MANONMANIAM SUNDARANAR UNIVERSITY

TIRUNELVELI– 627 012

TAMILNADU, INDIA.

M.Sc. MICROBIOLOGY
(FOR AFFILIATED COLLEGES)

CURRICULUM

REVISED BASED ON REGULATIONS ON CHOICE BASED CREDIT SYSTEM (CBCS)

FOR PG DEGREE PROGRAMS

(Effective from the academic year 2026-2027 onwards)

MANONMANIAM SUNDARANAR UNIVERSITY

ABHISHEKAPATTY, TIRUNELVELI– 627 012, TAMILNADU, INDIA

M.Sc. MICROBIOLOGY (CBCS PATTERN)

FOR AFFILIATED COLLEGES

(EFFECTIVE FROM THE ACADEMIC YEAR 2026-2027 ONWARDS)

REGULATIONS OF SYLLABUS

1. UNIVERSITY VISION

"To provide quality education to reach the un-reached"

2. UNIVERSITY MISSION

1. To conduct research, teaching and outreach programs to improve conditions of human living
2. To offer a wide variety of off-campus educational and training programs, including the use of information technology, to individuals and groups
3. To develop partnership with industries and government so as to improve the quality of the workplace and to serve as catalyst for economic and cultural development
4. To provide quality / inclusive education, especially for the rural and un-reached segments of economically downtrodden students including women, socially oppressed and differently abled.

3. PREAMBLE

Microbiology- a branch of life science dealing about microbes and their applications is a fusion of various areas of biology. Knowledge on microbiology is vital to understand the evolution of biology, various normal bioprocess driving the earth's quality and survival, natural resources sustainability and welfare of living being. The scope of the subject spreads it's wings in Pharmacy, Medicine, Clinical research, Agriculture, Dairy industry, Environmental, Water industry, Nanotechnology & Chemical technology, Space etc., .

The M.Sc. Microbiology programme offered by Manonmaiam Sundaranar University is of two years' duration and is divided into four semesters. The CBCS syllabus of the programme has been revised for the year 2026-2027 based on the communication of The Chairman, University

Grants Commission (UGC) has in his letter D.O.No.F.1- 1/2015 (CM) dated 8th January, 2015. The various courses of the programme are designed to include classroom teaching and diverse types of lectures, laboratory work, project work, viva, seminars, assignments, course project, field work, extension activities, industrial and institutional visits, field visits and internship / Training.

Every student doing Post Graduation in Microbiology will undertake a total 29 courses with 90 credits for total of 2900 marks.

4. PROGRAMME EDUCATIONAL OUTCOMES (PEOs)	
PEO1	Developing strong positive attitude to learn independently the concepts in the field of Microbiology and its related areas.
PEO2	Ensuring confidence among the learners to apply the knowledge and skills gained to solve real life issues.
PEO3	Habituating ethical values among the learners to succeed in personal and professional life.

5. PROGRAMME OUTCOMES (POs)

At the end of the programme, the student will be able to:

PO1	Comprehend the knowledge acquired and share the knowledge with other to convince them in discussion.
PO2	Analyse and compare the factual data / situation and formulate the problem in to a conceptual model to critically evaluate for finding solution.
PO3	Apply the theories and philosophies learned in formulating theoretical research problem with underlying assumptions and solve the problem scientifically.
PO4	Think reflectively on the earlier attempts for applications of the concepts with a sense of inquiring practices and attempt for self directed lifelong learning process.

PO5	Understand the existence of multicultural practices and global viewpoint and utilization of knowledge with the ability to prolong moral / ethical values in personal and professional life.
PO6	Expose the learner to the digital literacy and information explosion with latest technology for enabling the learner to learn through multiple sources.
PO7	Prepare the learner to be a responsible player in the varied teams with facilitating capability and formulate teams as a leader for defined purposes.

6. PROGRAMME SPECIFIC OUTCOMES (PSOs):

PSO1	Core Microbial and Systematics Expertise: Master the core principles of microbial diversity, taxonomy, and evolution. Students will be equipped to isolate, characterize, and systematically classify bacteria, archaea, fungi, algae, and protozoa using traditional cultural methods alongside advanced molecular techniques like 16S rRNA sequencing and phylogenetic mapping.
PSO2	**Analytical and Bio-Instrumentation Proficiency:** Acquire advanced, hands-on competencies in handling clinical and industrial laboratory instrumentation. Graduates will possess operational expertise in multi-modal microscopy (including phase-contrast, TEM, and SEM), spectrophotometry, preparative/analytical centrifugation, multi-dimensional chromatography, and diverse electrophoretic techniques (such as AGE and SDS-PAGE).
PSO3	**Advanced Molecular and Immunological Skills:** Demonstrate a profound theoretical and practical understanding of microbial genetics, metabolic pathways, and immunology. Students will be able to execute genetic manipulations (such as transformation and conjugation), troubleshoot DNA repair mechanisms, and design/execute standard immunological assays including agglutination, diagnostic serotyping, and Western blotting.
PSO4	**Bio-Nanotechnology and Industrial Application:** Synthesize and apply green-synthesis approaches using microbial machinery to engineer nanomaterials. Graduates will be trained to evaluate, optimize, and characterize metallic nanoparticles for targeted biomedical applications (such as nanoantibiotics and targeted drug delivery systems) and industrial processes.
PSO5	**Environmental Bioremediation and Climate Mitigation Compliance:** Appraise the role of microorganisms in addressing global climate change and pollution. Students will be capable of engineering and deploying microbial strategies for biostimulation, bioaugmentation, plastic/hydrocarbon biodegradation, waste-to-wealth biocomposting, and using methanotrophs and nitrogen-fixing systems for sustainable agricultural practices.

PSO6	**Quality Control, Bioethics, and Regulatory Literacy:** Implement rigorous statutory standards across pharmaceutical, food, and biotechnology sectors. Graduates will be proficient in documenting and enforcing international safety frameworks including Good Manufacturing Practices (GMP), Hazard Analysis and Critical Control Point (HACCP), and FSSAI/US-FDA guidelines, while operating within the boundaries of Intellectual Property Rights (IPR), biotechnology patent laws, and medical bioethics.
PSO7	**Bio-Entrepreneurship and Public Health Leadership:** Synthesize academic insights with real-world applications to tackle community health hazards and drive regional economic development. Students will possess the necessary fieldwork, biostatistical, and leadership skills to design viable business plans for micro-enterprises (such as spawn production, mushroom cultivation, and biofertilizers) with a strong emphasis on rural sustainability and women empowerment schemes.

7. PROGRAMME DETAILS

A. ELIGIBILITY CRITERIA FOR ADMISSION

Candidates shall be admitted to the course provided if he / she has obtained a bachelor's degree in science in Microbiology / Biotechnology / Advanced Zoology and Animal Biotechnology / Plant science and Biotechnology / Zoology / Botany / Biochemistry / Biology / Life Science / Nutrition and Dietetics / B.S.M.S. / B.A.M.S. / B.U.M.S. / B.Sc., in MLT / B.E or B.Tech in Biotechnology / Bioengineering / Bio medical sciences / B.Sc., in Nursing / Genetics / Agriculture / Industrial Microbiology /Immunology / Molecular biology / Environmental Science / Virology / Bioinformatics or any other degree with Ancillary (Allied) in any one of the life sciences / that may be considered as equivalent to the degree offered by the ManonmaniamSundaranar University.

B. QUALIFICATION NORMS FOR THE APPOINTMENT OF ASSISTANT PROFESSOR

Candidates fulfilling the following conditions shall be appointed as Assistant Professor.

i) A M.Sc., / M.Phil Degree in Microbiology / Applied Microbiology discipline (55% minimum) with Ph.D. or UGC-NET/ SLST / SLET .

C. MEDIUM OF INSTRUCTION

The medium of instruction as well as examination will be in English

D. DURATION OF THE PROGRAMME

The duration of the programme shall be for two consecutive years with four semesters.

E. COURSE DETAILS

Every student admitted to Post Graduation course shall undertake 29 courses, off which, 13 core theory courses, 2 elective theory courses, 8 practical courses , 1 Field work course, 1 Internship course, 1 Research project course, 1 Industrial and Institutional Visit course, 1 Paper Publication / Presentation course and 1 Comprehensive Viva Voce (Over all viva voce). All the theory (Both Core and Elective) courses will include Course Project (Core Course Project (CCP) and Elective Course Project (ECP). The course projects could be evaluated internally by allocating marks from internal marks allotted for the concerned.

F. SEMESTER WISE DISTRIBUTION OF COURSES AND CREDITS

NO	COURSES	SEM I		SEM II		SEM III		SEM IV	
		NUMBERS	***CREDITS***	***NUMBERS***	***CREDITS***	***NUMBERS***	***CREDITS***	***NUMBERS***	***CREDITS***
1	CORE THEORY	3	12	3	12	3	12	4	16
2	ELECTIVE	1	3	1	3	-	-	-	-
3	CORE PRACTICAL	2	6	2	6	2	6	2	6
4	FIELD WORK	1	1	-	-	-	-	-	-
5	INTERNSHIP	-	-	1	1	-	-	-	-
6	RESEARCH PROJECT	-	-	-	-	1	3	-	-
7	INDUSTRIAL / INSTITUTIONAL VISIT	-	-	-	-	-	-	1	1
8	PAPER PRESENTATION / PUBLICATIONS	-	-	-	-	-	-	1	1
9	COMPREHENSIVE VIVA VOCE	-	-	-	-	-	-	1	1
	TOTAL	7	**22 (22)**	**7 (14)**	**22 (44)**	**6 (20)**	**21 (65)**	**9 (29)**	**25 (90)**

G. CREDIT- HOUR RELATIONSHIP

The term credit is used to describe the quantum of syllabus for various programmes in term of study. It indicates differential weightage given according to the contents and duration of the courses in the curriculum design. The total number of credits for a Master's Programme is 90.

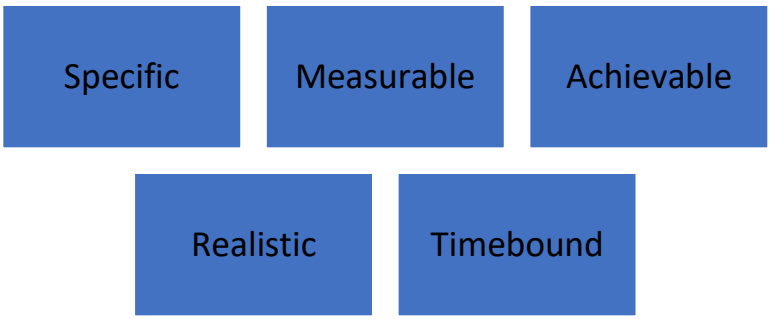
Assignment of Credits and Hours @

Quantum of credit	Core / Elective Theory Lecture	Practical	Project	Industrial & Institutional Visit	Field Work/ Internship
1 Credit	1 Hour	2 Hours	2 Hours	2 Hours	3 Hours

@ Regulations of choice based credit system for PG Programmes with a minor need based alteration.

H. COURSE OUTCOMES (COs)

For every course (Theory /Practical / Field Work / Internship / Industrial and Institutional Visit / Project etc.,), the course contents are fabricated in such way to have Course Outcomes (COs) based on SMART principles



I. COMPONENTS OF INNOVATIVE SKILL DEVELOPMENT STUDENTCENTRIC ACTIVITIES

SEM	EXTERNAL EVALUATION	MINOR ACTIVITIES – INTERNAL EVALUATION					
	MAJOR ACTIVITIES	I STUDENT - CENTRIC ACTIVITIES	II SHORT TERM ONLINE CERTIFICATIONS	III SPECIAL ASSIGNMENTS ON CURRENT TOPICS	IV RESEARCH CENTRIC ACTIVITIES	V. CELEBRATION ACTIVITIES	VI ENTREPRENEURIAL ACTIVITIES
I	1. FIELD GROUP PROJECT	NEWS CLIPPINGS COLLECTION	https://www.coursera.org/learn/introduction-to-ai	NOVEL TECHNIQUES FOR ADVANCED RESEARCH	RESEARCH INSTITUTIONAL VISIT	BREAST FEEDING WEEK	FIELD SURVEY ON PRODUCT OR PROCESS
II	2. INTERNSHIP– INDIVIDUAL	UPLOAD YOUR PPT IN SLIDESHARE / SLIDESERVE ETC	Medical Microbiology https://www.open.edu/openlearn/science-maths-technology/the-gut-microbiome-balancing-the-body/content-section-0?active-tab=description-tab Any time - Text based study material NOVEL TECHNIQUES FOR ADVANCED RESEARCH OR Microbial diversity, cell structure & microbial growth, vaccines https://alison.com/course/introduction-to-microbiology Entry at any time 3-4 hours – Online Course	ROLE OF MICROBES IN COMBATING CLIMATE CHANGE	(INT) NATIONAL RESEARCH INSTITUTES / SCHOLARSHIP AWARENESS	WORLD ANTIBIOTIC AWARENESS WEEK	INTERVIEWING A SUCCESSFUL ENTREPRENEUR (INDIVIDUAL / GROUP)
III	3. SUBJECT RESEARCH PROJECT	GROUP DISCUSSION / PANEL DISCUSSION	Environmental Microbiology https://www.open.edu/openlearn/nature-environment/microbes-friend-or-foe/content-section-0?active-tab=description-tab Any time- Text based study material OR Microbes Friends or Foe? https://www.open.edu/openlearn/nature-environment/microbes-friend-or-foe/content-section-0?active-tab=description-tab 3-4 hours – Online Course	ROLE OF MICROBES IN ENERGY / BIOFUEL PRODUCTION	JOURNEY THROUGH JOURNALS AND MEMBERSHIP IN PROFESSIONAL BODIES	WORLD IMMUNISATION WEEK	FERMENTED FOOD FEST / ZERO WASTE FOOD
IV	4. INDUSTRIAL VISIT (MINIMUM : 3 INDUSTRIES) 5. PAPER PRESENTATION / PUBLICATION IN STATE / REGIONAL / NATIONAL / INTERNATIONAL SEMINARS 6. COMPREHENSIVE VIVA VOCE	POSTER / MODEL CHART MAKING	Food Microbiology ttps://alison.com/course/introduction-to-food-microbiology#certificates 3-4 hours – Online Course OR The gut microbiome: balancing the body https://www.open.edu/openlearn/science-maths-technology/the-gut-microbiome-balancing-the-body/content-section-0?active-tab=description-tab Any time - Text based study material MICROBIAL FUELS	MICROBES AND SUSTAINABLE AGRICULTURE	SOFTWARE AND PLATFORMS FOR EFFECTIVE ADVANCED RESEARCH AND PLAGIARISM DETECTION	WORLD MICROBIOME DAY	SWOT ANALYSIS , CREATION OF IDs ON PROFESSIONAL PLATFORMS, AND BIODATA PREPARATION

J. INNOVATIVE PRACTICES IN TEACHING – LEARNING

(Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module[@] Self Learning[*] , Entrepreneurial model [$])

1. INTER DEPARTMENTAL EXPERTISE MODULE- [%]:

Utilizing inter-departmental expertise in a curriculum breaks down academic silos, fostering interdisciplinary learning and holistic problem-solving. It enables institutions to equip students with broad skill sets and diverse perspectives that mirror real-world challenges. Topic covered under this module is marked with **%** symbol in the curriculum. Classes can be handled through online or offline mode.

2. INTER INSTITUTIONAL EXPERTISE MODULE - &:

An **inter-institutional expertise module in curriculum teaching** involves collaborative educational programs where universities, colleges, or pedagogical centres pool their faculty and resources to educate students. These modules blend cross-institutional perspectives, instructional design, and shared evaluation methods to elevate modern teaching practices. Topic covered under this module is marked with **&** symbol in the curriculum. Classes can be handled through online or offline mode.

3. RESEARCHER MODULE +:

Topics which have close connection with research area shall be dealt with the help of researchers / research scholars. A researcher module in a curriculum transforms students from passive consumers of information into active knowledge creators. Integrating this framework early on equips learners with advanced competencies, builds vital critical thinking abilities, and vastly improves overall employability in knowledge-based economies. Researcher module is marked with + symbol in the curriculum. Classes can be handled through online or offline mode.

4. ALUMNI MODULE # :

In suitable courses selected topics shall be covered with the support of alumni module. An alumni module in an educational curriculum bridges the gap between academia and industry. It allows institutions to integrate real-world insights, update courses to match current job market trends, and provide students with valuable mentorship and networking opportunities. Alumni module is marked with # symbol in the curriculum. Classes can be handled through online or offline mode.

5. INDUSTRIAL MODULE @:

In suitable courses selected topic(s) shall be covered with the support of industrial collaboration. Integrating an industrial module into an academic curriculum bridges the gap between theory and practice. It provides immediate hands-on experience, ensures students learn relevant, job-ready skills, and significantly boosts overall employability. Industrial module component is marked with @ symbol in the curriculum. Classes can be handled through online or offline mode.

6. SELF STUDY / LEARNING COMPONENTS*:

Every core and elective papers have self study/ learning topics and units respectively. Integrating self-study topics into a curriculum cultivates independent learners by fostering time management, critical thinking, and a deeper, personalized understanding of the material. Students also build resilience and self-confidence by navigating challenges without immediate

teacher intervention. Self Learning component(s) is / are marked with * in the curriculum.

Key Advantages of Self-Study Topics:

- Promotes Deep Understanding
- Enhances Time Management
- Builds Critical Thinking
- Empowers Personalized Learning
- Prepares for Lifelong Learning

7. ENTREPRENEURIAL MODULE - $:

Integrating an entrepreneurial module in curriculum teaching shifts the focus from traditional memorization to experiential, project-based learning. It builds critical real-world skills—like opportunity recognition, financial literacy, customer discovery, and comfort with ambiguity—empowering students to turn ideas into tangible. Practical aspects shall be covered by this module with and the topics to be covered by this teaching method is marked with $ symbol.

K. LEARNING OUTCOMES (LOCs) Keeping the recommendations and expectations of UGC in mind, the courses are designed in such a way to bring the following learning outcomes directly or indirectly.

1. DISCIPLINARY KNOWLEDGE	6. RESEARCH RELATED SKILLS	11. SELF DIRECTED LEARNING
2.COMMUNICATION SKILLS	**7.** COOPERATION / TEAM WORK	**12**. MULTICULTURAL COMPONENTS
3. CRITICAL THINKING	8. SCIENTIFIC REASONING	13. MORAL ETHICAL AWARENESS & REASONING
4. PROBLEM SOLVING	9. REFLECTIVE THINKING	14. LEADERSHIPREADINESS & QUALITIES
5. ANALYTICAL REASONING	10. INFORMATION AND DIGITAL LITERACY	15. LIFELONG LEARNING

8. EXAMINATION SCHEME

Theory examination

The external evaluation will be based on the examination to be conducted by the university at the end of each semester.

Practical examination

Practical examinations will be conducted at the end of every semester. Along with practical examinations, evaluation of reports of Field work (I sem), Internship (II sem), Research Project (III sem), Industrial and Institutional visit, Paper Presentation / Publication (IV sem) will be done by the external examiner appointed by the university with viva voce. Comprehensive Viva-Voce will also be conducted by the university expert to test knowledge of all theory and practical courses studied in the programme on a separate date in Semester IV.

EVALUATION

All 29 courses carries an internal component

There is a pass minimum of 50% for P.G. external and overall components

Theories (Core & Elective) : External : internal Assessment = 75:25

Practical, Field Work, Internship, Research Project, Industrial / Institutional Visit / Paper publication / Presentation, Comprehensive Viva-voce :

External : Internal Assessment = 50:50

Internal Assessment

Regarding the internal assessment of theories, 25 marks are allocated in the following manner

COMPONENTS	MARKS
The average of the best two tests from the 3 compulsory tests (Off line / Online Tests)	15 Marks
Internal Innovative Skill Development Student centric Activities (Given in Table under I)	05 Marks
CCP, ECP	05 Marks
Total	25 Marks

Note: Each Internal test will be of one hour duration. A student has to attend minimum 2 internal test or off the three tests, the best of two can be taken.

Core Course Project / Elective Course Project (CCP & ECP)

1. Every Core / Elective paper and Practical will have a course (Mini) project / field work in all the semesters
2. It could be done individually by the students related to social issues pertaining to the area
3. Student could be permitted to go for the collection of samples / data along with staff members and Other Duty / Permission shall be granted for staff members for supporting CCP & ECP.
4. Maximum of a five page scientific report should be submitted

Internal marks for practical shall be allotted in the following manner

COMPONENTS	MARKS
Attendance	**05 Marks**
Discipline and Punctuality	**05 Marks**
Experimental works and other lab oriented and knowledge enrichment activities	**10 Marks**
Record	**05 Marks**
Model test	**15 Marks**
1 SWAYAM / MOOC / NPTEL ONLINE Courses or 2 SHORT TERM PAID / FREE WEB COURSES	**05 Marks**
Internal Innovative Skill Development Studentcentric Activities (Given in Table under I)	**05 Marks**
Total	**50 Marks**

INTERNAL ASSESSMENT

ACADEMIC KNOWLEDGE ENRICHMENT WEB COURSES

To encourage the students to update their knowledge about latest developments especially in practical part of microbiology, courses can be done through digital platforms such as NPTEL / SWAYAM – MOOC, or any other Free / Paid Online platforms which offer short term courses, for which marks could be given through practical internal evaluation. It is made mandatory to undertake a minimum of 6 web courses for the successful completion of the M.Sc., Programme. A minimum of two NPTEL / MOOC courses and Four Short Term Online Certificate Courses in any of the fields connected with practical aspects of Microbiology, which he / she likes could be opt during the two years period (One NPTEL course & Two Short Term Certificate Courses / Year). For the Three Certificate courses undertaken in an year, a total of 10 marks can be allotted from the practical internal marks of ODD / Even semester. For administrative reasons, students shall be asked to complete either NPTEL / MOOC or Short term certificate course in a semester. 10 Marks (5 Marks / NPTEL Course & 2.5 Marks / One Online Short Term Course – Total Two Short Term Online Courses) should be given from internal evaluation of **EACH** practical of the respective semester. ***Regarding Online courses are concerned, full liberty is given to the students for the selection of the course. Staff can assist the students in selection of course according to the potential of students.***

SKILL DEVELOPMENT COURSES (SDCs)

Even though core, elective , practical courses of post graduation programme in M.Sc., Microbiology assures a good number of learning outcomes expected by UGC in higher education, introduction of Skill Development Courses (SDCs) reassures possibility of harvesting all 15 learning outcomes (LOCs) in toto after the successful completion of degree. A skill development course is a structured educational program focused on building specific, practical competencies or soft skills—to bridge gaps between general education and industry demands. The SDCs *viz* Field work, Internship, Research Project, Industrial and Institutional visit, Paper presentation / Publication and Comprehensive Viva Voce are introduced with credits and external evaluation which are fabricated in such a way to weave all the 15 learning outcomes expected by UGC in higher education. The connectivity between each component and their learning outcomes are listed in the following table.

Summary Mapping Matrix

To see how these activities broadly cluster across UGC's 15 outcomes, primary impact distribution is given below:

NO	COURSE	LEARNING OUTCOMES
1	Field Work & Visits	Disciplinary Knowledge (1), Analytical Reasoning (5), Teamwork (7), Multi-cultural (12), Ethics (13)
2	Internship	Problem Solving (4), Digital Literacy (10), Self-Directed Learning (11), Leadership (14), Lifelong Learning (15)
3	Research Project & Publication	Critical Thinking (3), Analytical (5), Research Skills (6), Scientific Reasoning (8), Ethics (13)
4	Presentation & Viva Voce	Disciplinary Knowledge (1), Communication (2), Critical Thinking (3), Reflective Thinking (9)

The significance of each SDCs are as follows

FIELD WORK

For students, field work studies create opportunities for first-hand experiences that encourage critical thinking, long-term retention, transfer potential, positive attitudes towards science, appreciation for nature, and increased scientific curiosity. Cognitive development and motivation are also enhanced when students are active participants in the planning of the field study and in the activity itself. To enjoy the above benefits by students, Field work has been introduced in the **FIRST SEMESTER** with **1 CREDIT (3 Hours / Cycle)** to address microbes based problems and solution in the local area.

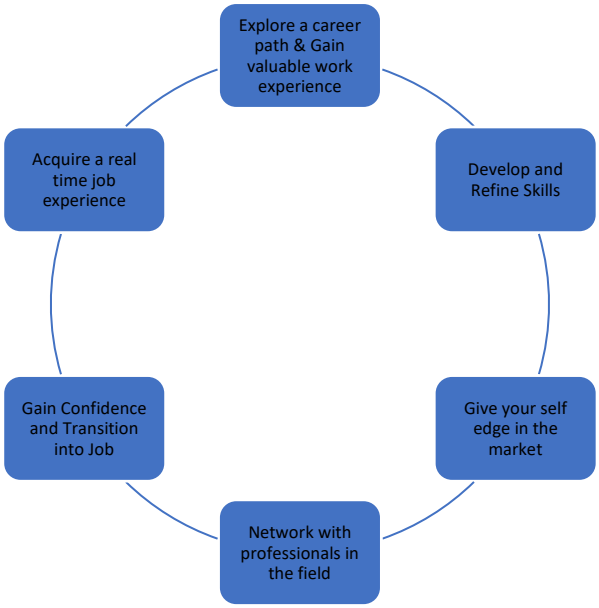
Evaluation

Student shall submit their computer typed report (Minimum of 6 pages focusing field work, excluding front page, declaration, certificate etc.,).

The evaluation will be done at the end of the **FIRST** semester by both **EXTERNAL of UNIVERSITY** (**50 %**) and internal (50%) examiners for a maximum marks of 100.

INTERNSHIP

To strengthen and elevate the professional skills of students, Internship (Part Time / Full Time) is incorporated with **1 CREDIT (3 Hours / Cycle)** in **SECOND SEMESTER**. An Internship for a minimum of 50 hours should be completed by every student and produce the certificate from the competent authority with a report.



Evaluation

Student shall submit their computer typed report (10 pages focusing the nature of the industry / institute, scope, applications, future, outcomes, limitations etc., excluding front page, declaration, certificate etc.,) individually.

The evaluation will be done at the end of the **SECOND** semester by both **EXTERNAL of UNIVERSITY (50 %)** and internal (50%) examiners for a maximum marks of 100.

RESEARCH PROJECT

A scientific research project is a systematic, evidence-based investigation designed to answer a specific question, solve a problem, or test a hypothesis. It follows the scientific method, which includes formulating a question, gathering data through experiments or observations, analyzing the results, and drawing valid conclusions. The characteristic feature includes systemic approach, empirical evidence, objectivity, reliability, logical reasoning, precision and accuracy and generalisability. Engaging in or utilizing scientific research projects provides substantial benefits for students, academics, and society as a whole: Develops Critical Thinking , Fosters Innovation and Discovery, Ensures Credibility, Promotes Real-World Application. To enjoy the above benefits by students, Research project has been introduced in the **THIRD** semester with **3 CREDITS (6 Hours / Cycle)** to address microbes based problems and solution in the local area.

Evaluation

Student shall submit their report (Minimum of 40 pages including Front Page, Declaration, Certificate by the guide, Certificate by the Head of the department / Principal, Certificate by the collaborating agency / agencies, Completion certificate offered by the External Examiners offered by the university, Acknowledgement, List of Tables, List of figure, List of Abbreviations, Abstract, Introduction, Review of Literature, Scope and Plan of work, objectives, Methodology, Materials and Methods, Result and Discussion, Summary, Bibliography)

The evaluation will be done at the end of the **THIRD** semester by both **EXTERNAL of UNIVERSITY** (**50 %**) and internal (50%) examiners for a maximum marks of 100.

INDUSTRIAL AND INSTITUTIONAL VISIT

To give exposure about scope and developments in the field of Microbiology for students, Industrial / Institutional visits is included in the Fourth semester with 1 credit (2 Hours / Cycle). It helps the students to make themselves aware of the demands in the fields, expectations of the concerned and the qualifications and skills to be developed in them. Understanding the societal needs, current status and market potential will explore the possibilities of becoming an entrepreneur. Staff accompanying the students should be given Special Non-Remunerative OD for such visits. The visit is expected to design for improving the knowledge of students by covering a minimum of 5 number of industries and institutions.

Evaluation

Student shall submit their report (10 pages focusing Industrial and Institutional, excluding front page, declaration, certificate etc.,) individually.

The evaluation will be done at the end of the **FOURTH** semester by both EXTERNAL **of UNIVERSITY (50 %)** and internal (50%) examiners for a maximum marks of 100.

PAPER PRESENTATION(S) / RESEARCH PUBLICATION(S)

For this, weightage can be given if the outcomes and data of the project carried out in the III Semester is used successfully. This will motivate students to design and carry out their 3rd Semester project meticulously with most sincerity, high quality and standards, commitment and dedication needed to publish / present in national / International level. Presenting a research work / an important concept in the core subject in regional / national / international level seminar / symposium at anywhere after the commencement of the programme and publishing research paper(s) individually or jointly with others preferably using the data generated through his / her project work done during the IIIrd semester of M.Sc. program builds critical academic skills, acts as a major competitive advantage for Ph.D. applications and scholarships, and elevates your professional credibility with future employers. It transforms one from a student into an active contributor to his / her field in addition to strengthening communication skill, networking ability, enhancement of employability, digital literacy etc.,

Evaluation

The credit allotted for this component with a separate subject code is 1 and the total mark is 100. In that, 50 marks shall be provided internally by the concerned staff who acts as guide. Evaluation of the nature and credibility of the Paper(s) presented / Paper(s) published can be done at end of **FOURTH SEMESTER** by an **EXTERNAL EXAMINER** appointed by the **UNIVERSITY** for a total of 50 Marks which involves viva voce for 25 marks in the 50.

COMPREHENSIVE VIVA VOCE

An " Comprehensive Viva voce or Overall Viva Voce" (Latin for "by word of mouth") is an all courses inclusive overall oral examination. It's goal is to assess broad understanding of a subject acquired over an entire semester or academic program, to test ability to think on feet, and to verify the authenticity of the knowledge gained by students. This component ensures holistic knowledge integration, tests higher order thinking, improvement of communication skill etc.,

Evaluation

Viva voce must be conducted at the end of fourth semester. A total of 100 Marks can be allotted for this component.

The evaluation will be done at the end of the **FOURTH** semester by both **EXTERNAL of UNIVERSITY** (**50 %**) and internal (50%) examiners. Knowledge of the student on all the theory (Core / Elective) / practicals / skill based components including parameters used for internal assessment can be tested.

PROJECT EVALUATION

Project work

Internal	External	Total
50 Marks	**50 Marks**	**100 Marks**

Distribution of Marks in Project Course

COMPONENTS	MARKS
INTERNAL	50 MARKS
EXTERNAL	
DISSERTATION	20 MARKS
PRESENTATION	20 MARKS
VIVA-VOCE	10 MARKS
TOTAL	100 MARKS

Note:

i) Student should carry out INDIVIDUAL PROJECTS only
ii) Project shall be allotted at the beginning of the III semester.
iii) In house projects are encouraged.
iv) Students may be allowed to carry out the project work in other research institutes without affecting normal academics.
v) Faculty members of the respective colleges must serve as guides
vi) Co- guides from the other institutions may be allowed.
vii) Project report evaluation will be done and Viva-voce will be conducted by both the external examiner and the guide at the end of the THIRD SEMESTER itself.
viii) Dissertation in THREE copies have to be submitted 15 days before the actual schedule of the exam.
ix) Evaluation of dissertation has to be done by the external examiner(s) appointed by the University for 50 Marks.
x) Special weightage may be given for the students who publish their research work in recognised journal including online.

PRACTICAL EXAMINATION

Microbiology is considered a highly practical-oriented programme because the discipline relies on hands-on manipulation to isolate, identify, and study microorganisms. Theoretical knowledge only explains concepts, but laboratory work is essential to visualize cells, understand microbial behaviour, and develop diagnostic skills. The programme has fabricated to increase the practical skill of the students with 8 practicals in the programme. There will be two practical examinations, which will be conducted at the end of each semester for maximum of 100 marks including 50 internal and 50 internal marks. The duration of the practical examination will be 9 hours.

EXTERNAL EXAMINATION

Theory External examination will be conducted for 3 hours at the end of each semester by the university for maximum of 75 marks. Questions will be taken based on Bloom's taxonomy.

9A. QUESTION PAPER FORMAT – THEORY

KNOWLEDGE LEVEL	SECTION	TYPE OF QUESTIONS	MARKS
(40 % K1,K2 &K3 60% K4,K5 & K6 WILL BE FOLLOWED IN ALL THE THREE SECTIONS)	Section –A	Multiple choice question (Three question from each unit)	15x1 = 15 Marks
	Section – B	Internal choice questions (one question from each unit)	5x4 = 20 Marks
	Section – C	Internal choice questions (one question from each unit)	5x8 = 40 Marks
Total			**75 Marks**

9B. QUESTION PAPER PATTERN – PRACTICAL

Max. Marks: 50

NO	COMPONENTS	MARKS	DURATION*
1	Major experiment	15 Marks	***Practical time: 9 hours* (8.00 AM – 5.00 PM (Including 1 Hour Lunch Break)***
2	Minor experiment	10 Marks	
3	Experimental procedure (Demonstration)	05 Marks	
4	Identification of spotters	10 Marks	
5	Record	05 Marks	
6	Viva-voce	05 Marks	
	Total	50 Marks	

***** Based on the understanding of practical difficulties (*More time is consumed for Media preparation, Sterilisation, Dispensing of media, Solidification of media, Inoculation and Incubation plates, Washing and Killing (Sterilization), proper and safe disposal of used materials and infectious biological samples*) in finishing the experiments / conducting the practicals and feed back of students, staff and lab technicians it is decided to follow the old timing for conducting practicals (9 Hours / Practical).

So the Board STRONGLY RECOMMENDS to increase the practical timing from 6 hours to 9 Hours. Increase of timing is indispensable for smooth conduct of practical, effective execution and biological safety of the environment and health of the students and staff members.

MODEL QUESTION PAPER – PRACTICAL

மனோன்மணியம் சுந்தரனார் பல்கலைக்கழகம்
Manonmaniam Sundaranar University
Reaccredited with 'A' Grade (CGPA 3.13 Out of 4.0) by NAAC (3rd Cycle)
Tirunelveli - 627 012, Tamilnadu, India.

UNIVERSITY PRACTICAL EXAMINATIONS NOVEMBER 2026

FIRST YEAR - M.Sc., Microbiology

Subject Code: VMBL11

Subject: LAB IN GENERAL MICROBIOLOGY AND MICROBIAL DIVERSITY

Time: 8.00 am -5 pm (9 Hours) **Max Marks: 50**

1.Enumerate the bacterial load in the given soil sample through pour plate technique and report your results. **15 Marks**

2. Check the Cell wall biochemistry of the given eubacterial culture adopting a suitable methodology after documenting the protocol in flow chart and report your findings with a clear justification and sketches. **10 Marks**

3. Highlight the principle, uses and limitations of Fumigation. **05 Marks**

4. Comment on the following spotters **10 Marks**

a. Autoclave
b. HEPA Filter
c. Transport Media
d. Lactophenol cotton blue
e. Inoculation loop

5. Record **05 Marks**

6. Viva-voce **05 Marks**

GOOD LUCK

MODEL QUESTION PAPER – THEORY

QUESTION CODE: 2026* **SUB CODE: VMBM13***

REGISTER NUMBER……..

M.Sc., (CBCS) DEGREE EXAMINATION NOVEMBER 2026

FIRST SEMESTER

MICROBIOLOGY

CORE THEORY – MICROBIAL PHYSIOLOGY AND METABOLISM

(For those who joined during 2026-2027)

Time: 3 Hours **Max.: 75 Marks**

Q.NO	Course Outcome (CO)	Bloom's K level	**SECTION – A (1 x 15 = 15 marks)** **Answer <u>ALL Questions</u>.**
1	CO1	K2	**What is the primary physiological function of the bacterial capsule during an infection?** a) Energy storage **b) Phagocytosis evasion** c) Protein synthesis d) Cell motility
2	CO3	K4	**If a mutation suppresses the synthesis of the lipid carrier bactoprenol, which specific stage of peptidoglycan biosynthesis will be immediately blocked?** a) Formation of UDP-NAM in the cytoplasm b) Cross-linking of pentapeptide chains **c) Transport of NAM-NAG precursors across the cell membrane** d) Attachment of L-alanine to UDP-NAM
3	CO4	K5	**Evaluate the structural adaptations of Archaeal membranes. Which of the following features most critically contributes to their stability in extreme hyperthermophilic environments?**

			a) Peptidoglycan cross-linking b) Ester-linked straight-chain fatty acids **c) Ether-linked isoprenoid lipids forming a monolayer** d) Presence of hopanoids in a phospholipid bilayer
4	CO1	K1	**Which of the following membrane transport mechanisms utilizes Phosphoenolpyruvate (PEP) as its primary energy source?** a) Facilitated diffusion b) Symport active transport **c) Group translocation** d) Iron siderophore transport
5	CO3	K4	**During the Entner-Doudoroff (ED) pathway, the enzyme KDPG aldolase catalyzes a cleavage reaction. If this enzyme is inhibited, which specific intermediate will accumulate in the cell?** a) Glucose-6-phosphate **b) 2-keto-3-deoxy-6-phosphogluconate (KDPG)** c) Pyruvate d) Glyceraldehyde-3-phosphate
6	CO5	K6	**Propose a metabolic strategy to maximize the cellular yield of glyoxylate. Which enzyme of the standard TCA cycle must bypass its usual function to achieve this?** a) Citrate synthase b) Alpha-ketoglutarate dehydrogenase **c) Isocitrate dehydrogenase** d) Malate dehydrogenase
7	CO1	K2	**In the context of the Pasteur effect, how does the metabolic rate of a facultative anaerobe change when it is shifted from an anaerobic environment to an aerobic one?** a) Glucose consumption rapidly increases **b) Glucose consumption significantly decreases** c) Fermentation product accumulation increases d) The rate of glycolysis remains completely unchanged

8	CO4	K5	**(K1) Which of the following anaerobic processes is entirely restricted to the domain Archaea?** a) Sulphate respiration b) Mixed acid fermentation c) Nitrate reduction **d) Methanogenesis**
9	CO5	K6	**(K4) When analyzing the electron transport chains of anaerobic respirers, why does sulphate respiration yield significantly less ATP compared to nitrate respiration?** a) Sulphate is a highly electropositive molecule. **b) Sulphate has a much lower (more negative) standard reduction potential than nitrate.** c) Sulphate reducers lack ATP synthase entirely. d) Nitrate respiration bypasses the generation of a proton motive force.
10	CO1	K2	**(K2) In Halobacterial photosynthesis, what is the specific role of bacterial rhodopsin?** a) Fixing atmospheric carbon dioxide **b) Acting as a light-driven proton pump** c) Generating NADH directly d) Splitting water molecules
11	CO3	K4	**In the nitrogenase enzyme complex, if the Fe-protein (dinitrogenase reductase) becomes permanently oxidized, which step of nitrogen fixation is immediately halted?** a) Binding of N_2 to the active site **b) Transfer of electrons to the MoFe-protein** c) Hydrolysis of ATP d) Release of ammonia
12	**CO4**	**K5**	**Contrast oxygenic and anoxygenic photosynthesis. Why is "reverse electron flow" an essential metabolic requirement for purple sulphur bacteria, but not for cyanobacteria?**

			a) Purple bacteria lack a cyclic ETS. **b) Their photosystem is not electronegative enough to reduce NAD(P)+ directly.** c) They utilize water as an electron donor. d) They operate primarily in the dark.
13	**CO1**	**K2**	**During which phase of a standard batch culture growth curve is the specific growth rate (μ) at its maximum and remains constant?** a) Lag phase **b) Exponential (log) phase** c) Stationary phase d) Decline phase
14	**CO4**	**K5**	**A researcher needs to maintain a bacterial culture where the growth rate is strictly controlled by a specific limiting nutrient (e.g., carbon source). Which system is most appropriate and why?** a) Batch culture, because nutrients are consumed steadily b) Turbidostat, because it maintains a constant optical density **c) Chemostat, because growth rate is regulated by the dilution rate of the limiting nutrient** d) Synchronous culture, because all cells divide simultaneously
15	**CO5**	**K6**	**Propose the physiological outcome if the expression of the *Spo0A* gene (the master regulator) is artificially deleted in a *Bacillus* species facing severe nutrient starvation.** a) The cell will rapidly form a highly resistant mature endospore. **b) The cell will fail to initiate asymmetric division and eventually undergo autolysis.** c) The cell will enter an endless exponential growth phase. d) The cell will form an exospore instead of an endospore.
SECTION – B (5 × 4= 20 Marks) **Answer <u>ALL</u> Questions Choosing Either A or B**			
16A	CO1	K2	Explain the differences in the cell wall structure between Gram-positive and Gram-negative bacteria.

16B	CO1	K2	Describe the structure and function of bacterial flagella and pili.
17A	CO3	K4	Compare and contrast active transport mechanisms (symport and antiport) with group translocation.
17B	CO3	K4	Analyze the energy yield and intermediate metabolites of the Entner-Doudoroff (ED) pathway compared to the standard EMP glycolysis pathway.
18A	CO3	K4	Examine the Pasteur effect and its regulatory significance in facultative anaerobes switching between fermentation and respiration.
18B	CO3	K4	Differentiate between the metabolic steps of mixed acid fermentation and butanediol fermentation pathways.
19A	CO1	K1	List the key photosynthetic and accessory pigments found in bacteria and state their primary functions.
19B	CO1	K1	Recall the specific roles of heterocysts and Nif genes in the mechanism of bacterial nitrogen fixation.
20A	CO4	K5	Evaluate the advantages and disadvantages of using a chemostat versus a turbidostat for continuous bacterial culture in industrial applications.
20B	CO4	K5	Assess how physical and chemical factors dynamically influence the different phases of a standard bacterial growth curve.
SECTION – B (5 × 8= 40 Marks) **Answer <u>ALL</u> Questions Choosing Either A or B**			
21A	CO4	K5	Evaluate the role of the peptidoglycan layer's biosynthesis pathway as a target for antibiotics, discussing potential resistance mechanisms.
21B	CO4	**K5**	Assess the survival advantage provided by extracellular components like capsules and slime layers in pathogenic bacteria facing severe environmental stress.
22A	CO3	K4	Analyze the components of the aerobic Electron Transport System (ETS) and explain how the chemiosmotic theory links it to oxidative phosphorylation.
22B	CO3	K4	Differentiate the metabolic roles of the TCA cycle and the glyoxylate cycle in bacteria growing on acetate as a sole carbon source.
23A	CO2	K2	Discuss the process of anaerobic respiration utilizing nitrate and sulphate as final electron acceptors.

23B	CO2	K2	Explain the biochemistry of bioluminescence in marine bacteria and summarize its ecological significance.
24A	CO5	K6	Design an experimental approach to demonstrate the differences between oxygenic and anoxygenic photophosphorylation in a mixed bacterial culture.
24B	CO5	K6	Propose a theoretical agricultural system that utilizes associative nitrogen-fixing bacteria to reduce reliance on chemical fertilizers. [K6]
25A	CO2	K3	Apply your knowledge of endospore structure to explain why spore-forming bacteria are highly resistant to standard sterilization techniques.
25B	CO2	K3	Apply standard models of binary fission to explain the growth rate differences between synchronous and asynchronous cultures under optimal conditions.

**** Dummy Question code and Subject Code***

MANONMANIAM SUNDARANAR UNIVERSITY

Tirunelveli – 627012, Tamil Nadu, INDIA

M.Sc., Microbiology (Colleges)

SEMESTER SYSTEM WITH CREDITS (CBCS PATTERN) SYLLABUS

(11. PROGRAMME STRUCTURE & SCHEME OF EXAMINATION)

(EFFECTIVE FROM THE ACADEMIC YEAR 2026-2027 ONWARDS AND THEREAFTER)

SEMESTER	NUMBER	STATUS	COURSE TITLE	COURSE CODES$	CONTACT HOURS/	CREDITS (00)	CCP / ECP	EH	CIA	ESE	TOTAL
FIRST	1	Theory / Core	General Microbiology & Microbial Diversity		4	4	+	3	25	75	100
	2	Theory /Core	Microbial Biochemistry		4	4	+	3	25	75	100
	3	Theory /Core	Microbial Physiology & Metabolism		4	4	+	3	25	75	100
	4	Theory / Elective (1 out of 4)	1. Biochemical Techniques and BioInstrumentation 2. Microbial Nanotechnology 3. Intellectual Property Rights and Bioethics 4. Public Health Microbiology		3	3	+	3	25	75	100
	5	SDC	Field Work		3	1	+	6	50	50	100
	6	Practical	Practical – Lab in General Micobiology and Microbial Diversity		6	3	-	9	50	50	100
	7	Practical	Practical – II – Lab in Microbial Biochemistry and Microbial Physiology		6	3	-	9	50	50	100
SECOND	8	Theory /Core	Microbial Genetics & Molecular Biology		4	4	+	3	25	75	100
	9	Theory /Core	Immunology and Immuno-techniques		4	4	+	3	25	75	100
	10	Theory /Core	Research Methodology and Biostatistics		4	4	+	3	25	75	100
	11	Theory / Elective (1 out of 4)	1. Biodegradation and Bio remediation 2. Microbial Quality Control in Industries 3. Entrepreneurship Microbiology 4. Microbes for Climate Change Control, Women Empowerment & Economy development		3	3	+	3	25	75	100
	12	SDC	Internship		3	1	+	6	50	50	100
	13	Practical	Practical – III Lab in Microbial Genetics & Molecular biology		6	3	-	9	50	50	100
	14	Practical	Practical – IV – Lab in Biostatistics and Immunology and Immunotehniques		6	3	-	9	50	50	100
THIRD	15	Theory /Core	Bioinformatics and AI in Life Sciences		4	4	+	3	25	75	100
	16	Theory /Core	Medical and Pharmaceutical Microbiology		4	4	+	3	25	75	100
	17	Theory /Core	Environmental and Agricultural Microbiology		4	4	+	3	25	75	100
	18	Project	Research Project*		6*	3	-	6	50	50	100
	19	Practical	Practical – V – Lab in Bioinformatics, AI, Medical and Pharmaceutical Microbiology		6	3	-	9	50	50	100
	20	Practical	Practical – VI – Lab in Environmental and Agricultural Microbiology		6	3	-	9	50	50	100
FOURTH	21	Theory /Core	Food and Diary Microbiology		4	4	+	3	25	75	100
	22	Theory /Core	Fermentation & Industrial Microbiology		4	4	+	3	25	75	100
	23	Theory /Core	Genetic Engineering & Biotechnology		4	4	+	3	25	75	100
	24	Theory /Core	Advanced Virology		4	4	+	3	25	75	100
	25	SDC	Industrial and Institutional Visit		2	1	-	6	50	50	100
	26	Practical	Practical – VII – Lab in Food Microbiology and Fermentation and Industrial Microbiology		6	3	-	9	50	50	100
	27	Practical	Practical – VIII - Lab in Genetic Engineering, Biotechnology and Advanced Virology		6	3	-	9	50	50	100
	28	SDC	Paper Publication / Presentation		-	1	-	6	50	50	100
	29	SDC	Comprehensive Viva Voce		-	1	-	6	50	50	100
			TOTAL		**120**	**90**			**1075**	**1825**	**2900**

Abbreviations: *Sem: Semester – No : Number* - *CCP: Core Course Project – ECP: Elective Course Project – EH: Examination Hours – CIA: Continuous Internal Assessment – ESE: End Semester Examination* - **# To be allotted by the university**

* Inclusive of Data collection, sample collection, sample processing, internal and external sample analysis, data analysis and result interpretation and report preparation which shall be done internally and externally.

(Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[`] Alumni Module [#] Industrial Module[@] Self Learning[*])

SDC : SKILL DEVELOPMENT COURSE - *$*

12. COURSE - PROGRAMME SPECIFIC OUTCOMES (PSOs) MAPPING

(BASED ON THE COURSES OF FIRST YEAR ONLY)

No	Course	PSO 1	PSO 2	PSO 3	PSO_4	PSO 5	PSO 6	PSO_7	TOTAL	Average	Average*
1	General Microbiology & Microbial Diversity	3.00	2.25	2.00	2.00	1.50	1.75	1.00	13.50	1.92	**2.00**
2	Microbial Biochemistry	1.00	2.50	2.50	1.25	0.50	1.75	0.75	10.25	1.46	**1.00**
3	Microbial Physiology & Metabolism	2.25	2.00	2.50	1.00	2.00	1.50	0.75	12.00	1.71	**2.00**
4	Biochemical Techniques & Bio Instrumentation	2.25	3.00	2.75	2.00	1.50	1.50	1.00	14.00	2.00	**2.00**
5	Microbial Nanotechnology	1.25	1.75	1.50	3.00	2.50	1.50	1.75	13.25	1.89	**2.00**
6	Intellectual Property Rights & Bioethics	0.50	0.00	1.50	1.75	1.50	3.00	2.50	10.75	1.53	**2.00**
7	Public Health Microbiology	1.75	1.50	2.00	0.25	1.00	2.00	3.00	11.50	1.64	**2.00**
8	Field Work	2.25	2.00	1.75	1.50	1.75	2.25	2.75	14.25	2.03	**2.00**
9	Practical I – General Microbiology &Microbial Diversity	2.75	2.25	1.50	0.25	1.50	1.75	1.25	11.25	1.60	**2.00**
10	Practical – II – Lab in Microbial Biochemistry and Microbial Physiology	2.25	2.50	2.25	1.00	1.50	1.75	1.50	12.75	1.82	**2.00**
11	Microbial Genetics and Molecular Biology	2.25	1.75	3.00	2.00	2.25	1.25	1.25	13.75	1.96	**2.00**
12	Immunology & Immuno-techniques	1.00	2.75	3.00	1.50	0.00	1.75	2.25	12.25	1.75	**2.00**
13	Research Methodology & Biostatistics	2.50	2.25	2.25	2.25	2.00	2.25	1.00	14.50/2.07	2.07	**2.00**
14	Biodegradation & Bio remediation	1.75	1.75	2.00	1.50	3.00	1.50	1.75	13.25	1.89	**2.00**
15	Microbial Quality Control in Industries	1.75	2.25	1.25	0.50	2.00	3.00	1.75	12.50	1.78	**2.00**
16	Entrepreneurship Microbiology	2.00	1.00	1.00	0.00	2.00	2.00	3.00	11.00	1.57	**2.00**
17	Microbes for Climate Change Control, Women Empowerment & Economy development	1.75	1.25	1.25	1.00	3.00	1.25	2.50	12.00	1.71	**2.00**
18	Internship	1.50	1.50	1.50	1.50	1.50	2.50	2.75	12.75	1.82	**2.00**
19	Practical – III Lab in Molecular biology	2.00	2.75	3.00	0.00	0.00	0.75	0.00	8.50	1.21	**1.00**
20	Practical – IV – Lab in Biostatistics and Immunology	0.25	1.75	3.00	0.00	0.00	1.25	2.75	8.00	1.14	**1.00**

** Rounder Value of the average of PSO*

The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*

First Year *1st Semester* *1 Core –Theory* *Credits 4*

GENERAL MICROBIOLOGY AND MICROBIAL DIVERSITY	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 (K1 & K2 – Remember & Understand): *Outline the history, evolution, and taxonomic classification of the microbial world, and describe the fundamental principles of microscopy, sterilization techniques, and the morphological characteristics of fungi, algae, and protozoa.*

CO2 (K3 – Apply): *Apply appropriate staining techniques, microscopy methods, and cultivation strategies, including media selection and isolation techniques, to effectively observe, identify, and maintain pure microbial cultures in a laboratory setting.*

CO3 (K4 – Analyze): *Analyze the structural and genetic differences between bacteria, archaea, and eukarya, and examine the efficacy of various physical, chemical, and biological control agents in eliminating specific microbial populations.*

CO4 (K5 & K6 – Evaluate & Create): *Evaluate the significance of taxonomic markers such as 16S rRNA sequencing and Bergey's Manual in microbial phylogeny, and design comprehensive protocols for the characterization and preservation of diverse microorganisms, including molds, lichens, and protozoa.*

L T P C

6 0 0 4

UNIT I – Evolution of Microorganisms & Microbiology

Members of the microbial world, Microbial evolution, Microbiology & it's origin and microbiology today - Scope, history & development of Microbiology – Characterization, Classification (Haeckel, Whittaker and Carl Woese) and Identification of Microorganisms – Comparison of bacteria, archaea & eukarya – Introduction to taxonomy: phenotypic classification, phylogenetic classification, genotypic classification, taxonomic ranks – Techniques for determining microbial taxonomy & phylogeny: Classical & molecular characteristics - Genetic relationship - DNA homology -16S rRNA sequencing + - Phylogenetic tree - Bergey's manual of systematic bacteriology.

UNIT II – Microscopy – It's Principles and Applications

Microscopy – It's principles and applications: Bright and dark field, phase contrast, fluorescence microscopy, TEM and SEM - Staining methods: Gram's, acid-fast, capsule, flagella spore, metachromatic granules, nuclear, silver impregnation & fungal staining.

UNIT III – Outline of Microbial Control Methods, Cultivation and Preservation of Microorganisms

Outline of microbial control methods - Methods of sterilization@: Physical control methods: heat, filtration and radiation, chemical control agents: phenolics, alcohol, halogens, heavy metals, quaternary ammonium compounds, aldehydes and sterilizing gases - biological control of microorganisms - Indicator microorganisms for sterilization methods - Cultivation of microorganisms - Culture media*: chemical and physical, functional types: supportive media (Transport), enriched media, selective media and differential media. Isolation of pure cultures: streak, spread and pour plate methods - Methods of preservation and maintenance of cultures – principle, applications and limitations of lyophilizer#.

UNIT IV – Fungi and Lichens

Fungi: Mold – General characters, morphology, nutrition and metabolism – reproduction – Classification of Fungi (Characters of selected groups) – Oomycetes- Zygomycetes – Ascomycetes – Basidiomycetes – Deuteromycetes. Lichens: General characters and economic importance.

UNIT V – Algae and Protozoa

Algae: Distribution, general characters, thallus and it's structure, nutrition and reproduction – Characters of selected groups – Blue green algae, Pyrrophyta, Euglenophyta, Chrysophyta, Phaeophyta and Rhodophyta. Protozoa: General characters, locomotion, nutrition, and reproduction – Characters of Sarcodina (Entamoeba histolytica) and Sporozoa (Plasmodium sp).

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module[@] Self Learning[*] Entrepreneurial module [$]

TEXTBOOKS:

1. Bernard D. Davis., Renato Dulbecco., Herman N. Elsen and Harold S. Ginsberg. (1990). Microbiology (4th edition). J.B. Lippincott Company, New York.
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3. Larry McKane and Judykandel (1996). Microbiology - Essentials and Applications. (2nd edition). McGraw Hill, New York.
4. Madigan M.T., Martinko, J. IVI and parker J. Brock T.D. (1997). Biology of microorganisms. (8th edition. Prentice hall international Inc, London.
5. Nester, E.W., Roberts, C.V., and Nester, M.Y. (1995). Microbiology. A Human perspective. IWOA, USA.
6. Salle, A.J. (1996). Fundamental Principles of Bacteriology. (7th edition). Tata McGraw-Hill Publishing Company Ltd., New Delhi.
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8. Stainer, R.Y., Ingraham, J.L., Wheelis, M.L. amd Painter, P.R. (1986). General Microbiology. MacMillan Education Ltd., London.
9. Starr, M.P., Stolp, H., Truper, H.C., Balows, A. and Schegel, H.C. (1991). The prokaryotes. A Handbook of Habitats, Isolation and Identification of Bacteria. Springer Verlag.
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11. Dubey, R.C. and Maheshwari, O.K., (2002). Practical Microbiology. S. Chand and Co Ltd., New Delhi.
12. John L. Ingraham and Catherine A. Ingrahani (2000). Introduction to Microbiology. Books / Cole Thomas Learning, New York.
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1. Holt, J.S. Kreig, N.R., Sneath, P.H.A. and Williams, S.T. (1994). Bergey's Manual of Determinative Bacteriology. (9th edition) – Williams & Wilkins, Balimore.
2. Brige E.A. (1992). Modern Microbiology – Wm C. Brown Publishers, Dubuque, U.S.A.
3. Goodfellow M. and O'Dennell A.C. (1994). Chemical methods in prokaryotic Systematics – John Wiley & Sons, New York.
4. Murray R.K., Granner M.D., Mayes P.A. and Rodewell V.W. (1990). Biochemistry – Prentice Hall International Inc., London.
5. Bryant D.A. (1994). The molecular Biology of Cyanabacteria. Kluwer Academic Publishers, London.
6. Gerhardt, P., Murray R. Ce., Wood, W.A. and Kreig, N.R. (ed) (1984). Methods for General and Molecular Bacteriology – American Society for Microbiology, Wahnington D.C.
7. Neidhardt, F.C. (ed) (1987). *Escherichia coli* and *Salmonella typhimurium* – Cellular and Molecular Biology (Vol.I). American Society for Microbiology, Washington D.C.
8. Hall, D.C. and Rao, K.K. (1995). Photosynthesis – Cambridge University Press.
9. Zubey C.L. Parson W.W. and vance D.E. (1994). Principles of Biochemistry – Wm.C. Brown Publishers, Oxford, England.
10. Mathews C.K. and Holde K.E.V. (1996). Biochemistry. The Benjamin / Cummings Publishing Company, Inc., New York.
11. Stryer L. (1995). Biochemistry. W.H. Freeman and Company, New York.

WEB RESOURCES:

1. https://www.microbe.net/resources/microbiology/web-resources/
2. https://www.omicsonline.org/medicalmicrobiology-diagnosis.php
3. guides.emich/immunology
4. http://oew.mit.edu/courses/.../hst-176-cellular-and molecular.
5. Immunology -fall-2005
6. https://serc.carleton.edu/microbelife/index.html
7. https://microbe.net/resources/microbiology-web-resources/
8. https://microbiologysociety.org/
9. https://open.umn.edu/opentextbooks/textbooks/404

JOURNAL RESOURCES:

General & Broad Microbiology

- Journal of Bacteriology (ASM): Focuses on fundamental processes in bacteria and archaea.
- Microbiology (Microbiology Society): Covers fundamental physiology, biochemistry, and genetics.
- Archives of Microbiology: Publishes basic research on microbial physiology and molecular biology.
- Antonie van Leeuwenhoek: Focuses on fundamental mechanisms, taxonomy, and theoretical microbiology.

Environmental & Evolutionary Basics

- Applied and Environmental Microbiology (AEM): Covers basic microbial ecology and environmental processes.
- FEMS Microbiology Ecology: Focuses on the basic ecology of natural microbial

Molecular & Cellular Mechanisms

- **Molecular Microbiology**: Focuses on molecular studies of gene expression and cell biology.
- **Cellular Microbiology**: Explores interactions between microbes and host cells at a molecular level.
- **FEMS Microbiology Letters**: Offers rapid publication of basic, short research communications.

High-Impact & Review Journals

- Nature Reviews Microbiology: Provides comprehensive reviews of fundamental and applied research.
- Microbiology and Molecular Biology Reviews (MMBR): Delivers deep, definitive reviews on basic mechanisms.
- Trends in Microbiology: Highlights emerging concepts and current debates in basic science.

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	***3***	***1***	***1***	***2***	***1***	***3***	***1***	***12***
CO2 (Apply/Observe)	***2***	***2***	***3***	***2***	***1***	***2***	***3***	***15***
CO3 (Analyze/Examine)	***2***	***3***	***2***	***3***	***2***	***2***	***1***	***15***
CO4 (Evaluate/Design)	***2***	***3***	***3***	***2***	***3***	***2***	***2***	***17***
Total PO Contribution	***9***	***9***	***9***	***9***	***7***	***9***	***7***	***59***
Average	***2.25***	***2.25***	***2.25***	***2.25***	***1.75***	***2.25***	***1.75***	***14.75/70.23***
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	3	2	1	0	1	1	1	**9**
CO2 (Apply/Observe)	3	3	2	0	1	2	1	**12**
CO3 (Analyze/Examine)	3	2	2	1	2	2	0	**12**
CO4 (Evaluate/Design)	3	2	3	1	2	2	2	**15**
Total PSO Contribution	**12**	**9**	**8**	**2**	**6**	**7**	**4**	48
Average of PSO	**3.00**	**2.25**	**2.00**	**2.00**	**1.50**	**1.75**	**1.00**	12/57.14
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year *1st Semester* *2 Core –Theory* *Credits 4*

MICROBIAL BIOCHEMISTRY	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 (K1 & K2 – Remember & Understand): *Identify and describe the fundamental structures, nomenclature, and properties of carbohydrates, lipids, proteins, enzymes, and nucleic acids, along with basic clinical laboratory protocols.*

CO2 (K3 – Apply): *Apply biochemical principles to determine the behavior of biomolecules (such as mutarotation or enzyme kinetics) and execute standard procedures for clinical specimen collection and preservation.*

CO3 (K4 – Analyze): *Analyze the structural relationships and functional differences between various classes of macromolecules, including the differentiation of DNA/RNA forms and the impact of factors on enzyme-catalyzed reactions.*

CO4 (K5 & K6 – Evaluate & Create): *Evaluate the clinical significance of biochemical data and design or justify quality control measures and auto-analytical methods for accurate diagnostic reporting in a clinical setting.*

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UNIT I – Carbohydrates

Carbohydrates: Monosaccharide and their relationship – Structure of Sugars: steroisomerism and optical isomer of sugars. Reactions of aldehyde and ketone groups, ring structure, tautomeric forms, mutarotation and reactions of sugars in OH groups – Disaccharides – structure, occurrence and biological importance: Maltose, Sucrose, Lactose & Inversion of sucrose. Structural polysaccharides: Homopolysaccharides and Heteropolysaccharides and Mucopolysaccharides – Cellulose, Chitin, Inulin, Glycogen, Hyaluronic acid, Chondroitin sulfates, Heparin, Dermatan sulfate and Keratan sulfate. Blood group substances.

UNIT II – Lipids

Lipids: Definition, detailed classification of lipids – Components of lipids: Fatty acids and Glycerals – Types of Fatty acids*: Essential and Non Essential – Triglycerols – Properties, types and their functions: Phospholipids, Glycolipids, Lipoproteins and Steroids.

UNIT III – Proteins and Enzymes

Elemental composition of protein, building blocks. Amino acids: classification based on their nature & requirements – selenocysteine – physical and chemical properties of amino acids - Peptide bond - classification, structure & properties of proteins: Functional, Solubility & Nutritional. Enzymes: Types based on their action - Mechanism of enzyme

action – factors influencing enzyme action – Michaelis-Menton Hypothesis%. A brief view over co- enzymes and Isoenzyme.

UNIT IV – Nucleic Acids

Nucleic Acids - brief history - nucleotides: Components, Types, Tautomeric Forms, Nomenclature & analogs. Different forms, structure and functions of DNA & RNA. Principle and role of Chemicals & buffers used in Genetic material studies+.

UNIT V – Clinical Biochemistry Laboratory

Clinical Biochemistry Laboratory – Collection of Blood: Anticoagulants, Hemolysis & Preservation of Blood Specimens. Types of laboratory tests – Collection of urine – cerebrospinal fluid (CSF) – Quality control methods – Autoanalysis in clinical chemistry – Analysis in clinical biochemistry laboratory and reference values@.

Inter Departmental Expertise Module% - Inter Institutional Expertise Module & Researcher Module+ Alumni Module # Industrial Module @ Self Learning Entrepreneurial module $*

TEXTBOOKS RECOMMENDED:

1. Stryer, L. (Ed) (1995). Biochemistry W.H. Freeman and Company, New York.
2. Donald Voet and Judith voet. (1990). Biochemistry. John Wiley and Sons, New York.
3. Henry, R., Mahler and Eugene – H. Cerdesz (1966). Biological Chemistry. Harper Internationsl Edition, New York.
4. Hubert Stryer (1995). Biochemistry – Freeman and Company, New York.
5. Dawn B. Markus (1994). Biochemistry. Harwad – Publishing, New York.
6. William. J. Marshall and Stephan K. Bangert. (1995). Clinical Biochemistry – Metabolic and Clinical Aspects – Churchill Livingston, New York.
7. Harper's Biochemistry, prentice – Hall International, INC Singapore.
8. Zubey C.L., Parson, W.W. and Vans, D.E. (1994). Principles of Biochemistry, Wm C. Brown Publ., England.
9. Talaro. K.P. and Talaro, A. (1999). Foundations of Microbiology. WCP McGraw – Hill, New York.
10. Lehninger, Nelson and Cox (2002). Principles of Biochemistry CBS Publishing and Distributors.
11. Caldwell, D.R. (1995). Microbial Physiology and Metabolism, Wm. C. Brown Publishers, USA.
12. Lansing M. Prescott, John P. Harley and Donald A. Klein (2003). Microbiology (5th edition). McGraw – Hill Company, New York
13. Larry McKane and Judy Kandel (1996). Microbiology – Essentials and Applications. (2nd edition). McGraw – Hill Inc, New York
14. Moat, A.G and Foster J.W. (1998). Microbial Physiology (2nd edition). Jihn Wiley and Sons, New York.
15. PelczarJr.,M.J., Chan E.C.S. and Kreig, N.R. (1993). Microbiology. McGraw Hill Inc., New York.
16. Salle, A.J. (1996). Fundamental Principles of Bacteriology (7th edition). Tata McGraw Hill Publishing Company Limited, New Delhi.
17. White, D. (1995). The Physiology and Biochemistry of prokaryotes. Oxford University Press. Oxford, New York.
18. Madigan M.T., Martinko, J. IVI and parker J. Brock T.D. (1997). Biology of microorganisms. (8th edition. Prentice hall international Inc, London.

19. Nester, E.W., Roberts, C.V., and Nester, M.Y. (1995). Microbiology. A Human perspective. IWOA, USA.
20. Veerakumari L. (2006). Bioinstrumentation. MJP Publishers, Chennai.
21. MeenaKumari. S. (2006). Microbial Physiology. MJP Publishers, Chennai.
22. Christopher K. Mathews and Van Holde, K.E. (1996). Biochemistry (2nd edition). The Benjamin / Cummings Publishing Company.
23. David E. Metzler and Coral M. Metzler (2001). Biochemistry – The chemical reactions of living cell – Vol 1 and 2 (2nd edition). Harcourt / Academic Press, New York.
24. Donald Voet and Judith voet. (1995). Biochemistry. (2nd edition). John Wiley and Sons Inc., New York.
25. Freifelder D. (1996). Molecular Biology. (2nd edition). Narosa Publishing House, New Delhi.
26. Geofferey, L. and Zubey, C.L. (1998). Biochemistry (4th edition). Wm. C. Brown Publishers.
27. Jeremy M. Berg, John L. Tymoczko and LubertStryer (2002). Biochemistry (5th edition). W.H. Freeman and Company, New York.
28. LubertStryer (1995). Biochemistry (4th edition). W.H. Freeman and Company, New York.
29. Reginald, h., garret and Charles M. Grishm. (199*8). Biochemistry (2nd edition). Saundars College Publishing.
30. Thomas S. Devlin. (2002). Textbook mof Biochemistry with Clinical Correlations (5th edition). John Willey and Sons Inc. Publication, New York.
31. Trudy Mckee and James R.Mc. Kee (1999). Biochemistry – An Introduction (2nd edition). WCB McGraw – Hill, U.S.A.

WEB RESOURCES:

1. https://onlinelearning.hms.harvard.edu/hmx/courses/biochemistry
2. https://openlearning.mit.edu/mit-faculty/residential-digital-innovations/online-resources-biochemistry-enhance-learning-well
3. https://nnlm.gov/data/guides/life-sciences/biochemistry
4. https://open.oregonstate.education/biochemfreeforall/chapter/introduction/
5. https://onlinecourses.swayam2.ac.in/cec19_bt02/preview

JOURNAL RESOURCES:

1. Biochemistry and Molecular Biology Education (BAMBED)
2. Journal of Chemical Education (JCE)
3. Journal of Microbiology & Biology Education (JMBE)
4. Trends in Biochemical Sciences (TIBS)
5. Indian Journal of Medical Biochemistry (IJMB)

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	3	1	1	2	1	1	1	**10**
CO2 (Apply/Observe)	2	2	3	2	2	1	1	**13**
CO3 (Analyze/Examine)	2	3	2	3	1	2	1	**14**
CO4 (Evaluate/Design)	2	3	3	2	3	3	3	**19**
Total PO Contribution	**9**	**9**	**9**	**9**	**7**	**7**	**6**	***56***
Average of PO Contribution	**2.25**	**2.25**	**2.25**	**2.25**	**1.75**	**1.75**	**1.50**	***14/66.66***
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	1	2	2	1	1	1	0	**8**
CO2 (Apply/Observe)	1	3	3	1	0	2	1	**11**
CO3 (Analyze/Examine)	2	2	3	2	1	1	0	**11**
CO4 (Evaluate/Design)	0	3	2	1	0	3	2	**11**
Total PO Contribution	**4**	**10**	**10**	**5**	**2**	**7**	**3**	*41*
Average of PSO Contribution	**1.00**	**2.50**	**2.50**	**1.25**	**0.50**	**1.75**	**0.75**	**10.25/48.80**
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year *1st Semester* *3 Core –Theory* *Credits 4*

MICROBIAL PHYSIOLOGY AND METABOLISM	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1: K1 & K2 (Remember & Understand): Describe and explain the fundamental structural components of microbial cells, nutritional requirements, metabolic pathways, and the principles of bacterial growth and sporulation.

CO2: K3 (Apply): Apply knowledge of microbial transport mechanisms, bioenergetics, and nitrogen fixation to solve problems related to microbial cultivation and metabolic efficiency.

CO3: K4 (Analyse): Analyze the structural and functional differences between diverse microbial systems, including cell wall compositions, aerobic vs. anaerobic respiratory chains, and photosynthetic mechanisms across different bacterial species.

CO4: K5 & K6 (Evaluate & Create): Evaluate the impact of various physical and chemical factors on microbial growth kinetics and design optimized strategies for large-scale cultivation (batch/continuous) or specialized metabolic processes.

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UNIT I – Cell Structure and Organization

Extracellular components: Capsule, slime layer, sheath, flagella and pili – Structure & Functions. Cell wall & Cell membrane: Archae bacteria, Gram positive & Gram negative – Structure & Functions. Intracellular membranes – Structure & functions. Biosynthesis of PG layer. Cytoplasm and it's inclusions*. Genetic materials: nucleoid.

UNIT II – Microbial Nutrition and Metabolism

Major nutritional types - Nutrients Transport: Simple, passive & facilitated diffusion, Active transport: symport & antiport, group translocation & iron transport - Introduction to metabolism - metabolic pathways like glycolysis, TCA cycle, EMP, ED & glyoxylate cycle. Respiration: Aerobic - ETS and it's components – oxidative & substrate level phosphorylation - Chemiosmosis theory.

UNIT III – Anaerobic Respiration and Fermentation

Anaerobic types of respiration – Nitrate, Sulphate respiration & diversity of anaerobic final electron acceptors. Fermentation&: Alcoholic, lactic acid, propionic, mixed acid, butanediol, butyric acid, and methanogenesis - Pasteur effect. Bioluminescence.

UNIT IV – Photosynthesis and Nitrogen Fixation

Photophosphorylation: oxygenic and anoxygenic – Cyclic and acylic ETS, Photosynthetic and accessory pigments. Photosystems of purple sulphur, purple non-sulphur and green sulphur bacteria. Halobacterial photosynthesis – bacterial rhodopsin. Nitrogen fixation: Symbiotic, asymbiotic and associative. Nitrogenase - mechanism of nitrogen fixation, heterocyst and Nif genes.

UNIT V – Bacterial Growth and Sporulation

Bacterial growth: Binary fission, Growth curve, Auxenic, synchronous, asynchronous cultures. Batch, fed batch & continuous cultures: chemostat and turbidostat. Factors affecting growth: Physical, chemical and biological. Spore: endo and exospores. Endospore: structure, factors influencing sporulation, process of sporulation and a bird's eye view on spore genes.

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module [@] Self Learning[*] Entrepreneurial module [$]

TEXTBOOKS :

1. Talaro. K.P. and Talaro, A. (1999). Foundations of Microbiology. WCP McGraw – Hill, New York.
2. Caldwell, D.R. (1995). Microbial Physiology and Metabolism, Wm. C. Brown Publishers, U.S.A.
3. Lansing M. Prescott, John P. Harley and Donald A. Klein (2003). Microbiology (5th edition). McGraw – Hill Company, New York
4. Larry McKane and Judy Kandel (1996). Microbiology – Essentials and Applications. (2nd edition). McGraw – Hill Inc, New York
5. Moat, A.G and Foster J.W. (1998). Microbial Physiology (2nd edition). Jihn Wiley and Sons, New York.
6. PelczarJr.,M.J., Chan E.C.S. and Kreig, N.R. (1993). Microbiology. McGraw Hill Inc., New York.
7. Salle, A.J. (1996). Fundamental Principles of Bacteriology (7th edition). Tata McGraw Hill Publishing Company Limited, New Delhi.
8. White, D. (1995). The Physiology and Biochemistry of prokaryotes. Oxford University Press. Oxford, New York.
9. Madigan M.T., Martinko, J. IVI and parker J. Brock T.D. (1997). Biology of microorganisms. (8th edition. Prentice hall international Inc, London.
10. Nester, E.W., Roberts, C.V., and Nester, M.Y. (1995). Microbiology. A Human perspective. IWOA, USA.
11. Mariappan C. (2010). A textbook of general microbial physiology, biochemistry and metabolism. Pooja Publishers, India.
12. MeenaKumari. S. (2006). Microbial Physiology. MJP Publishers, Chennai.
13. Jeremy M. Berg, John L. Tymoczko and LubertStryer (2002). Biochemistry (5th edition). W.H. Freeman and Company, New York.

WEBRESOURCES:

1. https://www.classcentral.com/course/swayam-microbial-physiology-and-metabolism-19950
2. https://onlinecourses.swayam2.ac.in/cec20_bt14/preview
3. https://nature.berkeley.edu/advising/majors/nutritional-sciences-physiology-metabolism

4. https://www.accessscience.com/content/bacterial-physiology-and-metabolism/069000

JOURNAL RESOURCES:

Microbial Cell Structure and Physiology

● Journal of Bacteriology (ASM): Focuses on bacterial cell structure, cell wall biosynthesis, membrane biology, and microbial physiology.
● Microbiology (Microbiology Society): Covers microbial cell organization, physiology, metabolism, and genetics.
● Archives of Microbiology: Publishes research on microbial structure, physiology, and biochemical functions.

Microbial Metabolism and Bioenergetics

● Journal of Biological Chemistry (JBC): Covers enzymology, metabolic pathways, and energy metabolism.
● FEMS Microbiology Letters: Publishes studies on microbial metabolism, transport systems, and respiration.
● Applied and Environmental Microbiology (AEM): Includes microbial metabolic diversity and ecological functions.

Respiration, Fermentation and Energy Production

● Molecular Microbiology: Focuses on molecular mechanisms of respiration, fermentation, and energy conservation.
● Environmental Microbiology: Covers microbial respiratory processes and anaerobic metabolism in diverse environments.
● Microbial Physiology and Metabolism Research: Explores electron transport systems, ATP synthesis, and bioenergetics.

Photosynthesis and Nitrogen Fixation

● Photosynthesis Research: Dedicated to oxygenic and anoxygenic photosynthesis and photophosphorylation.
● Journal of Photochemistry and Photobiology B: Covers photosynthetic pigments and microbial photobiology.
● FEMS Microbiology Ecology: Focuses on nitrogen fixation, microbial ecology, and nutrient cycling.

Bacterial Growth, Sporulation and Development

● Journal of Bacteriology (ASM): Publishes studies on bacterial growth kinetics, sporulation, and developmental biology.
● Microbiology Spectrum (ASM): Covers microbial growth, physiology, and cellular differentiation.
● Antonie van Leeuwenhoek: Focuses on microbial taxonomy, physiology, and life-cycle studies.

High-Impact & Review Journals

● Nature Reviews Microbiology: Provides authoritative reviews on microbial physiology, metabolism, and molecular biology.
● Microbiology and Molecular Biology Reviews (MMBR): Offers comprehensive reviews on microbial growth, bioenergetics, and cell biology.
● Trends in Microbiology: Highlights emerging concepts in microbial physiology, metabolism, and evolution.

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	3	1	1	1	1	2	1	**10**
CO2 (Apply/Observe)	2	2	3	2	1	2	1	**13**
CO3 (Analyze/Examine)	2	3	2	2	1	2	1	**13**
CO4 (Evaluate/Design)	2	3	3	3	2	3	2	**18**
Total PO Contribution	***9***	***9***	***9***	***8***	***5***	***9***	***5***	***13.5***
Average PO Contribution	**2.25**	**2.25**	**2.25**	**2.0**	**1.25**	**2.25**	**1.25**	***64.28 (54/84)***
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	3	1	2	0	1	1	0	**8**
CO2 (Apply/Observe)	2	2	3	1	2	1	1	**12**
CO3 (Analyze/Examine)	3	2	3	1	2	1	0	**12**
CO4 (Evaluate/Design)	1	3	2	2	3	3	2	**16**
Total PO Contribution	**9**	**8**	**10**	**4**	**8**	**6**	**3**	*48*
Average PSO Contribution	**2.25**	**2.00**	**2.50**	**1.0**	**2.00**	**1.50**	**0.75**	*12.00/57.14*
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year	*1st Semester*	*4. Elective 1 – Theory*	*Credits 3*

BIOCHEMICAL TECHNIQUES & BIO INSTRUMENTATION	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1: K1 & K2 (Remember & Understand): Describe the principles, instrumentation, and working mechanisms of biochemical laboratory equipment, spectroscopic instruments, chromatographic and electrophoretic separation methods, molecular biology workflows, and advanced analytical techniques across all units.

CO2:K3 (Apply) *Apply foundational laboratory concepts, calibration steps, and validation protocols to prepare standard/buffer solutions, operate analytical instruments, execute separation techniques, and perform molecular and biochemical assays across all units.*

CO3: K4 (Analyse) *Analyze experimental parameters, separation patterns, spectra, and molecular data obtained from spectroscopic, chromatographic, electrophoretic, PCR, blotting, and diagnostic techniques to differentiate and interpret biochemical samples across all units.*

CO4: K5 & K6 (Evaluate & Create)*Evaluate the performance, limitations, and suitability of specific analytical methodologies, biosensors, and AI-driven instrumentation for given biochemical challenges, and design comprehensive experimental strategies or diagnostic workflows to solve research problems across all units.*

UNIT I – Spectrophotometry and Related Analytical Techniques

pH meter – titration curve and measurement – principles, laws of absorbtion and radiation, visible, ultraviolet, infrared and mass spectrophotometry – Absorption spectrum, flame photometry – principles of colorimetry, turbidometry and viscometry.

UNIT II – Centrifugation Techniques

Principles of centrifugation – centrifugation techniques - preparative and analytical methods, density gradient centrifugation – types of rotors – Safety aspects in the use of centrifuges.

UNIT III – Chromatographic Techniques

General principles and application of chromatography: Partition (Paper, Thin layer & Gas chromatography), Adsorption (column Chromatography), Ion exchange, Gel filtration, Affinity & High performance liquid chromatography.

UNIT IV – Electrophoresis and Band Analysis

Electrophoresis – horizontal and vertical – moving boundary, zone (paper and gel) electrophoresis – immuno electrophoresis – Rocket immuno electrophoresis – iso electric focusing – Applications of electrophoresis: AGE and SDS-PAGE. An overview on the analysis of bands: direct photometric scanning, staining methods, radiolabelling, autoradiography, enzyme assay, immunological methods, blotting & detection.

UNIT V – Advanced Instrumentation and Radioisotopic Techniques

Advanced instrumentation – IR spectroscopy, Raman spectroscopy, X ray Spectroscopy, NMR & AAS – principles, component structure and applications. An overview on radio isotopic technique. Detection and measurement of Radioactivity – Safety aspects of radio isotopic techniques*.

Inter Departmental Expertise Module% - Inter Institutional Expertise Module & Researcher Module+ Alumni Module # Industrial Module@ Self Learning Entrepreneurial module $*

TEXTBOOKS RECOMMENDED:

1. Jayaramam . J. (1985) Laboratory Manual in Biochemistry. Wiley Eastern Ltd., New Delhi.
2. Plummer, D.T. (1998). An Introduction to practical Biochemistry. Tata McGraw Hill, New Delhi.
3. Palanivelu P. (2001). Analytical Biochemistry and Separation techniques – A Laboratory Manual.
4. Keith Wilson and Walker. J. (2003). Practical
5. Biochemistry – Cambridge University Press.
6. Veerakumari L. (2006). Bioinstrumentation. MJP Publishers, Chennai.

WEB RESOURCES

1. https://en.wikipedia.org/wiki/Chromatography
2. https://en.wikipedia.org/wiki/PH_meter
3. https://byjus.com/chemistry/uses-of-colorimeter/
4. https://byjus.com/chemistry/spectrophotometer-principle/
5. .https://www.researchgate.net/publication/277776146_20_Webster_J_G_ed_Bioinstrumentation_John_Wiley_Sons_New_York_2004
6. https://byjus.com/chemistry/types-of-electrophoresis/
7. https://en.wikipedia.org/wiki/Fourier-transform_infrared_spectroscopy#:~:text=Fourier%2Dtransform%20infrared%20spectroscopy%20(FTIR,over%20a%20wide%20spectral%20range.
8. https://www.open.edu/openlearn/ocw/mod/oucontent/view.php?id=83459&section=2.2#:~:text=IR%20spectroscopy%20detects%20the%20absorption,bond%20are%20not%20shared%20equally.
9. https://byjus.com/chemistry/infrared-spectroscopy/
10. https://lab-training.com/aas/
11. https://webstor.srmist.edu.in/web_assets/srm_mainsite/files/files/BIO217_BASIC_BIOTECHNOLOGY_LAB_MANUAL1.pdf

JOURNAL RESOURCES

Spectroscopy, Colorimetry and Analytical Biochemistry

- Analytical Biochemistry
- Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy
- Journal of Biochemical and Biophysical Methods

Centrifugation and Laboratory Techniques

- Journal of Visualized Experiments (JoVE)
- Analytical Methods
- Methods in Molecular Biology

Chromatography and Separation Science
- Journal of Chromatography A
- Journal of Chromatography B
- Journal of Separation Science

Electrophoresis and Molecular Analysis
- Electrophoresis
- Journal of Proteome Research
- Clinical Chemistry and Laboratory Medicine

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	3	1	1	2	1	2	1	**11**
CO2 (Apply/Observe)	2	2	3	2	1	2	2	**14**
CO3 (Analyze/Examine)	2	3	3	3	1	2	2	**16**
CO4 (Evaluate/Design)	3	3	3	3	2	3	3	**20**
Total PO Contribution	**10**	**9**	**10**	**10**	**5**	**9**	**8**	**61 / 84**
Average PO Contribution	***2.50***	***2.25***	***2.50***	***2.50***	***1.25***	***2.25***	***2.00***	**72.6**
The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	2	3	2	1	1	1	0	**10**
CO2 (Apply/Observe)	2	3	3	2	1	2	1	**14**
CO3 (Analyze/Examine)	3	3	3	2	2	1	1	**15**
CO4 (Evaluate/Design)	2	3	3	3	2	2	2	**17**
Total PO Contribution	**9**	**12**	**11**	**8**	**6**	**6**	**4**	*56*
Average of PSO Contribution	**2.25**	**3.00**	**2.75**	**2.00**	**1.50**	**1.50**	**1.00**	*14.00/66.66*
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year	*I Semester*	*4. Elective 2 – Theory*	*Credits 3*

MICROBIAL NANOTECHNOLOGY	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Outcome Statement: Recall foundational concepts and explain the classification, synthesis approaches, characterization techniques, and diverse applications of microbial nanotechnology across environmental, medical, and industrial sectors.*

CO2 K3 (Apply) *Outcome Statement: Apply green synthesis approaches, optimization parameters, and stabilization techniques to carry out the biosynthesis of metallic nanoparticles and implement them in targeted drug delivery, bioremediation, and food preservation systems.*

CO3 K4 (Analyze) Outcome Statement: Analyze spectral and microscopic data (UV-Vis, FTIR, XRD, SEM, TEM) to determine nanoparticle properties, and differentiate between the structural, cytotoxic, and ecological impacts of various nanomaterials.

CO4 K5 & K6 (Evaluate & Create) *Outcome Statement: Evaluate the biosafety, ethical implications, and environmental fates of engineered nanomaterials, and design sustainable, advanced nanobiotechnological solutions integrating AI, smart packaging, or nanodiagnostics for future biomedical and industrial challenges.*

L T P C	***6 0 0 4***

UNIT I – Fundamentals of Nanotechnology and Microbial Nanoparticle Synthesis

History and scope of nanotechnology*, classification of nanomaterials, physical and chemical properties of nanoparticles, concepts of nanoscale science, top-down and bottom-up approaches for nanoparticle synthesis, microbial nanotechnology and nanobiotechnology, interaction of microbes with nanomaterials, role of bacteria, fungi, algae, yeast, actinomycetes and viruses in nanoparticle synthesis, intracellular and extracellular synthesis mechanisms, advantages of biological nanoparticle synthesis over conventional methods.

UNIT II – Biosynthesis and Characterization of Nanoparticles

Isolation and screening of nanoparticle-producing microorganisms, biosynthesis of metallic nanoparticles including silver, gold, copper oxide, zinc oxide, iron oxide and titanium dioxide nanoparticles using microbes, optimization of nanoparticle synthesis parameters, green synthesis approaches, nanoparticle stabilization and capping agents, characterization techniques including UV-Visible spectroscopy, FTIR spectroscopy, X-ray diffraction (XRD), Dynamic Light Scattering (DLS), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Energy Dispersive X-ray Spectroscopy (EDX), zeta potential analysis and particle size analysis.

UNIT III – Biomedical Applications and Safety of Nanomaterials

Antimicrobial nanoparticles and mechanisms of action, antibiofilm activity, nanoantibiotics, nanoparticle-mediated drug delivery systems, nanoencapsulation, targeted drug delivery, nanoparticles in cancer therapy, nanotechnology in vaccine development, wound healing applications, nanotoxicology, cytotoxicity assessment, biosafety and ethical concerns associated with nanomaterials.

UNIT IV – Environmental and Agricultural Nanotechnology

Nanotechnology in bioremediation, microbial degradation of heavy metals and pollutants using nanomaterials, nano-enabled wastewater treatment, nanotechnology in soil microbiology, nano-biofertilizers, nano-pesticides, nanoparticle-assisted plant disease management, microbial fuel cells, biosorption and bioaccumulation, environmental fate and ecological impact of nanoparticles, sustainable approaches in environmental nanotechnology.

UNIT V – Industrial and Emerging Applications of Nanotechnology

Nanotechnology in food microbiology, nano-based food preservation systems, smart packaging materials, industrial enzymes and immobilization techniques using nanoparticles, nanotechnology in fermentation industries, nanodiagnostics, nanoelectronics in biological systems, nanorobotics in medicine, proteomics and nanoproteomics, nanotechnology in synthetic biology, AI and automation in nanobiotechnology, recent advances and future prospects of microbial nanotechnology.

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module [@] Self Learning[*] Entrepreneurial module [$]

REFERENCE BOOKS:

1. Nanobiotechnology: Concepts, Applications and Perspectives

Niemeyer, C.M. and Mirkin, C.A. Wiley-VCH Publishers, 2004.

2. Nanotechnology: Principles and Practices. Kulkarni, S.K.

Springer Publishers, 2015.

3. Microbial Nanotechnology, Rai, M. and Duran, N. Springer Publishers, 2013.

4. Nanobiotechnology Niemeyer, C.M. and Mirkin, C.A. Wiley Publishers, 2007.

5. Nanotechnology in Biology and Medicine Vo-Dinh, T. CRC Press, 2017.

6. Environmental Nanotechnology Wiesner, M. and Bottero, J.Y. McGraw Hill Education, 2007.

7. Nanotechnology and Food Safety Abd-Elsalam, K.A. and Prasad, R.

Springer Publishers, 2015.

8. Biosensors and Nanotechnology Serra, P.A. CRC Press, 2014.

9. Nanotechnology: An Introduction Ramsden, J. Elsevier Publishers, 2016.

WEB RESOURCES:

NCBI – https://www.ncbi.nlm.nih.gov

PubMed – https://pubmed.ncbi.nlm.nih.gov

ScienceDirect – https://www.sciencedirect.com

Springer Link – https://link.springer.com

Nature Nanotechnology –https://www.nature.com/nnano/

Nano.gov – https://www.nano.gov

Microbe Notes – https://microbenotes.com

NPTEL – https://nptel.ac.in

SWAYAM – https://swayam.gov.in

JOURNAL RESOURCES:

1. Top Review & High-Impact Journals (Best for Concept Overviews)
    - Nature Nanotechnology
    - Nano Today
2. Accessible & Open-Access Journals (No Library Subscription Required)
    - Frontiers in Nanotechnology (Biomedical Nanotechnology Section)
    - Journal of Nanobiotechnology

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	3	1	1	2	1	2	1	**11**
CO2 (Apply/Observe)	2	2	3	2	1	2	2	**14**
CO3 (Analyze/Examine)	2	3	3	3	1	3	1	**16**
CO4 (Evaluate/Design)	3	3	3	3	3	3	3	**21**
Total PO Contribution	**10**	**9**	**10**	**10**	**6**	**10**	**7**	**62/84**
Average PO Contribution	***2.50***	***2.25***	***2.50***	***2.50***	***1.25***	***2.50***	***1.75***	**16.21** **73.80**
The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	2	1	1	3	2	1	1	**11**
CO2 (Apply/Observe)	1	2	2	3	3	1	2	**14**
CO3 (Analyze/Examine)	1	3	1	3	2	1	1	**12**
CO4 (Evaluate/Design)	1	1	2	3	3	3	3	**16**
Total PO Contribution	**5**	**7**	**6**	**12**	**10**	**6**	**7**	*53*
Average of PSO Contribution	**1.25**	**1.75**	**1.50**	**3.00**	**2.50**	**1.50**	**1.75**	*13.25/63.09*
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year	***I Semester***	***4 Elective 3- Theory***	***Credits 3***
INTELLECTUAL PROPERTY RIGHTS & BIOETHICS			***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Understand the core concepts of various Intellectual Property Rights (IPRs), patenting processes, international treaties (TRIPS, WTO, WIPO), patentability criteria for biotechnological inventions, and the fundamental ethical and social issues associated with biodiversity, GMOs, medical research, and clinical trials.*

CO2 K3 (Apply) *Apply the knowledge of patent filing procedures, PCT applications, and search methodologies using global patent databases (USPTO, EPO, Indian Patent Office) to map patent landscapes and navigate international conventions for biotechnological innovations and bioethical compliance.*

CO3 K4 *(Analyze) Analyze the patentability of biotechnological inventions under the Indian Patent Act 1970 (amended 2005), the territorial versus global nature of patent regimes, and the complex bioethical dilemmas surrounding genetic modifications, gene pool contamination, and clinical research protocols.*

CO4 K5 & K6 *(Evaluate & Create) Evaluate and Assess the socio-economic implications of a uniform global patent system, the ethical boundaries of emerging medical technologies (cloning, stem cell research, gene therapy), and the adherence of clinical practices to established international guidelines like the Nuremberg Code.*

L T P C ***6 0 0 3***

UNIT I – Fundamentals of Intellectual Property Rights

Intellectual Property Rights: Different forms of Intellectual Property Rights their relevance, importance to industry, Academia. Role of IPR's in Biotechnology, Patent Terminology Patents, trademarks, copyrights, industrial designs, geographical indications, trade secrets, nondisclosure 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 – Patent Search and Filing Procedures

Process involved in patenting. Patent Search - Procedural steps in patenting, process of filing, PCT application, pregnant and 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 – Biotechnology Patents and Global Patent Regime

Patentability of biotechnology inventions – Indian scenario, statutory provisions regarding biotechnological inventions under the current Patent Act 1970 (as Amended 2005). Biotechnological inventions as patentable subject matter, territorial nature of patents from territorial to global patent regime, interpreting trips in the light of biotechnology inventions, feasibility of a uniform global patent system, merits and demerits of uniform patent law, relevance of the existing international patent, tentative harmonisation efforts, implications of setting up a uniform world patent system.

UNIT IV – Bioethics, Biodiversity and GMOs

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 and GMO's issues and concerns pertaining to genetically modified foods and food crops, organisms and their possible health implications and mixing up with the genepool.

UNIT V – Bioethics in Medicine and Research

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.

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module [@] Self Learning[*] Entrepreneurial module [$]

REFERENCE BOOKS:

1. GIick, B.R., Pasternak, J.J. 2003. Molecular Biotechnology – Principles and Applications of Recombinant DNA, ASM Press, Washington DC.
2. Winnacker, E.L. 2003. From Genes to Clones – Introduction to Gene Technology. First Indian reprint, PANIAMA publishing Co-operation, New Delhi. 2003.
3. Elsa Cooper. 2009. Microbial biotechnology. Syrawood Publishing House.
4. Padma Singh. 2009. Recent Trends in Microbial Biotechnology, CBS Publishers and Distributors.
5. Sandeep Gupta., Pawan Kumar B. 2016. Bioremediation and Microbial Biotechnology. Discovery Publishing House.
6. Swarna Latha, C. D., Bhaskara Rao, D. 2007. Microbial Biotechnology. Discovery Publishing House.
7. Ratul Saikia. 2008. Microbial Biotechnology. New India Publishing Agency.

8. Brown, T.A. 2001. Gene cloning and DNA analysis introduction, 4th edition, Blackwell Science Ltd, London.
9. Raledge, C., Kristiansen, B. 2001. Basic Biotechnology, 2nd edition, Cambridge University Press.
10. Puvanakrishnan, R., Sivasubramanian, S., Hemalatha,T. 2021. Microbial Techology, 1st edition. MJP publishers.
11. Borowitzka, M.A. Borowitzka, L.J. 1989. Microalgal Biotechnology, Cambridge University Press.
12. Glazer, A.N., Nikaido, H. 1994. Microbial Biotechnology – Fundamentals of Applied Microbiology, WH Freeman and Company, New York.

TEXT BOOKS:

1. Bioethics – S.Ignacimuthu, S.J – Narosa Publishers
2. IPR, Biosafety and Bioethics, 1st Edition- Deepa Goel and Shaini Parashar - Publisher: Pearson Education India
3. Bioethics and Biosafety , Edition - M. K. Sateesh - I.K. International Publishing House Pvt. Ltd.
4. Textbook of Bioethics, Biosafety and IPR - Latest Revised Edition - Na. Vikraman - Publisher: Best Publishers
5. Law Relating to Intellectual Property Rights - 5th Edition - V. K. Ahuja - LexisNexis India
6. Title: Biosafety and Bioethics - 1st Edition - Rajmohan Joshi - Gyan Publishing House

WEB RESOURCES :

1. https://www.biotechnologynotes.com/industrial-biotechnology/anaerobic fermentations/production-process-of-ethyl-alcohol-production-and applications-anaerobic-fermentations/13723
2. https://archive.nptel.ac.in/courses/102/105/102105058/
3. https://www.biologydiscussion.com/biotechnology/microbial-polysaccharides-application-production-and-features/10412

JOURNAL RESOURCES:

Bioethics & Biotech Policy (Best for the Ethical & Social Angle)

- The American Journal of Bioethics (AJOB)
- Journal of Medical Ethics
- Bioethics

2. Intellectual Property & Law Journals (Best for Patents & Biopiracy)

- Journal of Intellectual Property Rights (JIPR)

- Nature Biotechnology (Patents & Regulatory Sections)

3. Applied Biosafety & Biorisk (Best for Lab Safety & Containment)
    - Applied Biosafety: Journal of ABSA International
    - Frontiers in Bioengineering and Biotechnology (Biosafety and Biosecurity section)

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	3	1	0	2	3	1	1	**11**
CO2 (Apply/Observe)	2	2	3	2	2	3	1	**15**
CO3 (Analyze/Examine)	2	3	3	2	3	2	1	**16**
CO4 (Evaluate/Design)	3	3	2	3	3	1	2	**17**
Total PO Contribution	**10**	**9**	**8**	**9**	**11**	**7**	**5**	**59/84**
Average PO Contribution	***2.50***	***2.25***	***2.00***	***2.25***	***2.75***	***1.75***	***1.25***	14.75 (70.2%)
The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	1	0	1	1	1	3	2	**9**
CO2 (Apply/Observe)	0	0	1	2	1	3	3	**10**
CO3 (Analyze/Examine)	1	0	2	2	2	3	2	**12**
CO4 (Evaluate/Design)	0	0	2	2	2	3	3	**12**
Total PO Contribution	**2**	**0**	**6**	**7**	**6**	**12**	**10**	**43 / 84**
Average of PSO Contribution	**0.50**	**0.00**	**1.50**	**1.75**	**1.50**	**3.00**	**2.50**	*10.75/51.2*
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year	*I Semester*	*4. Elective 4 – Theory*	*Credits 3*

PUBLIC HEALTH MICROBIOLOGY	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Recall and describe the fundamental concepts of public health microbiology, including health indicators, disease transmission routes (air, food, water, sexual, and vector-borne), vaccination schedules, key microbial characteristics, and the roles of national and international health organizations.*

CO2 K3 (Apply) *Apply the principles of public health microbiology to implement air sanitation techniques, execute proper vaccine storage and transport protocols, interpret disease symptoms for field-level identification, and promote community awareness regarding immunization and rational antibiotic usage.*

CO3 K4 (Analyze) *Analyze the epidemiological patterns, transmission mechanisms, and diagnostic data of major communicable diseases—ranging from respiratory and gastrointestinal infections to STDs, vector-borne illnesses, and hospital-acquired infections—to trace outbreak sources within a community.*

CO4 K5 & K6 *(Evaluate & Create) Evaluate the efficacy of existing national health programs, vaccination strategies, and government intervention frameworks, and design comprehensive, integrated public health action plans to control, prevent, and manage infectious disease hazards and vector-borne outbreaks.*

L T P C	***6 0 0 3***

UNIT I – Public Health Microbiology and Immunization

Definition, scope, concept and importance of public health microbiology, Roles of microbiologist in public health, Concept of health and disease, Indicators of health. – Primary International Health Organisations - National Health Authority : Key organisations - Mission and Initiatives - National health programs and public health hazard in the community. Vaccine - types- live, killed, toxoid, recombinant, edible vaccine – Transport - Storage and Handling - National Immunization Schedule – Universal Immunization Programme – Key Vaccines used in India - Public awareness about vaccination and celebration of Vaccination day. Public awareness on the usage of antibiotics.

UNIT II – Airborne Diseases and Air Sanitation

Composition of Air -Transmission of air borne infections – Causative agent characters, symptoms, control and treatment of air borne infections* - Bacterial pneumonia, Diphtheria, Tuberculosis, Influenza, Measles, Covid-19. Method of measuring microorganisms in air. Air Sanitation – Key filters used and their applications.

UNIT III – Foodborne and Waterborne Diseases

Types of food borne diseases, Food poisoning and food intoxication. Food borne infection*, Awareness of Peptic ulcer and its consequences. Food spoilage and spoilage of food by microorganisms. Water pollution and sanitation, Nature of causative agent, Transmission, control and treatment of diseases from food and water: gastroenteritis, Cholera, Typhoid, bacillary dysentery, amoebic dysentery (Amoebiasis, Giardiasis) and Poliomyelitis.

UNIT IV – Sexually Transmitted Diseases

Key facts on STD in India - Characters of causal organisms and Prevention, Control, Diagnosis and Treatment of the following diseases - Syphilis, HIV/AIDS, Hepatitis B and C, Gonorrhoea, Genital herbs, Chlamydia, Trichomoniasis. Control of sexually transmitted infections.

UNIT V – Vector-Borne Diseases and Communicable Disease Control

Vector and its types- Vector borne diseases, Transmission, character, Prevention, Control, Diagnosis and Treatment of the following vector borne diseases Malaria - Dengue – Filaria - Kala-azar, Japanese Encephalitis and Chikungunya. Hospital-Acquired Infection – National Rabies Control Programme – Central and State Government Departments in preventing Communicable diseases – National Centre for Vector Borne Disease Control.

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module [@] Self Learning[*] Entrepreneurial module [$]

REFERENCES BOOKS:

1. Robert S. Burlage. 2012. Principles of Public Health Microbiology. Jones & Bartlett learning LLC, Canada.

2. Ghimire P. & Parajuli K. 2005. A Text Book of Microbiology, Vidhyarthi Pustak Bhandar Publication, Kathmandu.

3. Brownson, RC., Baker, EA., Leet. TL., Follespie. KN., 2003. Evidence Based Public Health. Oxford University Press.

4. Dixit H. 1999.The Quest for Health, Educational Enterprises, Kathmandu, 6. Friis, RH., and Sellers, TA, (1999). Epidemiology for Public Health Practice, 2nd Edition, Gaithersburg, MD: Aspen Publication.

5. Jay, J, H, Modern. 1987. Food Microbiology, 3rd Edition CBS Publication and Distributors Delhi.

6. Rajan S and Selvi Christy R. Essentials of Microbiology, CBS publishers New Delhi 2018.

WEB RESOURCES:

1. UNEP – https://www.unep.org
2. EPA – https://www.epa.gov
3. NCBI – https://www.ncbi.nlm.nih.gov
4. ScienceDirect – https://www.sciencedirect.com
5. Springer Link – https://link.springer.com
6. Microbe Notes – https://microbenotes.com
7. NPTEL – https://nptel.ac.in
8. SWAYAM – https://swayam.gov.in

JOURNAL RESOURCES :

Epidemiology & Outbreak Surveillance

- **Emerging Infectious Diseases** (CDC): A premier open-access journal covering global public health threats, emerging pathogens, and outbreak tracks.
- **Eurosurveillance** (ECDC): Focuses heavily on the epidemiology, surveillance, prevention, and control of communicable diseases with European and global relevance.
- **JMIR Public Health and Surveillance**: Features data-driven research on digital disease detection, public health monitoring, and infectious trends.

Pathogen Biology & Clinical Impact

- **The Lancet Microbe**: A high-impact journal dedicated to clinical and environmental microbes that present a direct risk to human health.
- **Journal of Clinical Microbiology** (ASM): Explores laboratory diagnostics and the transmission dynamics of public health-relevant pathogens.
- **Journal of Microbiology and Infectious Diseases**: Focuses on epidemiological studies, novel pathogens, and surveillance advancements.

One Health, Food & Environment

- **Applied and Environmental Microbiology** (ASM): Frequently publishes critical public health research regarding waterborne pathogens, environmental reservoirs, and sanitation safety.
- **Foodborne Pathogens and Disease**: Concentrates on public health risks stemming from food supply contamination, tracking pathogens from farm to table.
- **Microorganisms** (MDPI - Public Health Microbiology Section): Covers molecular epidemiology, pathogen surveillance, and microbial food safety.

Infection Control & Resistance

- **Antimicrobial Resistance and Infection Control**: Dedicated strictly to tracking global drug resistance patterns and preventive healthcare measures.
- **Journal of Hospital Infection**: Concentrates on healthcare-associated infections (HAIs), sterilization methods, and clinical outbreak management.

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	3	1	0	2	2	1	1	**10**
CO2 (Apply/Observe)	2	2	3	2	1	2	2	**14**
CO3 (Analyze/Examine)	2	3	3	2	1	3	1	**15**
CO4 (Evaluate/Design)	3	3	3	3	2	2	3	**19**
Total PO Contribution	**10**	**9**	**9**	**9**	**6**	**8**	**7**	**(58/84)**
Average PO Contribution	***2.50***	***2.25***	***2.25***	***2.25***	***1.25***	***2.00***	***1.75***	***14.5*** ***69.04***
The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	2	1	2	0	1	1	3	**10**
CO2 (Apply/Observe)	2	2	2	1	1	2	3	**13**
CO3 (Analyze/Examine)	2	2	3	0	1	2	3	**13**
CO4 (Evaluate/Design)	1	1	1	0	1	3	3	**10**
Total PO Contribution	**7**	**6**	**8**	**1**	**4**	**8**	**12**	**46/84**
Average of PSO Contribution	**1.75**	**1.50**	**2.00**	**0.25**	**1.00**	**2.00**	**3.00**	**11.5/54.76**
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year	*I Semester*	*5. Field Work*	*Credits 1*

FIELD WORK	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Understand and Explain Field Concepts and Methodologies: Describe, recall, and explain abstract theories, models, and diverse human/environmental perspectives, demonstrating a foundational understanding of how academic concepts align with real-world scenarios and local community dynamics.*

CO2 K3 (Apply) *Apply Practical Skills and Classroom Theories in the Field: Execute hands-on primary data collection by implementing specific field techniques (such as surveying, interviewing, sampling, and observation) to bridge classroom theories with actual, real-world situations.*

CO3 K4 (Analyze) *Analyze On-the-Ground Scenarios and Data: Critically analyze on-the-ground scenarios, dissect complex local environmental or community dynamics, and examine collected field data to identify practical, underlying problems.*

CO4 K5 & K6 (Evaluate & Create) *Evaluate Field Challenges and Formulate Solutions: Critically evaluate identified field problems, appraise the ethical and professional dimensions of the environment, and design/formulate actionable solutions, interventions, or frameworks while demonstrating professional teamwork and communication skills.*

L T P C	***1 2 0 1***

Fieldwork is the process of observing, collecting, and analyzing data directly in a natural or real-world environment rather than in a controlled lab or classroom. It is a fundamental component of disciplines like anthropology, geography, and the environmental sciences, allowing researchers to study subjects firsthand.

Academic Benefits of Fieldwork

Fieldwork bridges the gap between abstract concepts and real-world application. Its core academic benefits include:

- **Experiential Learning:** Students move beyond textbook theories to experience phenomena firsthand, making complex concepts more tangible and memorable.
- **Data Collection & Methodology:** It provides practical training in gathering primary data, using tools like field sketches, interviews, surveys, and technical equipment.
- **Enhanced Critical Thinking:** Fieldwork requires students to evaluate methodologies, adapt to unexpected environmental factors, and challenge pre-existing assumptions.

- **Improved Observation Skills:** Regular practice in the field trains students to identify patterns, spatial relationships, and nuances in their surroundings.
- **Transferable Skills:** It builds highly valued abilities such as project management, teamwork, problem-solving, and adaptability

To enjoy the above benefits by students, Field work has been introduced in the First semester with 1 credits (3 Hours / Cycle) to address microbes based problems and solution in the local area.

Evaluation

Student shall submit their report (Minimum of 5 pages focusing field work, excluding front page, declaration, certificate etc.,).

The evaluation will be done at the end of the first semester by both external (50 Marks) and internal (50 Marks) examiners for a maximum marks of 100.

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module [@] Self Learning[*] Entrepreneurial module [$]

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	3	1	1	2	2	1	0	**10**
CO2 (Apply/Observe)	2	2	3	2	1	2	1	**13**
CO3 (Analyze/Examine)	2	3	2	3	1	2	1	**14**
CO4 (Evaluate/Design)	3	3	2	2	3	1	3	**17**
Total PO Contribution	**10**	**9**	**8**	**9**	**7**	**6**	**5**	**54/84**
Average of PO Contribution	**2.50**	**2.25**	**2.00**	**2.25**	**1.75**	**1.50**	**1.25**	**13.50/64.28**
The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	3	2	2	1	2	2	2	**14**
CO2 (Apply/Observe)	3	3	2	1	3	2	3	**17**
CO3 (Analyze/Examine)	2	2	2	2	3	2	3	**16**
CO4 (Evaluate/Design)	1	1	1	2	3	3	3	**14**
Total PSO Contribution	**9**	**8**	**7**	**6**	**11**	**9**	**11**	61/84
Average of PSO Contribution	**2.25**	**2.00**	**1.75**	**1.50**	**1.75**	**2.25**	**2.75**	15.25/72.61
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year *I Semester* *6.Core Practical* *Credits 3*

PRACTICAL - I - LAB IN GENERAL MICROBIOLOGY AND MICROBIAL DIVERSITY	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Describe the fundamental principles of laboratory safety, sterilization methods, and the theoretical basis of various staining and cultivation techniques used in microbiology.*

CO2 K3 (Apply) *Execute standard laboratory procedures including glassware maintenance, smear preparation, serial dilutions, and the application of diverse staining methods to visualize microbial structures.*

CO3 K4 (Analyze) *Examine the morphological and cultural characteristics of microorganisms and differentiate between various sterilization techniques and media types based on specific experimental requirements.*

CO4 K5 & K6 (Evaluate & Create) *Assess the efficacy of microbial isolation and enumeration methods and formulate a comprehensive Practical Course Project (PCP) or Field Work Report based on synthesized experimental data.*

L T P C ***0 0 6 3***

1. Laboratory precautions*
2. Washing and cleaning of glasswares*
3. Biological safety cabinets
4. Light microscopy
5. Wet mount technique
6. Hanging drop technique
7. Sterilization - principle, methods, applications and limitations@
   a. Moist heat
   b. Dry heat
   c. Filtration
8. Fumigation - Standard Operative Procedure (SOP)
9. Smear preparation
10. Counting bacterial / yeast cells using Micrometry
11. Simple staining
12. Negative staining

13. Gram's staining
14. Acid-fast staining (Ziehl-Neelson method - Demonstration)
15. Spore staining (Schaffer-Fulton method)
16. Capsule staining
17. Flagella staining (Demonstration)
18. Preparation of liquid, solid and semi-solid media
19. Preparation of agar deeps, agar slants and agar plates
20. Preparation of basal, differential, enriched, selective, enrichment media and transport media*
21. Serial dilution technique
22. Plating techniques – pour plate and spread plate
23. Enumeration of bacteria – soil and water samples
24. Cultural characteristics of microorganisms
25. Culture transfer techniques
26. Techniques of isolation of pure cultures – Streak plate method
27. Morphology of molds – Lactophenol cotton blue staining (LPCB Method)
28. Fungal slide culture technique

Inter Departmental Expertise Module% - Inter Institutional Expertise Module & Researcher Module+ Alumni Module # Industrial Module @ Self Learning Entrepreneurial module $*

LABORATORY MANUALS :

1. Cappuccino.J.C:7 and Sherman. N. (1996). Microbiology – Laboratory Manual. Benjamin Cummins, New York
2. Kannan. N. (1996). Laboratory manual in General Microbiology. Palan Paramount Publication, Palani.
3. Gunasekharan. P. (1996). Laboratory manual in Microbiology, New Age International Ltd., Publishers, New Delhi.
4. Sundararaj, T. (2005). Microbiology – laboratory manual. (1st edition). Pubinj. Sunciararaj. T, Chennai
5. Jayaraman, J. (1985). Laboratory manual in Biochemistry. Wiley Eastern Ltd, New Delhi.
6. Plummer, D.T. (1998). An Introduction to practical Biochemistry. Tata McGraw Hill, New Delhi.
7. Palanivelu P. (2001). Analytical Biochemistry and Separation techniques – A Laboratory Manual.
8. Benson (2002). Microbiological applications – Laboratory Manual in General Microbiology. International edition. McGraw Hill Higher education.
9. Collins, C.R. and Lyne P.M. (1976). Microbiological methods (4th edition). Butterwoths, London.
10. Dubey, R.C. and Maheshwari, O.K., (2002). Practical Microbiology. S. Chand and Co Ltd., New Delhi.

11. Baron, E.J. and Finegold, S.M. (1995). Diagnostic Microbiology. Blackwell Scientific Press.
12. Davis, L., Dipner, M.O and Battey, J.F. (1986). Basic methods in Molecular Biology .Elseiver, Amsterdam
13. S.Rajan. (2012): Experimental Procedures in Life Sciences. Anjanaa Book House, Chennai 600107.

WEB RESOURCES :

1. https://microbiologyinfo.com
2. https://microbenotes.com
3. https://www.onlinebiologynotes.com
4. http://universe84a.com
5. https://laboratoryinfo.com
6. https://webstor.srmist.edu.in/web_assets/srm_mainsite/files/files/BIO217_BASIC_BIOTECHNOLOGY_LAB_MANUAL1.pdf

JOURNAL RESOURCES:

General Microbiology
- Journal of Bacteriology
- Microbiology
- Archives of Microbiology

Microbial Diversity and Taxonomy
- Antonie van Leeuwenhoek
- International Journal of Systematic and Evolutionary Microbiology (IJSEM)
- FEMS Microbiology Letters

Environmental Microbiology
- Applied and Environmental Microbiology
- FEMS Microbiology Ecology
- Environmental Microbiology

Microbial Techniques and Laboratory Methods
- Journal of Microbiological Methods
- Methods in Microbiology
- Journal of Visualized Experiments (JoVE)

Microbial Physiology and Cell Biology
- Molecular Microbiology
- Cellular Microbiology
- Microbiology Spectrum

Public Health and Applied Microbiology
- Journal of Applied Microbiology
- Letters in Applied Microbiology
- Clinical Microbiology Reviews

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	3	1	1	1	2	2	1	**11**
CO2 (Apply/Observe)	2	2	3	2	1	1	2	**13**
CO3 (Analyze/Examine)	2	3	2	3	1	2	2	**15**
CO4 (Evaluate/Design)	3	3	3	3	2	3	3	**20**
Total PO Contribution	**10**	**9**	**9**	**9**	**6**	**8**	**8**	***59***
Average of PO Contribution	**2.50**	**2.25**	**2.25**	**2.25**	**1.50**	**2.0**	**2.0**	***14.75/70.23***
The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	3	2	1	0	1	2	0	**9**
CO2 (Apply/Observe)	3	3	2	0	1	2	1	**12**
CO3 (Analyze/Examine)	3	2	1	0	2	1	1	**10**
CO4 (Evaluate/Design)	2	2	2	1	2	2	3	**14**
Total PSO Contribution	**11**	**9**	**6**	**1**	**6**	**7**	**5**	**45/84**
Average of PSO Contribution	**2.75**	**2.25**	**1.50**	**0.25**	**1.50**	**1.75**	**1.25**	**11.25/53.57**
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year ***I Semester*** ***7. Core Practical*** ***Credits 3***

PRACTICAL – II LAB IN BIOCHEMISTRY AND MICROBIAL PHYSIOLOGY	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Define and describe the fundamental principles of microbial metabolism, hematological parameters, and biochemical instrumentation techniques.*

CO2 K3 (Apply) *Apply standardized laboratory protocols to perform blood counts, biochemical estimations, and microbial identification tests using specific reagents and equipment.*

CO3 K4 (Analyze) *Analyze and interpret experimental data, including growth curves, chromatographic separations, and biochemical profiles, to differentiate between microbial species and physiological states.*

CO4 K5 & K6 (Evaluate & Create) *Evaluate the validity of clinical results against reference values and design a comprehensive project or field report based on synthesized experimental findings.*

L T P C ***0 0 6 3***

1. Cultivation of anaerobic microorganisms – Pyrogallol method &anaerobic jar.
2. Extracellular enzymatic activities of microorganisms (Utilization of gelatin, starch, casein and lipid).
3. Carbohydrate fermentation (Any one carbohydrate source)
4. Triple sugar iron test
5. IMVIC tests
6. H_2S test
7. Urease test
8. Nitrate reduction test
9. Catalase test
10. Oxidase test
11. Growth curve (turbidity method)
12. Total Erythrocyte Count
13. Total Leucocyte Count
14. Total Platelet Count
15. Haemoglobin estimation
16. Erythrocyte Sedimentation Rate (ESR)
17. Serum Cholesterol analysis (DEMO)

18. Estimation of urine albumin
19. Estimation of urine bile salts
20. Estimation of urine sugar
21. Reference values of biochemical tests
22. Preparation of buffers
23. Calibration of pH meter
24. Verification of Beer- Lambert's law (Colorimetry and Spectrophotometry)
25. Preparation of standard graph – Widely used Methods (Protein, DNA, RNA and Carbohydrates)
26. Separation of amino acids by paper chromatography[+]

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module [@] Self Learning[*] Entrepreneurial module s

LABORATORY MANUALS :

1. Cappuccino.J.C:7 and Sherman. N. (1996). Microbiology – Laboratory Manual. Benjamin Cummins, New York
2. Kannan. N. (1996). Laboratory manual in General Microbiology. Palan Paramount Publication, Palani.
3. Gunasekharan. P. (1996). Laboratory manual in Microbiology, New Age International Ltd., Publishers, New Delhi.
4. Sundararaj, T. (2005). Microbiology – laboratory manual. (1st edition). Pubinj. Sunciararaj. T, Chennai
5. Jayaraman, J. (1985). Laboratory manual in Biochemistry. Wiley Eastern Ltd, New Delhi.
6. Plummer, D.T. (1998). An Introduction to practical Biochemistry. Tata McGraw Hill, New Delhi.
7. Palanivelu P. (2001). Analytical Biochemistry and Separation techniques – A Laboratory Manual.
8. Benson (2002). Microbiological applications – Laboratory Manual in General Microbiology. International edition. McGraw Hill Higher education.
9. Collins, C.R. and Lyne P.M. (1976). Microbiological methods (4th edition). Butterwoths, London.
10. Dubey, R.C. and Maheshwari, O.K., (2002). Practical Microbiology. S. Chand and Co Ltd., New Delhi.
11. Baron, E.J. and Finegold, S.M. (1995). Diagnostic Microbiology. Blackwell Scientific Press.
12. Davis, L., Dipner, M.O and Battey, J.F. (1986). Basic methods in Molecular Biology .Elseiver, Amsterdam
13. S.Rajan. (2012): Experimental Procedures in Life Sciences. Anjanaa Book House, Chennai 600107.

WEB RESOURCES :

1. https://microbiologyinfo.com

2. https://microbenotes.com
3. https://www.onlinebiologynotes.com
4. http://universe84a.com
5. https://laboratoryinfo.com
6. https://webstor.srmist.edu.in/web_assets/srm_mainsite/files/files/BIO217_BASIC_BIOTECHNOLOGY_LAB_MANUAL1.pdf

JOURNAL RESOURCES:

Microbial Cultivation and Identification
- Journal of Microbiological Methods
- International Journal of Systematic and Evolutionary Microbiology (IJSEM)
- Antonie van Leeuwenhoek

Biochemical and Enzymatic Characterization
- Applied and Environmental Microbiology
- FEMS Microbiology Letters
- Journal of Applied Microbiology

Clinical Hematology and Diagnostic Microbiology
- International Journal of Laboratory Hematology
- Clinical Microbiology Reviews
- Journal of Clinical Microbiology

Analytical Biochemistry and Instrumentation
- Analytical Biochemistry
- Journal of Biochemical and Biophysical Methods
- Clinical Biochemistry

Urinalysis and Clinical Diagnostics
- Clinical Chemistry
- Clinical Chemistry and Laboratory Medicine
- Journal of Clinical Laboratory Analysis

Laboratory Techniques and Experimental Methods
- Journal of Visualized Experiments (JoVE)
- Methods in Microbiology
- Methods in Molecular Biology

High-Impact & Review Journals
- Nature Reviews Microbiology
- Microbiology and Molecular Biology Reviews (MMBR)
- Trends in Microbiology

MAPPING

COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	3	1	1	2	1	1	1	**10**
CO2 (Apply/Observe)	2	2	3	2	2	2	2	**15**
CO3 (Analyze/Examine)	2	3	3	3	1	2	2	**16**
CO4 (Evaluate/Design)	3	3	3	3	3	3	3	**21**
Total PO Contribution	**10**	**9**	**10**	**10**	**7**	**8**	**8**	**62/84**
Average of PO Contribution	**2.50**	**2.25**	**2.50**	**2.50**	**1.75**	**2.00**	**2.00**	**15.50 /73.80**
The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	3	2	2	0	1	1	1	**10**
CO2 (Apply/Observe)	2	3	3	1	1	2	1	**13**
CO3 (Analyze/Examine)	3	3	2	1	2	1	1	**13**
CO4 (Evaluate/Design)	1	2	2	2	2	3	3	**15**
Total PSO Contribution	**9**	**10**	**9**	**4**	**6**	**7**	**6**	*51/84*
Average of PSO Contribution	**2.25**	**2.50**	**2.25**	**1.00**	**1.50**	**1.75**	**1.50**	*12.75/60.71*
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution)								

First Year *II Semester* *8 Core Theory* *Credits 4*

MICROBIAL GENETICS AND MOLECULAR BIOLOGY	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Describe the foundational experiments establishing DNA as genetic material, outline the structural organization of genes, plasmids, and transposable elements, and explain the fundamental mechanisms of replication, transcription, translation, gene regulation, and horizontal gene transfer across prokaryotes and eukaryotes.*

CO2 K3 (Apply) *Apply the principles of molecular genetics to predict the outcomes of DNA repair mechanisms, illustrate the transport of proteins using signal sequences, and determine how changing environmental conditions alter gene expression via specific operon or gene transfer pathways.*

CO3 K4 (Analyze) *Analyze and differentiate between prokaryotic and eukaryotic molecular processes, examine the structural differences in transposable elements, and dissect the multi-layered regulatory networks—including transcriptional, translational (antisense RNA, RNAi), and post-transcriptional controls.*

CO4 K5 & K6 (Evaluate & Create) *Evaluate the efficiency of various gene transfer mechanisms and regulatory circuits (such as two-component systems and catabolite repression), and formulate/design theoretical models or experimental strategies leveraging plasmids, transposons, or RNA interference for genetic modification.*

L T P C ***6 0 0 4***

UNIT I – DNA Replication and Repair

DNA replication and repair. Identification of genetic material (Griffith, Avery and Hershey and Chase experiments). DNA replication - Meselson–Stahl experiment, Molecular mechanisms of DNA Replication – bidirectional and rolling circle replications. Differences in prokaryotic and eukaryotic replication. Plasmids – types, structure and replication*. DNA repair – mechanism of excision repair, SOS repair, mismatch repair and photoreactivation.

UNIT II – Transcription and Translation

Process of transcription – initiation, elongation – termination. Synthesis of mRNA in prokaryotes and eukaryotes. Synthesis of rRNA and tRNA. RNA processing – capping and polyadenylation. Genetic code, process of translation – initiation, elongation and termination. Signal sequences and protein transport.

UNIT III – Concept of Gene and Gene Regulation

Organization of Gene in Prokaryotes and Eukaryotes - Introduction – Operon concept, lac, trp and ara operons, promoters and repressors. Regulation of gene expression – Transcriptional control – promoters, terminators, attenuators and antiterminators; Induction and repression; the lac operon – catabolite repression; Biosynthesis: trp operon – upstream activator sequences and enhancers, two component regulatory systems. Translational control – ribosome binding, codon usage, antisense RNA; post-transcriptional modifications – gene silencing – RNAi.

UNIT IV – Gene Transfer Mechanisms

Transformation – competence cells, regulation, general process; Transduction – general and specialized; Conjugation – Hfr, triparental mating, self transmissible and mobilizable plasmids, sex pili.

UNIT V – Transposable Elements

Introduction - Discovery of insertion sequences, complex and compound transposons – T10, T5, and retroposon – Nomenclature- Insertion sequences – Mechanism – Transposons of E.coli, Bacteriophage and Yeast.

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module [@] Self Learning[*] Entrepreneurial module [$]

TEXTBOOKS :

1. Watson, JD., Hopkins, N.H., Roberts J.W., Steitz J.A and Weiner, A.A.M. (1987). Molecular Biology of the gene. The Benjamin/Cummings Publishing Company.
2. Lewin, B. (2007). Genes IX Oxford University press, UK.
3. Lodish, H., Baltimore, D., Berk, A., Zipursky, S.L., Matsudaira, P., and Darnell, J. (1995). Molecular cell Biology. Scientific American Books.
4. Maloy, S.R., Cronan, Jr. J.E. and Freifelder, D. (1994). Microbial Genetics. Jones and Bartlett Publishers.
5. Freifelder, D. (1991). Molecular Biology. Narosa Publishing House.
6. Talaro, K.P. and Talaro, A (1999). Foundations in Microbiology. WCP McGraw – Hill, NewYork.
7. Jeyanthi, G.P. (2008). Molecular Biology. MJP Publishers, Chennai.

REFERENCE BOOKS:

1. Friedberg EC, Walker GC, Siede W. (2005). DNA repair and mutagenesis. ASM press
2. James D. Watson, Tania A. Baker, Stephen P. Bell, and Alexander Gann, Molecular Biology of the Gene, Fifth Edition
3. Rowland H. Davis, The Microbial Models of Molecular Biology: From Genes to Genomes.
4. Antony JF, Griffiths, Gilbert WM, Lewontin RC and Miller JH (2002).
5. Modern Genetic Analysis, Integrating Genes and Genomes, 2nd edition, WH
6. Blackburn GM, Gait MJ. (1996). Nucleic acids in chemistry and biology. Oxford University press.
7. Malacinski GM and Freifelder D (1998) Essentials of Molecular Biology, 3rd edition, John and Bartlett Publishers.
8. Lewin B. (2018-2019). Genes XII. 12th Edition, Oxford University press
9. Maloy SR, Cronan Jr. JE, Freifelder D (1994). Microbial genetics. Jones and Bartlett publishers.
10. Singer M, Berg P. (1991). Genes and Genomes. University Science Books.

11. Stryer L. (2002). Biochemistry. 5th edition, W.H.Freeman and company.
12. Watson JD, Hopkins NH, Roberts JW, Steitz JA, Weiner AM. (1998).
13. Molecular biology of the gene, 4th edition, Benjamin/Cummings publishing company.
14. Eckstein F., and Lilley, D.M. (1992). Nucleic Acids and Molecular Biology – Springer – Verlag
15. Blackburn, C. M. and Gait M.J. (1996). Nucleic acids in HCemistry and biology – Oxford University Press.
16. Stryer L. (1995). Biochemistry, W.H. Freemand and Company.
17. Eckstein F, Lilley DM. (1996). Catalytic RNA – Springer – Verlag.
18. Frielderg EC, Walker GC, Siede W. (1995). DNA repair and mutagenesis, ASM Press
19. Gardner EJ, Simmons, MJ, Snustad DP (1991). Principles of Genetics. John Wiley and Sons, New York.
20. Singer M, Berg P. (1991). Genes and Genomes. University Science Books.

WEB RESOURCES:

1. https://www.ndsu.edu/pubweb/~mcclean/plsc731/dna/dna3.htm
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5474181/
3. https://www.atdbio.com/content/14/Transcription-Translation-and-Replication#:~:text=The%20process%20by%20which%20DNA,produce%20proteins%20is%20called%20translation.
4. https://www.shomusbiology.com/
5. https://www2.estrellamountain.edu/faculty/farabee/biobk/BioBookGENCTRL.html#:~:text=The%20operon%20model%20of%20prokaryotic,%2C%20regulator%2C%20and%20structural%20genes.
6. https://microbeonline.com/key-information-regarding-gene-transfer-mechanism-bacteria/
7. https://www.nature.com/scitable/topicpage/transposons-the-jumping-genes-518/#:~:text=Transposable%20elements%20(TEs)%2C%20also,Harbor%20Laboratory%20in%20New%20York.

JOURNAL RESOURCES:

General & Broad Microbiology

- Journal of Bacteriology (ASM): Focuses on fundamental processes in bacteria and archaea.
- Microbiology (Microbiology Society): Covers fundamental physiology, biochemistry, and genetics.
- Archives of Microbiology: Publishes basic research on microbial physiology and molecular biology.
- Antonie van Leeuwenhoek: Focuses on fundamental mechanisms, taxonomy, and theoretical microbiology.

Environmental & Evolutionary Basics

- Applied and Environmental Microbiology (AEM): Covers basic microbial ecology and environmental processes.
- FEMS Microbiology Ecology: Focuses on the basic ecology of natural microbial

Molecular & Cellular Mechanisms

- **Molecular Microbiology**: Focuses on molecular studies of gene expression and cell biology.
- **Cellular Microbiology**: Explores interactions between microbes and host cells at a molecular level.
- **FEMS Microbiology Letters**: Offers rapid publication of basic, short research communications.

HIGH-IMPACT & REVIEW JOURNALS:

- Nature Reviews Microbiology: Provides comprehensive reviews of fundamental and applied research.
- Microbiology and Molecular Biology Reviews (MMBR): Delivers deep, definitive reviews on basic mechanisms.
- Trends in Microbiology: Highlights emerging concepts and current debates in basic science.

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME OUTCOMES (POs)								**TOTAL SCORE**
CO#	***PO$_1$***	***PO$_2$***	***PO$_3$***	***PO$_4$***	***PO$_5$***	***PO$_6$***	***PO$_7$***	
CO1 (Outline/Describe)	3	1	1	2	0	1	0	**8**
CO2 (Apply/Observe)	2	3	2	2	0	1	0	**10**
CO3 (Analyze/Examine)	2	3	3	2	0	2	0	**12**
CO4 (Evaluate/Design)	3	3	3	3	1	2	2	**17**
Total PO Contribution	**10**	**10**	**9**	**9**	**1**	**6**	**2**	***47/84***
Average PO Contribution	**2.5**	**2.5**	**2.25**	**2.25**	**0.25**	**1.25**	**1.0**	***11.75/ 55.9***
*The values above represent the level of contribution: **3 (High)**, **2 (Medium)**, **1 (Low)**, and **0 (No Contribution)***								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO$_1$***	***PSO$_2$***	***PSO$_3$***	***PSO$_4$***	***PSO$_5$***	***PSO$_6$***	***PSO$_7$***	
CO1 (Outline/Describe)	2	1	3	1	2	1	1	**11**
CO2 (Apply/Observe)	2	2	3	2	2	1	1	**13**
CO3 (Analyze/Examine)	3	2	3	2	2	1	1	**14**
CO4 (Evaluate/Design)	2	2	3	3	3	2	2	**17**
Total PSO Contribution	**9**	**7**	**12**	**8**	**9**	**5**	**5**	*55/84*
Average PSO Contribution	**2.25**	**1.75**	**3.00**	**2.00**	**2.25**	**1.25**	**1.25**	*13.75/65.47*
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution)								

First Year *II Semester* *9. Core Theory* *Credits 4*

IMMUNOLOGY AND IMMUNOTECHNIQUES	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand)*: Describe and explain the foundational principles of immunology, encompassing the history, cells, and organs of the immune system, antigen-antibody structures, basic clinical diagnostic principles, immunological disorders, and the fundamental concepts of vaccination.*

CO2 K3 (Apply)*: Apply the concepts of innate and acquired immunity, antigen-antibody interactions, and complement pathways to demonstrate how clinical immunological techniques (like agglutination and blotting) and immunization schedules are utilized in healthcare and disease management.*

CO3 K4 (Analyze)*: Analyze and differentiate the complex mechanisms of cellular and humoral immune responses, compare various immunological assays, and examine the underlying pathways of hypersensitivity, autoimmunity, transplantation rejection, and tumor immunology.*

CO4 K5 & K6 (Evaluate & Create)*: Evaluate the efficacy and suitability of various clinical diagnostic techniques, assess the clinical implications of immunosuppression, and formulate perspectives on monoclonal antibody applications and modern vaccine development (including current schedules like Mission Indradhanush and COVID-19 vaccines).*

L T P C ***6 0 0 4***

UNIT I – Fundamentals of Immunology and Immune System

History and development of immunology - Phylogeny and ontogeny of immune systems. Immunity: Innate & Acquired. Infection. Pathogenicity. Virulence factors. Resistance. An over view on the cells of immune system. Phagocytosis. Inflammation. Organs & tissues of immune system. Clonal selection theory. Immune response: HIR & CMI. Cytokines*.

UNIT II – Antigens, Antibodies and Immune Components

Antigens and antibody – structure, types and functions. Antibody diversity: isotypes, allotypes and idiotypes. Biology of T & B cells. Major Histocompatibility Complex (MHC). Human Leucocyte Antigen (HLA). Complement pathways: classical, alternative & lectin.

UNIT III – Clinical Immunology and Immunological Techniques

Clinical immunology: serotyping. Agglutination. Precipitation. Complement fixation. Immunoblotting (Western blotting). Immunofluorescence. Immunodiffusion: SRID, ODD, RIEP & Immunoelectrophoresis. Flow cytometry. Radioimmune assay.

UNIT IV – Applied Immunology and Immune Disorders

Applied Immunology - Hypersensitivity - immediate & delayed type. Autoimmunity. Transplantation immunology. Tumor immunology. Immunological tolerance. Immunosuppression. Immuno deficiency diseases&.

UNIT V – Monoclonal Antibodies and Vaccination

Monoclonal antibody: production & applications@. Vaccination: types, principle & applications. Current basic immunization schedule – Indradanush* – Corona vaccines.

Inter Departmental Expertise Module% - Inter Institutional Expertise Module & Researcher Module+ Alumni Module # Industrial Module @ Self Learning Entrepreneurial module $*

TEXTBOOKS :

1. Donald M. Weir and John Sterward (1993). Immunology (7theditoin). ELBS, London.
2. Hue Davis (1997). Introductory Immunology (1st edition). Chapman and Hall Publisher, London.
3. Ivan M. Roit (1998). Essential Immunology – Blackwell Scientific Publishers, London.
4. Paul (1998). Fundamental Immunology, (2nd edition). Raver Press, New Yoek.
5. Peter J. Delves and Ivan M. Roit (Eds) (1998). Encyclopedia of immunology – (2nd edition). Academic Press.
6. Ridklad, M. Aydl (1995). Immunology, (2nd edition), Baltimore, Hong Kong, NMS Publication.
7. Roit, J.M., Brostaff, J.J and male, D.K. (1996). Imunology (4th edition). C.V. Mosby Publisher, St. Loius.
8. Stewart Sell (2001). Immunology, immunopathology and immunity. (6th edition). ASM Press, USA.
9. Ajnanthanarayanan, R. and Panicxker, J. (2000). Textbook of Microbiology, orient Longmans.
10. Rajan, S. (2007). Medical microbiology, MJP Publishers, Chennai.
11. Fathimunisa Begum (2008). Monoclonal antibodies: The hopeful drugs. MJP Publishers, Chennai.
12. Kannan, I. (2007). Immunology. MJP Publishers, Chennai.

REFERENCE BOOKS:

1. Stefan, H. and Kaufmann, E. (2002). Immunology of infectious diseases. ASM Press, USA.
2. Abbas, A.K., Lichtman, A.H. and Pober, J.S. (1994). Cellular and Molecular Immunology. (2nd edition). WB Saunders, USA.
3. Humphrey, J.H, and Wite, R.G. (1995). Immunology for students of Medicine, (5th edition) ELBS, London.
4. Weir, D.M. (1995). Experimental Techniques in Immunology. Blackwell Scientific Publishers, London.

WEB RESOURCES:

1. https://www.shomusbiology.com/

2. https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/11%3A_Immunology/11.01%3A_Overview_of_Immunity/11.1A%3A_Cells_and_Organs_of_the_Immune_System
3. https://www.immunology.org/public-information/bitesized-immunology/cells/helper-and-cytotoxic-t-cells#:~:text=There%20are%20two%20major%20types,virally%20infected%20cells%20and%20tumours.
4. https://primaryimmune.org/immune-system-and-primary-immunodeficiency
5. https://teachmephysiology.com/immune-system/immune-responses/hypersensitivity-reactions/#:~:text=Hypersensitivity%20reactions%20are%20an%20overreaction,may%20originate%20from%20the%20body.
6. https://www.immunology.org/public-information/bitesized-immunology/immune-dysfunction/autoimmunity-introduction
7. https://microbeonline.com/monoclonal-antibodies-types-and-applications/
8. http://www.nrhmhp.gov.in/content/immunisation

JOURNAL RESOURCES:

1. Educational & Review Journals (Best for Concept Overviews)

Nature Reviews Immunology

Trends in Immunology

Advances in Physiology Education

2. Core Research Journals (Best for Course Assignments & Literature Reviews)

The Journal of Immunology (The JI)

Frontiers in Immunology

3. Specialized Interdisciplinary Venues (Immuno-informatics & Vaccines)

ImmunoInformatics

Vaccine

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME OUTCOMES (POs)								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	3	1	1	2	1	1	0	**9**
CO2 (Apply/Observe)	2	2	3	2	2	1	1	**13**
CO3 (Analyze/Examine)	2	3	2	2	1	2	1	**13**
CO4 (Evaluate/Design)	2	3	3	3	3	3	2	**19**
Total PO Contribution	**9**	**9**	**9**	**9**	**7**	**7**	**4**	**54**
Average of PO Contribution	**2.25**	**2.25**	**2.25**	**2.25**	**1.75**	**1.75**	**1.00**	**13.5/64.28**
*The values above represent the level of contribution: **3 (High)**, **2 (Medium)**, **1 (Low)**, and **0 (No Contribution)**.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	1	1	3	1	0	1	2	**9**
CO2 (Apply/Observe)	1	2	3	1	0	2	2	**11**
CO3 (Analyze/Examine)	1	2	3	2	0	2	2	**12**
CO4 (Evaluate/Design)	1	2	3	2	0	2	3	**13**
Total PSO Contribution	**4**	**7**	**12**	**6**	**0**	**7**	**9**	**45/84**
Average of PSO Contribution	**1.00**	**2.75**	**3.00**	**1.50**	**0.00**	**1.75**	**2.25**	**11.25/53.57**
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

Second Year ***III Semester*** ***10 Core –Theory*** ***Credits 4***

RESEARCH METHODOLOGY AND BIOSTATISTICS	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Understand the foundational principles of research methodology, ethical guidelines, scientific writing frameworks, and the core biostatistical concepts utilized in biological sciences.*

CO2 K3 (Apply) *Apply appropriate experimental designs, sampling techniques, mathematical probability distributions, and reference management tools to structure and address specific microbiological research problems.*

CO3 K4 (Analyze) *Analyze empirical data, research impact metrics, and experimental variables by employing hypothesis testing, inferential statistical tools, and analytical software (MS Excel, SPSS) to interpret research findings.*

CO4 K5 & K6 (Evaluate & Create) *Evaluate publication practices and statistical significance to formulate original research hypotheses, and design, construct, and ethically prepare comprehensive scientific manuscripts or academic theses.*

L T P C ***4 0 0 4***

Unit I: Fundamentals of Research Methodology and Ethics

Objectives and significance of research – Principles of research – Types of research and research approaches – Research process – Criteria of good research – Research and scientific method – Identification, selection of research problems – Techniques in defining research problems – Research ethics and integrity – Ethical principles and guidelines in scientific research. (12 L)

Unit II: Hypothesis Formulation and Research Design

Hypothesis: Concept, formulation, types and characteristics – Hypothesis testing and its procedures – Research design: meaning, importance and characteristics of a good research design – Experimental design: principles, components and types – Interpretation of research findings and drawing conclusions. (12 L)

Unit III: Scientific Writing, Publication Ethics and Research Impact

Scientific writing and report preparation – Structure of thesis, dissertation and research papers – Preparation of abstract, introduction, review of literature, materials and methods, results and discussion – Citation styles, bibliography and reference management – Publication ethics, plagiarism and predatory journals – Journal indexing and abstracting services (Scopus, Web of

Science and PubMed) – Research impact metrics (Impact Factor, CiteScore, h-index and i10-index) – Manuscript submission, peer review process and publication practices. (12 L)

Unit IV: Fundamentals of Biostatistics and Data Presentation

Biostatistics: Introduction, Branches, Scope and Applications in Microbiology – Types of data and methods of data collection – Sampling techniques - Graphical and diagrammatic presentation of data - Measures of central tendency (arithmetic mean, median and mode) – Measure of dispersion (standard deviation). Probability concepts and distributions (binomial and normal). (12 L)

Unit V: Statistical Inference and Data Analysis

Tests of significance: t-test, Z-test, Chi-square test, Mann–Whitney U test, Wilcoxon Signed-Rank test and Kruskal–Wallis test. Analysis of Variance (ANOVA): One-way and two-way – Correlation: types and Pearson's correlation coefficient - Regression and its types – Applications of MS Excel and SPSS in biological research. (12 L)

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module [@] Self Learning[*] Entrepreneurial module [$]

TEXTBOOKS RECOMMENDED:

1. ***Vijayalekshmi, G. and C. Sivapragasam (2008). Research Methods (Tips and techniques). MJP Publishers, Chennai.***
2. ***Gurumani, N. (2006). Research methodology for Biological Sciences. MJP Publishers, Chennai.***
3. ***Gupta, S. P. (2021). Statistical Methods. Sultan Chand & Sons, New Delhi.***
4. ***Khan, I. A., Khanum, A. and Khan, S (2020). Fundamentals of Biostatistics. 6th Revised Edition. Ukaaz Publications, Hyderabad.***

WEB RESOUCES

5. ***http://nptel.ac.in/syllabus.php?subject Id= 102107028.***
6. ***http://b-ok.xyz/book/674611/288bc3***

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO$_1$***	***PO$_2$***	***PO$_3$***	***PO$_4$***	***PO$_5$***	***PO$_6$***	***PO$_7$***	
CO1 (Outline/Describe)	3	1	2	1	3	2	1	**13**
CO2 (Apply/Observe)	2	2	3	2	1	3	1	**14**
CO3 (Analyze/Examine)	2	3	2	2	1	3	1	**14**
CO4 (Evaluate/Design)	3	3	3	3	3	2	2	**19**
Total PO Contribution	**10**	**9**	**10**	**8**	**8**	**10**	**5**	**60/84**
Average of PO Contribution	**2.50**	**2.25**	**2.50**	**2.00**	**2.00**	**2.50**	**1.25**	**15.00/71.42**
The values above represent the level of contribution: ***3 (High)***, ***2 (Medium)***, ***1 (Low)***, *and* ***0 (No Contribution)***.								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO$_1$***	***PSO$_2$***	***PSO$_3$***	***PSO$_4$***	***PSO$_5$***	***PSO$_6$***	***PSO$_7$***	
CO1 (Outline/Describe)	3	1	1	2	3	1	0	**11**
CO2 (Apply/Observe)	2	2	3	2	1	3	1	**14**
CO3 (Analyze/Examine)	2	3	2	2	1	3	1	**14**
CO4 (Evaluate/Design)	3	3	3	3	3	2	2	**19**
Total PSO Contribution	**10**	**9**	**9**	**9**	**8**	**9**	**4**	**58**
Average of PSO Contribution	**2.50**	**2.25**	**2.25**	**2.25**	**2.00**	**2.25**	**1.00**	**14.5/69.04**
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year	*II Semester*	*11. Elective 1 – Theory*	*Credits 3*

BIODEGRADATION AND BIOREMEDIATION	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Explain the foundational principles, mechanisms, and types of microbial degradation, bioleaching, and bioremediation of natural polymers, industrial materials, and xenobiotic compounds across various ecosystems.*

CO2 K3 (Apply) *Apply specific microbial processes and bioremediation techniques to manage environmental challenges, such as treating oil spills, executing metal recovery from ores, and handling solid and liquid wastes.*

CO3 K4 (Analyze) *Analyze the mechanisms and environmental impacts of biomagnification, xenobiotic toxicity, and the constraints, priorities, and functional differences between various in-situ and ex-situ bioremediation strategies*

CO4 K5 & K6 (Evaluate & Create) *Evaluate the effectiveness of bioremediation processes through case histories to design and propose sustainable, eco-friendly biological solutions, such as custom bioreactors, vermicomposting systems, and bioplastics.*

L T P C ***6 0 0 4***

UNIT I – Fundamentals of Biodegradation and Bioremediation

Concept and scope of biodegradation and bioremediation, types and sources of environmental pollutants, microbial ecology of polluted environments, biodegradation mechanisms+, microbial metabolism of pollutants, aerobic and anaerobic biodegradation, environmental factors affecting biodegradation, bioaccumulation and biomagnification, microbial adaptation to toxic compounds, environmental impact of pollutants.

UNIT II – Microbial Degradation of Organic Pollutants

Microbial degradation of hydrocarbons, petroleum and oil spills, degradation of pesticides and insecticides, degradation of phenols, dyes and xenobiotic compounds, lignin and cellulose degradation, microbial degradation of plastics and synthetic polymers, genetically engineered microorganisms in biodegradation#.

UNIT III – Heavy Metal Remediation and Solid Waste Management

Sources and toxicity of heavy metals, microbial resistance mechanisms to heavy metals, biosorption, bioaccumulation and bioleaching, microbial remediation of lead, cadmium, chromium, mercury and arsenic, treatment of industrial effluents and sewage, solid waste management, composting technologies, vermitechnology and vermicomposting*, landfill microbiology and waste treatment methods.

UNIT IV – Bioremediation Technologies and Environmental Monitoring

Microbes in Agriculture and Climate Adaptation&. Bio-pesticides & In situ and ex situ bioremediation%, biostimulation and bioaugmentation, phytoremediation, rhizoremediation and mycoremediation, bioreactors used in bioremediation, immobilization techniques, molecular approaches in environmental microbiology, environmental impact assessment, microbial indicators of pollution.

UNIT V – Applications and Future Perspectives of Bioremediation

Applications of bioremediation in agriculture, industry and marine environments, microbial fuel cells, climate change and environmental sustainability, public health implications of pollution, legal and ethical issues in environmental biotechnology, bioenergy@ production from wastes, future prospects and emerging trends in biodegradation and bioremediation.

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module [@] Self Learning[*] Entrepreneurial module [$]

REFERENCES BOOKS :

1. Environmental Microbiology
   Maier, R.M., Pepper, I.L. and Gerba, C.P.
   Academic Press, 2015.
2. Biodegradation and Bioremediation
   Alexander, M.
   Academic Press, 1999.
3. Environmental Biotechnology
   Thakur, I.S.
   I.K. International Publishing House, 2011.
4. Wastewater Microbiology
   Bitton, G.
   Wiley-Blackwell Publishers, 2010.
5. Principles of Bioremediation
   Crawford, R.L. and Crawford, D.L.
   Cambridge University Press, 2005.
6. Environmental Biotechnology: Principles and Applications
   Rittmann, B.E. and McCarty, P.L.
   McGraw Hill Education, 2001.
7. Microbial Biodegradation and Bioremediation
   Das, S.
   Elsevier Publishers, 2014.
8. Biotechnology: Environmental Processes
   Rehm, H.J. and Reed, G.
   Wiley-VCH Publishers, 2000.
9. Environmental Pollution and Control
   Rao, C.S.
   New Age International Publishers, 2017.
10. Microbiology
    Willey, J.M., Sherwood, L.M. and Woolverton, C.J.
    McGraw Hill Education, 2020.

WEB RESOURCES :

1. UNEP – https://www.unep.org
2. EPA – https://www.epa.gov
3. NCBI – https://www.ncbi.nlm.nih.gov
4. PubMed – https://pubmed.ncbi.nlm.nih.gov
5. ScienceDirect – https://www.sciencedirect.com
6. Springer Link – https://link.springer.com
7. Microbe Notes – https://microbenotes.com
8. NPTEL – https://nptel.ac.in
9. SWAYAM – https://swayam.gov.in

JOURNAL RESOURCES:

- International Biodeterioration & Biodegradation
- Biodegradation
- Journal of Bioremediation & Biodegradation2. High-Impact Environmental Biotechnology Journals
- Trends in Biotechnology / Current Opinion in Biotechnology
- Frontiers in Microbiology (Micro biotechnology section)

Biodegradation and Environmental Microbiology
● Biodegradation
● Applied and Environmental Microbiology
● Environmental Microbiology

Pollution Control and Bioremediation
● Journal of Hazardous Materials
● Chemosphere
● Environmental Pollution

Microbial Ecology and Environmental Monitoring
● FEMS Microbiology Ecology
● Microbial Ecology
● Ecotoxicology and Environmental Safety

Waste Management and Resource Recovery
● Waste Management
● Bioresource Technology
● Journal of Environmental Management

Agricultural and Industrial Biotechnology
● Applied Microbiology and Biotechnology
● World Journal of Microbiology and Biotechnology
● Journal of Applied Microbiology

Bioenergy and Sustainable Technologies

- Renewable Energy
- Biomass and Bioenergy
- BioEnergy Research

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO₁***	***PO₂***	***PO₃***	***PO₄***	***PO₅***	***PO₆***	***PO₇***	
CO1 (Outline/Describe)	3	1	1	1	2	1	0	**9**
CO2 (Apply/Observe)	2	2	3	2	2	1	1	**13**
CO3 (Analyze/Examine)	2	3	2	2	3	2	1	**15**
CO4 (Evaluate/Design)	2	3	3	3	3	2	2	**18**
Total PO Contribution	**9**	**9**	**9**	**8**	**10**	**6**	**4**	**55/ 84**
Average of PO Contribution	**2.25**	**2.25**	**2.25**	**2.00**	**2.50**	**1.50**	**1.00**	**13.75/65.47**
The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO₁***	***PSO₂***	***PSO₃***	***PSO₄***	***PSO₅***	***PSO₆***	***PSO₇***	
CO1 (Outline/Describe)	2	1	2	1	3	1	1	**11**
CO2 (Apply/Observe)	2	2	2	2	3	1	2	**14**
CO3 (Analyze/Examine)	2	2	2	1	3	2	1	**13**
CO4 (Evaluate/Design)	1	2	2	2	3	2	3	**15**
Total PSO Contribution	**7**	**7**	**8**	**6**	**12**	**6**	**7**	53/84
Average of PSO Contribution	**1.75**	**1.75**	**2.00**	**1.50**	**3.00**	**1.50**	**1.75**	13.25/63.09
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year	*II Semester*	*11. Elective 2 – Theory*	*Credits 3*

MICROBIAL QUALITY CONTROL IN INDUSTRIES	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Draws on explaining basic QC concepts (Unit I), identifying pharma contamination (Unit II), outlining sterilization principles (Unit III), recognizing rapid methods (Unit IV), and recalling regulatory agencies (Unit V).*

CO2 K3 (Apply) *Focuses on actively using SSOP/HACCP (Unit I), conducting sterility/limit tests (Unit II), executing environmental sampling (Unit III), utilizing specific media for food/dairy (Unit IV), and applying FSSAI limits (Unit V).*

CO3 K4 (Analyze) *Involves dissecting safety monitoring data (Unit I), validating pharmaceutical methods (Unit II), analyzing disinfectant evaluation tests and biofilms (Unit III), comparing traditional vs. molecular methods (Unit IV), and breaking down Indian Standard Monitoring Methods (Unit V).*

CO4 K5 & K6 (Evaluate & Create) *Requires assessing the overall QA organization (Unit I), formulating clean room classifications (Unit II), developing waste disposal/effluent strategies (Unit III), designing audit and documentation systems (Unit IV), and evaluating future perspectives alongside international regulations (Unit V).*

L T P C	***6 0 0 4***

UNIT I – Quality Assurance and Quality Control Systems

Concept and importance of microbial quality control, quality assurance and quality control systems, microbial contamination and spoilage in industries, industrial microbiology laboratories and organization, Good Manufacturing Practices (GMP), Good Laboratory Practices (GLP), Good Hygiene Practices (GHP), Standard Operating Procedures (SOP), Sanitary Standard Operating Procedures (SSOP), Hazard Analysis and Critical Control Point (HACCP), Safety Monitoring: Air, Water, Surface, Personnel Health & Hygiene, Utility and Raw materials, Finished Product.

UNIT II – Pharmaceutical Microbiological Quality Control

Sources of microbial contamination in pharmaceutical industries, sterile and non-sterile products, clean room classification and environmental monitoring, sterility testing, pyrogen testing, endotoxin testing, microbial limit tests, preservative efficacy testing, validation of sterilization methods, aseptic processing, microbiological quality control of vaccines, antibiotics and biopharmaceutical products, regulatory guidelines in pharmaceutical microbiology.

UNIT III – Sterilization, Disinfection and Environmental Monitoring

Principles of sterilization and disinfection, physical and chemical sterilization methods, filtration techniques, validation of sterilization processes, disinfectant evaluation tests, environmental monitoring of air, water and surfaces, microbial air sampling techniques, biofilms and industrial contamination control, waste disposal and biosafety management, industrial effluent microbiology and contamination prevention strategies.

UNIT IV – Rapid Microbiological Methods and Industrial Quality Assessment

Rapid microbiological methods in quality control: Traditional Culture Method, Molecular methods, Immuno Assays, Biosensor, Direct Microscopic method - Tests and Media used to check microbiological quality in Food, Diary, Meat, Fisheries, Packaged water, Sweet and Confectionaries, Pharma, Cosmetics and neutraceuticals - Automation in industrial quality control - documentation and audit systems.

UNIT V – Regulatory Standards and Industrial Biosafety

An over view on biosafety and industrial hygiene, industrial regulatory agencies related to Microbiology: ISO, FSSAI, Codex Alimentarius, EU, BU, US-FDA (BAM), ISO – Indian Standard Monitoring Methods and Limits – Types (Only) of standards in FSSAI (17 Items) - Recent advances in industrial microbial quality control and future perspectives.

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module [@] Self Learning[*] Entrepreneurial module [$]

REFERENCES:

1. Quality Control in Microbiology
   Rose, A.H.
   Academic Press, 2012.
2. Pharmaceutical Microbiology
   Hugo, W.B. and Russell, A.D.
   Blackwell Scientific Publications, 2007.
3. Industrial Microbiology
   Casida, L.E.
   New Age International Publishers, 2015.
4. Food Microbiology
   Frazier, W.C. and Westhoff, D.C.
   McGraw Hill Education, 2018.
5. Microbiological Examination Methods of Food and Water, Harrigan, W.F.Academic Press, 1998.
6. Fundamentals of Food Microbiology
   Ray, B. and Bhunia, A.
   CRC Press, 2013.
7. Pharmaceutical Biotechnology
   Crommelin, D.J.A. and Sindelar, R.D.
   Springer Publishers, 2019.
8. Manual of Industrial Microbiology and Biotechnology
   Baltz, R.H., Demain, A.L. and Davies, J.E.
   ASM Press, 2010.

9. Prescott's Microbiology
   Willey, J.M., Sherwood, L.M. and Woolverton, C.J.
   McGraw Hill Education, 2020.
10. Environmental Monitoring in Pharmaceutical Industries Moldenhauer, J.
   PDA Publishers, 2002.

WEB RESOURCES :

1. WHO – https://www.who.int
2. US FDA – https://www.fda.gov
3. Indian Pharmacopoeia Commission – https://ipc.gov.in
4. FSSAI – https://www.fssai.gov.in
5. NCBI – https://www.ncbi.nlm.nih.gov
6. PubMed – https://pubmed.ncbi.nlm.nih.gov
7. Microbe Notes – https://microbenotes.com
8. NPTEL – https://nptel.ac.in

JOURNAL RESOURCES:

Quality Assurance and Industrial Microbiology
● Journal of Applied Microbiology
● Letters in Applied Microbiology
● Applied Microbiology and Biotechnology

Pharmaceutical Microbiology
● European Journal of Pharmaceutics and Biopharmaceutics
● PDA Journal of Pharmaceutical Science and Technology
● Journal of Pharmaceutical Sciences

Sterilization, Biosafety and Environmental Monitoring
● Journal of Hospital Infection
● American Journal of Infection Control
● Biofouling

Food, Dairy and Industrial Quality Control
● Food Microbiology
● International Journal of Food Microbiology
● Journal of Food Protection

Rapid Microbiological Methods and Diagnostics
● Journal of Microbiological Methods
● Biosensors and Bioelectronics
● Analytical Methods

Regulatory Affairs and Industrial Standards
● Regulatory Toxicology and Pharmacology
● Food Control
● Quality Assurance Journal

High-Impact & Review Journals

- Nature Reviews Microbiology
- Trends in Biotechnology
- Microbiology and Molecular Biology Reviews (MMBR)

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	**3**	**1**	**1**	**1**	**2**	**1**	**0**	**9**
CO2 (Apply/Observe)	**2**	**2**	**3**	**2**	**1**	**1**	**1**	**12**
CO3 (Analyze/Examine)	**2**	**3**	**2**	**2**	**1**	**2**	**1**	**13**
CO4 (Evaluate/Design)	**2**	**3**	**3**	**3**	**3**	**2**	**2**	**18**
Total PO Contribution	**9**	**9**	**9**	**8**	**7**	**6**	**4**	**52 / 84**
Average PO Contribution	***2.25***							***13&61.90***
The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	2	2	1	0	1	3	1	**10**
CO2 (Apply/Observe)	2	3	1	0	2	3	2	**13**
CO3 (Analyze/Examine)	2	3	2	1	2	3	1	**14**
CO4 (Evaluate/Design)	1	1	1	1	3	3	3	**13**
Total PSO Contribution	**7**	**9**	**5**	**2**	**8**	**12**	**7**	**50/84**
Average of PSO Contribution	**1.75**	**2.25**	**1.25**	**0.50**	**2.00**	**3.00**	**1.75**	**12.5/59.52**
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year	*II Semester*	*11. Elective 3 – Theory*	*Credits 3*

ENTREPRENEURSHIP MICROBIOLOGY	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Understand the fundamental concepts of bio-based entrepreneurship, funding schemes, sources of contamination, and the core principles behind the production of mushrooms, single-cell proteins, biofertilizers, biopesticides, and fermented foods.*

CO2 K3 (Apply) *Apply business planning strategies, market research methodologies, and standardized mass cultivation techniques to establish and manage small or large-scale bio-based production systems.*

CO3 K4 (Analyze) *Analyze the financial feasibility, cost-benefit ratios, and market demands for diverse biotechnological products, while diagnosing industrial contamination issues and project formulation requirements*

CO4 K5 & K6 (Evaluate & Create) *Evaluate quality control methods and business scalability models, and formulate comprehensive, innovative project proposals or business plans for commercializing bio-based products globally.*

L T P C	***6 0 0 4***

UNIT I – Entrepreneurship and Biobusiness Development

Definitions-concept of entrepreneurship, development. Structure of a biobased technology, start-up of biobased technology company and biobased business development. Government and non-Govt. Schemes for entrepreneurship programmes. Funding agency and opportunity.

UNIT II – Business Planning and Financial Management

Sources of microbial contamination in pharmaceutical industries, communication skills, problem solving skills; Business plan development; Market need- distribution, price, promotion and market goal setting, Develop the business at Global level. Financial plan - Financial support for business, business.

UNIT III – Mushroom Cultivation and Single Cell Protein Production

Project: identification, classification, formulation, appraisal. Small, large-scale production and cost benefit analysis and marketing of edible and medicinal mushroom cultivation-button, Oyster, Ganoderma. Single cell protein - Production of Yeast and Spirulina.

UNIT IV – Biofertilizers and Biopesticides

Mass multiplication, production cost analysis and marketing of Cyanobacterial biofertilizer, Bacterial biofertilizer- Rhizobium, Azospirillum, Fungal biofertilizers AMF, Actinobacterial biofertilizer-Frankia sp. Seaweed liquid biofertilizer, Biopesticides - Bacillus, Bacillus thuringiensis, Bacillus sphaericus, etc.

UNIT V – Fermented Foods, Composting and Quality Control

Rapid microbiological methods in quality control, molecular Small, large-scale production and cost benefit analysis and marketing of agar Gellidium and fermented foods- cheese, pickles and other probiotic food. Mass production and marketing of compost- Vermicomposting and microbial compost - types of compost pits- Laboratory and field application; cost-benefit analysis.

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module [@] Self Learning[*] Entrepreneurial module [$]

REFERENCES:

1. Quality Control in Microbiology
   Rose, A.H.
   Academic Press, 2012.
2. Pharmaceutical Microbiology
   Hugo, W.B. and Russell, A.D.
   Blackwell Scientific Publications, 2007.
3. Industrial Microbiology
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4. Food Microbiology
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5. Microbiological Examination Methods of Food and Water
   Harrigan, W.F.
   Academic Press, 1998.
6. Fundamentals of Food Microbiology
   Ray, B. and Bhunia, A.
   CRC Press, 2013.
7. Pharmaceutical Biotechnology
   Crommelin, D.J.A. and Sindelar, R.D.
   Springer Publishers, 2019.
8. Manual of Industrial Microbiology and Biotechnology
   Baltz, R.H., Demain, A.L. and Davies, J.E.
   ASM Press, 2010.
9. Prescott's Microbiology
   Willey, J.M., Sherwood, L.M. and Woolverton, C.J.
   McGraw Hill Education, 2020.
10. Environmental Monitoring in Pharmaceutical Industries
    Moldenhauer, J.
    PDA Publishers, 2002.

WEB RESOURCES:

9. WHO – https://www.who.int
10. US FDA – https://www.fda.gov
11. Indian Pharmacopoeia Commission – https://ipc.gov.in
12. FSSAI – https://www.fssai.gov.in
13. NCBI – https://www.ncbi.nlm.nih.gov
14. PubMed – https://pubmed.ncbi.nlm.nih.gov
15. Microbe Notes – https://microbenotes.com
16. NPTEL – https://nptel.ac.in
17. SWAYAM – https://swayam.gov.in

JOURNAL RESOURCES:

Entrepreneurship and Biotechnology Business
- Journal of Commercial Biotechnology
- Technovation
- Biotechnology Advances

Business Development and Innovation Management
- International Journal of Entrepreneurship and Innovation
- Journal of Small Business Management
- Entrepreneurship Theory and Practice

Mushroom Cultivation and Single Cell Protein
- World Journal of Microbiology and Biotechnology
- Journal of Fungi
- Bioresource Technology

Biofertilizers and Biopesticides
- Applied Soil Ecology
- Journal of Applied Microbiology
- Biological Control

Fermentation, Probiotics and Industrial Microbiology
- Food Microbiology
- International Journal of Food Microbiology
- Applied Microbiology and Biotechnology

Composting and Waste Management
- Waste Management
- Bioresource Technology
- Compost Science & Utilization

- Trends in Biotechnology
- Nature Biotechnology
- Microbiology and Molecular Biology Reviews (MMBR)

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO_1***	***PO_2***	***PO_3***	***PO_4***	***PO_5***	***PO_6***	***PO_7***	
CO1 (Outline/Describe)	3	1	1	2	2	1	1	***11***
CO2 (Apply/Observe)	2	2	3	2	1	2	2	***14***
CO3 (Analyze/Examine)	2	3	3	2	2	2	1	***15***
CO4 (Evaluate/Design)	3	3	2	3	3	3	3	***20***
Total PO Contribution	**10**	**9**	**9**	**9**	**8**	**8**	**7**	**60 /84**
Average PO Contribution	***2.50***	***2.25***	***2.25***	***2.25***	***2.00***	***2.00***	***1.75***	***15& 71.42***
The values above represent the level of contribution: ***3 (High)***, ***2 (Medium)***, ***1 (Low)***, *and* ***0 (No Contribution)***.								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO_1***	***PSO_2***	***PSO_3***	***PSO_4***	***PSO_5***	***PSO_6***	***PSO_7***	
CO1 (Outline/Describe)	2	1	1	0	2	2	3	**11**
CO2 (Apply/Observe)	2	1	0	0	3	2	3	**11**
CO3 (Analyze/Examine)	1	1	0	0	2	3	3	**10**
CO4 (Evaluate/Design)	0	0	0	1	2	3	3	**9**
Total PSO Contribution	**5**	**3**	**1**	**1**	**9**	**10**	**12**	**41/84**
Average of PSO Contribution	2	1	1	0	2	2	3	**11**
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year	*II Semester*	*11. Elective 4 – Theory*	*Credits 3*

MICROBES FOR CLIMATE CHANGE CONTROL, WOMEN EMPOWERMENT & ECONOMY DEVELOPMENT	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Define and explain the basics of climate change, the role of greenhouse gases, microbial feedback mechanisms, and the foundational concepts of microbial processes in mitigation, women entrepreneurship, and rural sustainability.*

CO2 K3 (Apply) *Apply knowledge of microbial drivers, mitigation strategies (such as carbon sequestration and biofertilizers), biotechnological techniques (like Azolla or mushroom cultivation), and government schemes to solve environmental, agricultural, and entrepreneurial challenges.*

CO3 K4 (Analyze) *Analyze the impacts of climate change on society and ecosystems, the complex microbial cycles (Carbon, Methane, and Nitrogen), the structural challenges faced by women entrepreneurs, and the efficiency of different waste-to-wealth bioprocesses.*

CO4 K5 & K6 (Evaluate & Create) *Evaluate the effectiveness of next-gen green industrial solutions and organic inputs, and design/formulate sustainable microbe-based products, business strategies, or rural development models utilizing central and state government startup schemes.*

L T P C ***6 0 0 4***

UNIT I – Climate Change and Microbial Interactions

Basics of Climate Change : Definition – Green House Gases - Types, Source and its effects - Factors responsible for Climate Change – Impact – Daily CO2 Emission – Impacts – Climate Change and Society: Effect on Food Security, Health – Emergence of Diseases - Antimicrobial Resistance Development. Introduction to Microbes and Climate Change : Overview "Invisible Effect" of / on microbes - Microbial Feedback Mechanisms: Positive and negative feedbacks to global warming.

UNIT II – Microbial Drivers and Responses to Climate Change

Microbial Drivers of Climate Change (Greenhouse Gas Producers) Carbon Cycle: Microbial decomposition of organic matter, CO, CO2 - respiration. Methane Production: Anaerobic archaea in wetlands, oceans, and termite guts. Nitrous Oxide Emissions: Nitrification and denitrification processes. Microbial Responses to Environmental Change- Effect of climate change on Soil Microbial Communities – Ocean Microbes – Plant Microbes Interaction – Agricultural pathogens - Permarost Thaw.

UNIT III – Microbial Strategies for Climate Mitigation and Green Technologies

Microbial Strategies for Climate Mitigation : Methane Eaters (Methanotrophs) – Nitros Oxide Reduction – Carbon Sequestration. Sustainable Agriculture : Role of Biofertilizers as an alternate for inorganic fertilisers and their positive effects - Ecosystem Resilence – Live Stock

Emission Control – Role of organic inputs in climate change control / Reduction. Green Industrial Solutions : Next-Gen Biofuels – Biomanufacturing – Energy Generation: Microbial Fuel Cells- Biofuels – Need of E20 Fuel.

UNIT IV – Women Entrepreneurship and Microbial Technologies

Microbial Techniques for Women Development : Women Entrepreneurship in India – Entrepreneurial skills in Women - Challenges and its Management – Azolla & Spirulinia Cultivation – Mushroom Production – Yogurt Production – Cheese Making – Government Schemes for Women Start Ups – Successful Women Bio-Entrepreneurs : Mrs Mallika Srinivasan (TAFE) - Kiran Mazumdar Shaw (Biocon) • Saloni Godbole (Occamy Bioscience) - • Dr. Shrilakshmi Desiraju (Triphase) - Anuja Duklan (Suraitech Innovation) - Vanita Prasad - Rupali Bhatnagar (Sula Vineyards) - Ivy Jose and Sini Sha – Scope and Central and State Government Schemes for Women Entrepreneurship.

UNIT V – Microbe-Based Products for Rural Development and Sustainability

Microbe Based Products / Process for Rural Development and Sustainability: Biofertilizer (Nitrogen Fixers, Phosphate Solubilisers, Biodecomposers) Biopesticides (Microbial, Botanical and Biochemical) and Bioinoculant production – Fermented food and beverage production – Waste to wealth biocomposting and Biogas-Indigenous microorganisms harvesting – Organic inputs production: Panchakavya, Fish aminoacid – Effective Microbes – Vermiwash – Herbal pest repellent - Scope and Central and State Government Schemes for Microbe based Entrepreneurship.

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module [@] Self Learning[*] Entrepreneurial module [$]

REFERENCE BOOKS:

1. Environmental Microbiology by Ian L. Pepper, Charles P. Gerba, and Terry J. Gentry.
2. Brock Biology of Microorganisms by Madigan, Bender, Buckley, Sattley, and Stahl
3. Microbial Ecology: Fundamentals and Applications by Ronald M. Atlas and Richard Bartha.
4. Bio-fertilizers in Agriculture and Forestry by N.S. Subba Rao.
5. Textbook of Fungi, Bacteria and Plant Pathology by H.C. Dube
6. The Complete Book on Organic Farming and Production of Organic Compost by NPCS Board.
7. Mushroom Cultivation by J.N. Kapoor
8. Dairy Microbiology by R.K. Robinson.
9. Rural Development: Principles, Policies and Management by Katar Singh

WEB RESOURCES:

1. https://www.fao.org/soils-portal/soil-management/soil-carbon-sequestration/en/

2. https://www.fao.org/climate-smart-agriculture/en/

3. https://www.icar-crida.res.in/assets/img/Books/FTF%20ITI%20Compendium%20of%20lectures-2019.pdf

4. https://dmrsolan.res.in/

5. https://agrimoon.com/mushroom-culture-horticulture-icar-pdf-book/

6. https://kvkwestkhasihills.nic.in/publication/2024/TrainingManual/TrainingManualOysterMushroom.pdf

7. https://www.rbi.org.in/commonperson/English/scripts/Notification.aspx?Id=2662

8. https://www.myscheme.gov.in/schemes/cbssc-msy

9. https://mksp.nrlm.gov.in/portal/images/SLACC_training_manual_English.pdf

JOURNAL RESOURCES:

Climate Change and Environmental Microbiology
- Environmental Microbiology
- FEMS Microbiology Ecology
- Global Change Biology

Microbial Ecology and Biogeochemical Cycles
- ISME Journal
- Microbial Ecology
- Biogeochemistry

Climate Mitigation and Sustainable Agriculture
- Agriculture, Ecosystems & Environment
- Applied Soil Ecology
- Journal of Environmental Management

Bioenergy and Green Technologies
- Biomass and Bioenergy
- BioEnergy Research
- Renewable Energy

Women Entrepreneurship and Biotechnology
- Journal of Entrepreneurship and Innovation in Emerging Economies
- International Journal of Entrepreneurship and Small Business
- Journal of Commercial Biotechnology

Rural Development and Sustainable Technologies
- Bioresource Technology
- Waste Management
- World Journal of Microbiology and Biotechnology

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO_1***	***PO_2***	***PO_3***	***PO_4***	***PO_5***	***PO_6***	***PO_7***	
CO1 (Outline/Describe)	3	1	0	1	2	1	0	***08***
CO2 (Apply/Observe)	2	2	3	2	2	2	1	***14***
CO3 (Analyze/Examine)	2	3	2	2	3	2	1	***15***
CO4 (Evaluate/Design)	3	3	3	3	2	3	3	***20***
Total PO Contribution	**10**	**9**	**8**	**8**	**9**	**8**	**5**	**57/84**
Average PO Contribution	***2.50***	***2.25***	***2.00***	***2.00***	***2.25***	***2.00***	***1.25***	***14.25 &67.85***
The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO_1***	***PSO_2***	***PSO_3***	***PSO_4***	***PSO_5***	***PSO_6***	***PSO_7***	
CO1 (Outline/Describe)	2	1	1	0	3	1	2	**10**
CO2 (Apply/Observe)	2	2	1	1	3	1	3	**13**
CO3 (Analyze/Examine)	2	1	2	1	3	1	2	**12**
CO4 (Evaluate/Design)	1	1	1	2	3	2	3	**13**
Total PSO Contribution	**7**	**5**	**5**	**4**	**12**	**5**	**10**	**48 /84**
Average of PSO Contribution	**1.75**	**1.25**	**1.25**	**1.00**	**3.00**	**1.25**	**2.50**	**12.00/57.14**
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year

II Sem 12 Skill Development Course Credit 1	
IIINTERNSHIP	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Identify and explain the core theoretical concepts, industry-specific technical skills, and professional standards required to understand workplace culture and organizational behavior.*

CO2 K3 (Apply) *Apply classroom knowledge, analytical frameworks, and communication skills to practical problem-solving scenarios and real-world workplace tasks.*

CO3 K4 (Analyze) *Analyze workplace hierarchies, operational workflows, and professional network dynamics to distinguish effective career advancement strategies and identify areas for personal improvement.*

CO4 K5 & K6 (Evaluate & Create) *Evaluate hands-on field experiences to validate career goals, and design a strategic professional development plan incorporating feedback from industry experts and mentors*

L T P C ***2 101***

An internship is a temporary work opportunity offered by organizations to students or recent graduates to gain hands-on practical experience in a specific industry. It bridges the gap between classroom theory and real-world application, typically lasting anywhere from a few weeks to several months.

Key Benefits of an Internship

- **Real-World Experience:** You get to apply theoretical knowledge to actual industry projects, learning how a professional workplace operates.
- **Skill Development:** Internships help you hone both hard technical skills and soft skills like communication, time management, and teamwork.
- **Resume Enhancement:** Listing tangible experience and accomplishments makes your resume stand out in a highly competitive job market.
- **Professional Networking:** You get the chance to interact with industry professionals, managers, and executives, which can lead to mentorship and future job references.
- **Career Clarity:** It allows you to "test drive" a specific role or industry to see if it aligns with your long-term interests and strengths.
- **Higher Employability:** Companies frequently hire / recruit successful interns.

To enjoy the above benefits by students, Internship has been introduced in the second semester with 2 credits (3 Hours / Cycle) to get trained in industries involving microbiological applications.

Evaluation

Student shall submit their report (Minimum of 10 pages focusing microbiological operations, excluding front page, declaration, certificate etc.,).

The evaluation will be done at the end of the first semester by both external (50 Marks) and internal (50 Marks) examiners for a maximum marks of 100.

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	2	1	1	2	1	1	1	**9**
CO2 (Apply/Observe)	3	3	2	2	2	1	1	**14**
CO3 (Analyze/Examine)	2	2	2	3	3	1	1	**14**
CO4 (Evaluate/Design)	3	1	3	2	3	3	3	**18**
Total PO Contribution	**10**	**7**	**8**	**9**	**9**	**6**	**6**	***55***
Average of PO Contribution	**2.50**	**1.75**	**2.00**	**2.25**	**2.25**	**1.50**	**1.50**	**13.75/ 65.47**
The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	1	1	1	1	1	2	2	**9**
CO2 (Apply/Observe)	2	2	2	2	2	3	3	**16**
CO3 (Analyze/Examine)	1	1	1	1	1	2	3	**10**
CO4 (Evaluate/Design)	2	2	2	2	2	3	3	**16**
Total PSO Contribution	**6**	**6**	**6**	**6**	**6**	**10**	**11**	**51 /84**
Average of PSO Contribution	**1.50**	**1.50**	**1.50**	**1.50**	**1.50**	**2.50**	**2.75**	**12.75/6071**
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year ***II Semester*** ***13 Core Practical*** ***Credits 3***

PRACTICAL - III - LAB IN MICROBIAL GENETICS & MOLECULAR BIOLOGY	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Explain the fundamental principles, theoretical concepts, and underlying mechanisms of essential molecular biology techniques, including nucleic acid isolation, mutagenesis, electrophoresis, and bacterial gene transfer.*

CO2 K3 (Apply) *Perform standard laboratory protocols to successfully isolate chromosomal and plasmid DNA, induce mutations, separate biomolecules, and execute genetic recombination techniques (transformation and conjugation) in E. coli.*

CO3 K4 (Analyze) *Analyze experimental data from agarose gel electrophoresis, SDS-PAGE, and mutation assays to interpret genetic variations, distinguish between mutant and wild-type strains, and troubleshoot procedural anomalies.*

CO4 K5 & K6 (Evaluate & Create) *Evaluate the efficacy of specific genetic mapping and screening strategies, and design comprehensive experimental workflows using antibiotic markers and auxotrophic selection to isolate and validate modified bacterial strains.*

L T P C ***0 0 6 3***

1. Isolation of chromosomal DNA
2. Isolation of bacterial plasmids
3. Induced mutagenesis – UV and NTG
4. Spontaneous mutation
5. Agarose gel electrophoresis – plasmid and DNA samples
6. SDS-PAGE – Demonstration^{+}
7. Transformation in *E.coli.*
8. Conjugation in *E.coli* – Uninterrupted and interrupted
9. Isolation of auxotrophic mutants.
10. Checking for antibiotic markers.

Inter Departmental Expertise Module$^{\%}$ - Inter Institutional Expertise Module $^{\&}$ Researcher Module^{+} Alumni Module $^{\#}$Industrial Module$^{@}$ Self Learning* Entrepreneurial module $^{\$}$

LABORATORY MANUALS :

1. Cappuccino.J.C:7 and Sherman. N. (196). Microbiology – Laboratory Manual. Benjamin Cummins, New York
2. Kannan. N. (1996). Laboratory manual in General Microbiology. Palan Paramount Publication, Palani.
3. Gunasekharan. P. (1996). Laboratory manual in Microbiology, New Age International Ltd., Publishers, New Delhi.
4. Sundararaj, T. (2005). Microbiology – laboratory manual. (1st edition). Pubinj. Sundararaj. T, Chennai

5. Jayaraman, J. (1985). Laboratory manual in Biochemistry. Wiley Eastern Ltd, New Delhi.
6. Plummer, D.T. (1998). An Introduction to practical Biochemistry. Tata McGraw Hill, New Delhi.
7. Palanivelu P. (2001). Analytical Biochemistry and Separation techniques – A Laboratory Manual.
8. Benson (2002). Microbiological applications – Laboratory Manual in General Microbiology. International edition. McGraw Hill Higher education.
9. Collins, C.R. and Lyne P.M. (1976). Microbiological methods (4tyh edition). Butterwoths, London.
10. Dubey, R.C. and Maheshwari, O.K., (2002). Practical Microbiology. S. Chand and Co Ltd., New Delhi.
11. Baron, E.J. and Finegold, S.M. (1995). Diagnostic Microbiology. Blackwell Scientific Press.
12. Davis, L., Dipner, M.O and Battey, J.F. (1986). Basic methods in Molecular Biology. Elseiver, Amsterdam

WEB RESOURCES

1. https://webstor.srmist.edu.in/web_assets/srm_mainsite/files/files/BI501%20Advanced%20Biochemistry%20and%20Immunology.pdf
2. https://webstor.srmist.edu.in/web_assets/srm_mainsite/files/files/GeneticEngineeringLaboratorymanual.pdf
3. https://webstor.srmist.edu.in/web_assets/srm_mainsite/files/files/BIO217_BASIC_BIOTECHNOLOGY_LAB_MANUAL1.pdf
4. https://vlab.amrita.edu
5. https://www.urmc.rochester.edu/MediaLibraries/URMCMedia/labs/frelinger-lab/documents/Immunology-Lab-Manual.pdf
6. https://webstor.srmist.edu.in/web_assets/downloads/2021/18BTC106J-lab-manual.pdf
7. https://www.researchgate.net/publication/275045725_Practical_Immunology-_A_Laboratory_Manual

MAPPING								
COURSE OUTCOMES ***(COs) Vs*** *PROGRAMME OUTCOMES* ***(POs)***								**TOTAL SCORE**
CO#	***PO1***	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***	
CO1 (Outline/Describe)	3	1	1	2	0	1	0	**8**
CO2 (Apply/Observe)	2	2	3	2	1	1	2	**13**
CO3 (Analyze/Examine)	2	3	3	2	1	2	1	**14**
CO4 (Evaluate/Design)	3	3	3	3	2	2	2	**18**
Total PO Contribution	**10**	**9**	**10**	**9**	**4**	**6**	**5**	**53**
Average of PO	**2.50**	**2.25**	**2.50**	**2.25**	**1.00**	**1.50**	**1.25**	**13.25/63.09**
The values above represent the level of contribution: ***3 (High)****,* ***2 (Medium)****,* ***1 (Low)****, and* ***0 (No Contribution)****.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO1***	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***	
CO1 (Outline/Describe)	2	3	3	0	0	0	0	**8**
CO2 (Apply/Observe)	2	3	3	0	0	1	0	**9**
CO3 (Analyze/Examine)	2	3	3	0	0	0	0	**8**
CO4 (Evaluate/Design)	2	2	3	0	0	2	0	**9**
Total PSO Contribution	**8**	**11**	**12**	**0**	**0**	**3**	**0**	**34**
Average of POS Contribution	**2.00**	**2.75**	**3.00**	**0.00**	**0.00**	**0.75**	**0.00**	**8.50/40.47**
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								

First Year *II Semester* *14 Core Practical* *Credits 3*

PRACTICAL - IV - LAB IN BIOSTATISTICS AND IMMUNOLOGY AND IMMUNOTECHNIQUES	***SUB CODE:***

COURSE OUTCOMES (COs)

CO1 K1 & K2 (Remember & Understand) *Describe the fundamental principles of biostatistical measures and explain the underlying theoretical mechanisms of clinical immunological assays, including agglutination, precipitation, and advanced diagnostic tests.*

CO2 K3 (Apply) *Perform standard hematological procedures, clinical serological tests (such as blood grouping and latex agglutination), and calculate measures of central tendency, dispersion, and probability to represent biological data accurately.*

CO3 K4 (Analyze) *Analyze graphical data and experimental serological reactions to interpret diagnostic test results (e.g., Widal, CRP), and differentiate between the applications of various immunological techniques based on statistical significance.*

CO4 K5 & K6 (Evaluate & Create) *Evaluate the clinical validity, sensitivity, and limitations of advanced immunodiagnostic procedures (like ELISA and Western Blot), and formulate comprehensive, statistically validated laboratory conclusions for diagnostic reporting.*

L T P C ***0 0 6 3***

1. Construction of graph and bar diagram.
2. Calculation of mean, median and mode,
3. Calculation of standard deviation and standard error
4. Basics of Chi-Square test.
5. Collection of venous blood from human and separation and preservation of serum / plasma
6. Blood grouping
7. Latex agglutination tests: CRP, RA, ASO and VDRL[@]
8. Widal (Qualitative and Quantitative)
9. Precipitation reactions – SRID, DID, Rocket electrophoresis and immunoelectrophoresis and staining of precipitin lines (DEMO).
10. ELISA technique – (DEMO)[+]
11. Skin test – Mantoux test - (DEMO)[@]
12. Western Blot - (DEMO)

Inter Departmental Expertise Module[%] - Inter Institutional Expertise Module [&] Researcher Module[+] Alumni Module [#] Industrial Module[@] Self Learning[*] Entrepreneurial module [$]

LABORATORY MANUALS:

1. Cappuccino.J.C:7 and Sherman. N. (196). Microbiology – Laboratory Manual. Benjamin Cummins, New York
2. Kannan. N. (1996). Laboratory manual in General Microbiology. Palan Paramount Publication, Palani.
3. Gunasekharan. P. (1996). Laboratory manual in Microbiology, New Age International Ltd., Publishers, New Delhi.
4. Sundararaj, T. (2005). Microbiology – laboratory manual. (1st edition). Pubinj. Sundararaj. T, Chennai
5. Jayaraman, J. (1985). Laboratory manual in Biochemistry. Wiley Eastern Ltd, New Delhi.
6. Plummer, D.T. (1998). An Introduction to practical Biochemistry. Tata McGraw Hill, New Delhi.
7. Palanivelu P. (2001). Analytical Biochemistry and Separation techniques – A Laboratory Manual.
8. Benson (2002). Microbiological applications – Laboratory Manual in General Microbiology. International edition. McGraw Hill Higher education.
9. Collins, C.R. and Lyne P.M. (1976). Microbiological methods (4tyh edition). Butterwoths, London.
10. Dubey, R.C. and Maheshwari, O.K., (2002). Practical Microbiology. S. Chand and Co Ltd., New Delhi.
11. Baron, E.J. and Finegold, S.M. (1995). Diagnostic Microbiology. Blackwell Scientific Press.
12. Davis, L., Dipner, M.O and Battey, J.F. (1986). Basic methods in Molecular Biology. Elseiver, Amsterdam

WEB RESOURCES :

1. http://www.ndvsu.org/images/StudyMaterials/Micro/Exercise-4-Micro.pdf
2. https://www.asmscience.org/docserver/fulltext/10.1128/9781555815974/9781555814625_FM.pdf?expires=1624436187&id=id&accname=guest&checksum=7B63E33525150AC808AFD5B2102A757B
3. https://microbiologyinfo.com
4. https://user.eng.umd.edu/~nsw/ench485/lab11.htm

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME OUTCOMES (POs)								**TOTAL SCORE**
CO#	***PO_1***	***PO_2***	***PO_3***	***PO_4***	***PO_5***	***PO_6***	***PO_7***	
CO1 (Outline/Describe)	3	1	1	1	0	1	0	**7**
CO2 (Apply/Observe)	2	2	3	1	1	2	2	**13**
CO3 (Analyze/Examine)	2	3	2	2	1	2	1	**13**
CO4 (Evaluate/Design)	3	3	3	3	2	3	2	**19**
Total PO Contribution	**10**	**9**	**9**	**7**	**4**	**8**	**5**	**52/84**
Average of PO Contribution	**2.50**	**2.25**	**2.25**	**1.75**	**1.00**	**2.00**	**1.25**	**13.00/61.90**
*The values above represent the level of contribution: **3 (High)**, **2 (Medium)**, **1 (Low)**, and **0 (No Contribution)**.*								

MAPPING								
COURSE OUTCOMES (COs) Vs PROGRAMME SPECIFIC OUTCOMES (PSOs)								**TOTAL SCORE**
CO#	***PSO_1***	***PSO_2***	***PSO_3***	***PSO_4***	***PSO_5***	***PSO_6***	***PSO_7***	
CO1 (Outline/Describe)	1	1	3	0	0	1	2	**8**
CO2 (Apply/Observe)	1	2	3	0	0	1	3	**10**
CO3 (Analyze/Examine)	0	2	3	0	0	2	3	**10**
CO4 (Evaluate/Design)	0	2	3	0	0	3	3	**11**
Total PSO Contribution	**2**	**7**	**12**	**0**	**0**	**7**	**11**	**39**
Average of PSO Contribution	**0.25**	**1.75**	**3.00**	**0.00**	**0.00**	**1.25**	**2.75**	**9.75/46.42**
The values above represent the level of contribution: 3 (High), 2 (Medium), 1 (Low), and 0 (No Contribution).								