scientific communication and professional skills through the preparation of a comprehensive project dissertation and presentation of research outcomes in academic forums such as seminars and conferences. Students will gain hands-on research experience under faculty supervision and, where necessary, engage in interdisciplinary collaborations to achieve project objectives. Exposure to industrial and applied aspects of Microbiology through industrial visits and report preparation will enhance their understanding of real-world applications and promote the integration of theoretical knowledge with professional practice.

The method of valuation of the project and Industrial visit report submitted by the candidate is outlined as follows:

Internal (2 out of 3 presentations)	**-25 Marks**
Project Report and Viva Voce	**-75 Marks**
Total	**- 100 Marks**

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