Annamalai University

(Accredited with 'A' Grade by NAAC)

Faculty of Science

Department of Microbiology

M.Sc. MICROBIOLOGY (Two - Year)
(TANSCHE Syllabus)

Programme Code: SMIC21

Regulations, Curricula and Syllabi
2023-24onwards

Annamalai University

Faculty of Science

DEPARTMENT OF MICROBIOLOGY

M.Sc. MICROBIOLOGY

Programme Code: SMIC21

These rules and regulations shall govern the Two year post graduate studies leading to the award of degree of **Master of Science in Microbiology** in the Faculty of Science. These academic Regulations shall be called "**Annamalai University, Faculty of Science M.Sc. Microbiology (Two- year) Regulations 2023**". They shall come into force with effect from the academic year 2023 – 2024.

1. **Definitions and Nomenclature**

1.1 **University** refers to Annamalai University.

1.2 **Department** means any of the academic departments and academic centers at the University.

1.3 **Discipline** refers to the specialization or branch of knowledge taught and researched in higher education. For example, Biochemistry is a discipline in the Natural Sciences, while Economics is a discipline in Social Sciences.

1.4 **Programme** encompasses the combination of courses and/or requirements leading to a degree. For example, M.A., M.Sc.

1.5 **Course** is an individual subject in a programme. Each course may consist of Lectures / Laboratory / Seminar / Project work / viva-voce etc. Each course has a course title and is identified by a course code.

1.6 **Curriculum** encompasses the totality of student experiences that occur during the educational process.

1.7 **Syllabus** is an academic document that contains the complete information about an academic programme and defines responsibilities and outcomes. This includes course information, course objectives, policies, evaluation, grading, learning resources and course calendar.

1.8 **Academic Year** refers to the annual period of sessions of the University that comprises two consecutive semesters.

1.9 **Semester** is a half-year term that lasts for a minimum duration of 90 days.

1.10 **Choice Based Credit System**: A mode of learning in higher education that enables a student to have the freedom to select his/her own choice of elective courses across various disciplines for completing the Degree programme.

1.11 **Credit** refers to the quantum of course work in terms of number of class hours in a semester required for a programme. The credit value reflects the content and duration of a particular course in the curriculum.

1.12 **Credit Hour** refers to the number of class hours per week required for a course in a semester. It is used to calculate the credit value of a particular course.

1.13 **Programme Outcomes** (POs) are statements that describe crucial and essential knowledge, skills and attitudes that students are expected to achieve and can reliably manifest at the end of a programme.

1.14 **Programme Specific Outcomes** (PSOs) are statements that list what the graduate of a specific programme should be able to do at the end of the programme.

1.15 **Course Objectives**are statements that define the expected goal of a course in terms of demonstrable skills or knowledge that will be acquired by a student.

1.16 **Course Outcomes** (COs) are statements that describe what students should be able to achieve/demonstrate at the end of a course. They allow follow-up and measurement of learning objectives.

1.17 **Grade Point Average** (GPA) is the average of the grades acquired in various courses that a student has taken in a semester. The formula for computing GPA is given in section 11.3

1.18 **Cumulative Grade Point Average** (CGPA) is a measure of overall cumulative performance of a student over all the semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. is given in section11.4.

1.19 **Letter Grade** is an index of the performance of a student in a particular course. Grades are denoted by the letters S, A, B, C, D, E, RA, and W.

2. Programme Offered and Eligibility Criteria:

The Department of Microbiology offers a M.Sc. Microbiology (Two - Year)programme. A pass in B.Sc. Microbiology / Biotechnology /Zoology and B.Sc. Botany / Chemistry / Biochemistry /Physics with any one ancillary subjects of Microbiology / Zoology / Botany or any other science subjects with biology accepted by the Syndicate of Annamalai University as equivalent thereto are eligible for admission.

2.1 In the case of SC/ST and Differently-abled candidates, a pass is the minimum qualification for all the above Programmes.

3. **Reservation Policy:** Admission to the various programmes will be strictly based on the reservation policy of the Government of Tamil Nadu.

4. Programme Duration

4.1 The Two Year Master's Programme consist of two academic years.

4.2 Each academic year is divided into two semesters, the first being from July to November and the second from December to April.

4.3 Each semester will have 90 working days (18 weeks).

5. Programme Structure

5.1 The Two Year Master's Programme consists of Core Courses, Elective Courses (Discipline Centric/Generic), Project, Skill Enhancement Course, Internship/industrial visit and extension activity.

5.2 Core courses

5.2.1 Core Course is mandatory and an essential requirement to qualify for the Degree.

5.2.2 These are a set of compulsory courses essential for each programme.

5.2.3 The core courses include both Theory (Core Theory) and Practical (Core Practical) courses.

5.3 Project

5.3.1 Each student shall undertake a Project and submit a dissertation as per guidelines in the final semester.

5.3.2 The Head of the Department shall assign a Research Supervisor to the student.

5.3.3 The Research Supervisor shall assign a topic for research and monitor the progress of the student periodically.

5.3.4 Students who wish to undertake project work in recognized institutions/industry shall obtain prior permission from the Department. The Research Supervisor will be from the host institute.

5.4 Elective courses

5.4.1 **Elective Course: Generic/Discipline Centric** is a course that a student can choose from a range of alternatives.

5.5 **Internship/Industrial Activity (Experiential Learning)**

5.5.1 Experiential learning in the form of internship/industrial activity provides opportunities to students to connect principles of the discipline with real-life situations.

5.5.2 In-plant training/field trip/internship/industrial visit fall under this category.

5.5.3 Experiential learning is categorized as non-core course.

5.6 **Industry/Entrepreneurship**

This course is to introduce students to the activity of setting up a business or businesses, taking on financial risks in the hope of profit.

5.7 **Skill Enhancement Course: SEC** is a course designed to provide value-based or skill-based knowledge. The main purpose of this course is to provide students with skills in the hands-on-mode to increase their employability.

5.8 Extension Activity The basic objective of extension activity is to create social awareness among the students by providing the opportunities to work with people and also to create an awareness and knowledge of social realities to have concern for the welfare of the community and engage in creative and constructive societal development.

5.8.1 It is mandatory for every student to participate in extension activity.

5.8.2 All the students should enroll under NSS/NCC/CYRC/RRC or any other service organization in the University.

5.8.3 Students should put a minimum attendance of 40 hours in a year duly certified by the Programme Co-Ordinator.

5.8.4 Extension activity shall be conducted outside the class hours.

5.8.5 Extension activity is categorized as non-core course.

5.9 Value Added Course (VAC)

Students may opt to take Value Added Course beyond the minimum credits required for the award of the degree. VACs are outside the normal credit paradigm.

5.10 Online Courses

5.10.1 The Heads of Departments shall facilitate enrolment of students in Massive Open Online Courses (MOOCs) platform such as SWAYAM to provide academic flexibility and enhance the academic career of students.

5.10.2 Students who successfully complete a course in the MOOCs platform shall be exempted from one elective course of the programme.

5.11 Credit Distribution: The credit distribution is organized as follows

Component	Course	Credits
Part A	**Core (Theory)**	**39**
	Core (Practical)	**18**
	Project with Viva voce	**7**
Part B (i)	**Elective (Generic/Discipline Centric)**	**18**
Part B (ii)	**Internship/Industrial Visit**	**02**
Part B (iii)	**Skill Enhancement Course/Professional Competency Skill**	**06**
Part C	**Extension Activity**	**01**
	TOTAL CREDITS	**91**

Part A component and Part B (i) will be taken into account for CGPA calculation for the post graduate programme and the other components of Part B and Part C will not be included for CGPA calculation and have to be completed during the duration of the programme as per norms, to be eligible for obtaining the PG degree.

5.12 Credit Assignment

Each course is assigned credits and credit hours on the following basis:

1 Credit is defined as

1 Lecture period of one hour duration per week over a semester

1 Tutorial period of one hour duration per week over a semester

1 Practical/Project period of two hours duration per week over a semester.

6 Attendance

6.1 Each faculty handling a course shall be responsible for the maintenance of Attendance and Assessment Record for candidates who have registered for the course.

6.2 The Record shall contain details of the students' attendance, marks obtained in the Continuous Internal Assessment (CIA) Tests, Assignments and Seminars. In addition the Record shall also contain the organization of lesson plan of the Course teacher.

6.3 The record shall be submitted to the Head of the Department and Dean once a month for monitoring the attendance and syllabus coverage.

6.4 At the end of the semester, the record shall be placed in safe custody for any future verification.

6.5 The Course teacher shall intimate to the Head of the Department at least seven calendar days before the last instruction day in the semester about the attendance particulars of all students.

6.6 Each student shall have a minimum of 75% attendance in all the courses of the particular semester failing which he or she will not be permitted to write the End-Semester Examination. The student has to redo the semester in the next year.

6.7 Relaxation of attendance requirement up to 10% may be granted for valid reasons such as illness, representing the University in extracurricular activities and participation in NCC/NSS/YRC/RRC.

7 Mentor-Mentee System

7.1 To help the students in planning their course of study and for general advice on the academic programme, the Head of the Department will attach certain number of students to a member of the faculty who shall function as a Mentor throughout their period of study.

7.2 The Mentors will guide their mentees with the curriculum, monitor their progress, and provide intellectual and emotional support.

7.3 The Mentors shall also help their mentees to choose appropriate electives and value-added courses, apply for scholarships, undertake projects, prepare for competitive examinations such as NET/SET, GATE etc., attend campus interviews and participate in extracurricular activities.

8 Examinations

8.1 The examination system of the University is designed to systematically test the student's progress in class, laboratory and field work through Continuous Internal Assessment (CIA) Tests and End-Semester Examination (ESE).

8.2 There will be two CIA Tests and one ESE in each semester.

8.3 The Question Papers will be framed to test different levels of learning based on Bloom's taxonomy viz. Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation/Creativity.

8.4 Continuous Internal Assessment Tests

8.4.1 The CIA Tests shall be a combination of a variety of tools such as class tests, assignments and seminars. This requires an element of openness.

8.4.2 The students are to be informed in advance about the assessment procedures.

8.4.3 The pattern of question paper will be decided by the respective faculty.

8.4.4 CIA Tests will be for one- or two-hours duration depending on the quantum of syllabus.

8.4.5 A student cannot repeat the CIA Test-I and CIA Test-II. However, if for any valid reason, the student is unable to attend the test, the prerogative of arranging a special test lies with the teacher in consultation with the Head of the Department.

8.4.6 For the CIA Tests, the assessment will be done by the Course teacher

8.5 End Semester Examinations (ESE)

8.5.1 The ESE for the first and third semester will be conducted in November and for the second and fourth semester in May.

8.5.2 Candidates who failed in any course will be permitted to reappear in failed course in the subsequent examinations.

8.5.3 The ESE will be of three hours duration and will cover the entire syllabus of the course.

9 Evaluation

9.1 Marks Distribution

9.1.1 For each course, the Theory, Practical and project shall be evaluated for a maximum of 100 marks.

9.1.2 For the theory courses, CIA Tests will carry 25% and the ESE 75% of the marks.

9.1.3 For the Practical courses, the CIA Tests will carry 25% and the ESE 75% of the marks.

9.2 Assessment of CIA Tests

9.2.1 For the CIA Tests, the assessment will be done by the Course Instructor

9.2.2 For the Theory Courses, the break-up of marks shall be as follows:

	Marks
Test-I and Test-II	15
Seminar	5
Assignment	5
Total	25

9.2.3 For the Practical Courses (wherever applicable), the break-up of marks shall be as follows:

	Marks
Test-I	10
Test-II	10
Viva-voce and Record	05
Total	25

9.3 Assessment of End-Semester Examinations

9.3.1 Evaluation for the ESE is done by internal examiners.

9.4 Assessment of Project/Dissertation

9.4.1 The Project Report/Dissertation shall be submitted as per the guidelines.

9.4.2 The Project Work/Dissertation shall carry a maximum of 100 marks.

9.4.3 CIA for Project will consist of a Review of literature survey, experimentation/field work, attendance etc.

9.4.4 The Project Report evaluation and viva-voce will be conducted by a committee constituted by the Head of the Department.

9.4.5 The Project Evaluation Committee will comprise the Head of the Department, Project Supervisor, and a senior faculty.

9.4.6 The marks shall be distributed as follows:

Continuous Internal Assessment (25 Marks)		End Semester Examination (75 Marks)	
Review-I - 10	Review-II -15	Project / Dissertation Evaluation	Vivavoce
		60	15

9.5 Assessment of Value-added Courses

9.5.1 Assessment of VACs shall be internal. Two CIA Tests shall be conducted during the semester by the Department(s) offering VAC.

9.5.2 The grades obtained in VACs will not be included for calculating the GPA/CGPA.

9.6 Passing Minimum

9.6.1 A student is declared to have passed in each course if he/she secures not less than 50% marks in the ESE and not less than 50% marks in aggregate taking CIA and ESE marks together.

9.6.2 A candidate who has not secured a minimum of 50% of marks in a course (CIA + ESE) shall reappear for the course in the next semester/year.

10. Conferment of the Master's Degree

A candidate who has secured a minimum of 50% marks in all courses prescribed in the programme and earned the minimum required credits shall be considered to have passed the Master's Programme.

11. Marks and Grading

11.1 The performance of students in each course is evaluated in terms Grade Point (GP).

11.2 The sum total performance in each semester is rated by Grade Point Average (GPA) while Cumulative Grade Point Average (CGPA) indicates the Average Grade Point obtained for all the courses completed.

11.3 **The GPA** is calculated by the formula

$$GPA = \frac{\sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{n} C_i}$$

where, $\boldsymbol{C_i}$ is the Credit earned for the Course $\boldsymbol{i}$ in any semester;

$\boldsymbol{G_i}$is the Grade Point obtained by the student for the Course $\boldsymbol{i}$ and

$\boldsymbol{n}$is the number of Courses passedin that semester.

11.4 **CGPA** is the Weighted Average Grade Point of all the Courses passed starting from the first semester to the current semester.

$$CGPA = \frac{\sum_{i=1}^{m} \sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{m} \sum_{i=1}^{n} C_i}$$

Where, $\boldsymbol{C_i}$ is the Credit earned for the Course $\boldsymbol{i}$ in any semester;

$\boldsymbol{G_i}$is the Grade Point obtained by the student for the Course $\boldsymbol{i}$ and

$\boldsymbol{n}$is the number of Courses passedin that semester.

$\boldsymbol{m}$is the number of semesters.

11.5 **Evaluation:**

11.5.1 **Performance of the student for each course will be rated as shown in the Table.**

Range of Marks	Grade Points	Letter Grade
90 and above	10	S
80-89	9	A
70-79	8	B
60-69	7	C
55-59	6	D
50-54	5	E
Less than 50	0	RA
Withdrawn from the examination	0	W

11.5.2 A ten-point rating scale is used for evaluation of the performance of the student to provide overall grade for the Master's Programme.

CGPA	CLASSIFICATION OF FINAL RESULT
8.25 and above	First Class with Distinction
6.5 and above but below 8.25	First Class
5.0 and above but below 6.5	Second Class
0.0 and above but below 5.0	Re-appear

11.6 **Classification of Results**. The successful candidates are classified as follows:

11.6.1 **For First Class with Distinction:** Candidates who have passed all the courses prescribed in the Programme in the first attempt with a CGPA of 8.25and above within the programme duration. Candidates who have withdrawn from the End Semester Examinations are still eligible for First Class with Distinction (See Section 12 for details).

11.6.2 **For First Class:** Candidates who have passed all the courses with a CGPA of 6.5and above.

11.6.3 **For Second Class:** Candidates who have passed all the courses with a CGPA between 5.0 and less than 6.5.

11.6.4 Candidates who obtain overall highest CGPA in all examinations in the first appearance itself are eligible for University Rank.

11.6.5 **Formula for Conversion of CGPA into Percentage**

CGPA × 9.5 = Percentage

11.7 **Course-Wise Letter Grades**

11.7.1 The percentage of marks obtained by a candidate in a course will be indicated in a letter grade.

11.7.2 A student is considered to have completed a course successfully and earned the credits if he/she secures an overall letter grade other than RA.

11.7.3 A course successfully completed cannot be repeated for the purpose of improving the Grade Point

11.7.4 A letter grade RA indicates that the candidate shall reappear for that course. The RA Grade once awarded stays in the grade sheet of the student and is not deleted even when he/she completes the course successfully later. The grade acquired later by the student will be indicated in the grade sheet of the Odd/Even semester in which the candidate has appeared for clearance of the arrears.

11.7.5 If a student secures RA grade in the Project Work/Field Work/Practical Work/Dissertation, he/she shall improve it and resubmit if it involves only rewriting/ incorporating the clarifications suggested by the evaluators or he/she can re-register and carry out the same in the subsequent semesters for evaluation.

12. Provision for Withdrawal from the End Semester Examination

12.1 The letter grade W indicates that a candidate has withdrawn from the examination.

12.2 A candidate is permitted to withdraw from appearing in the ESE for one course or courses in ANY ONE of the semesters ONLY for exigencies deemed valid by the University authorities.

12.3 Permission for withdrawal from the examination shall be granted only once during the entire duration of the programme.

12.4 Application for withdrawal shall be considered only if the student has registered for the course(s), and fulfilled the requirements for attendance and CIA tests.

12.5 The application for withdrawal shall be made ten days prior to the commencement of the examination and duly approved by the Controller of Examinations. Notwithstanding the mandatory prerequisite of ten days notice, due consideration will be given under extraordinary circumstances.

12.6 Withdrawal will not be granted for arrear examinations of courses in previous semesters and for the final semester examinations.

12.7 Candidates who have been granted permission to withdraw from the examination shall reappear for the course(s) when the course(s) are offered next.

12.8 Withdrawal shall not be taken into account as an appearance for the examination when considering the eligibility of the candidate to qualify for First Class with Distinction.

13. Academic misconduct: Any action that results in an unfair academic advantage/interference with the functioning of the academic community constitutes academic misconduct. This includes but is not limited to cheating, plagiarism, altering academic documents, fabrication/falsification of data, submitting the work of another student, interfering with other students' work, removing/defacing library or computer resources, stealing other students' notes/assignments, and electronically interfering with other students'/University's intellectual property. Since many of these acts may be committed unintentionally due to lack of awareness, students shall be sensitized on issues of academic integrity and ethics.

14. Transitory Regulations: Wherever there has been a change of syllabi, examinations based on the existing syllabus will be conducted for two consecutive years after implementation of the new syllabus in order to enable the students to clear the arrears. Beyond that, the students will have to take up their examinations in equivalent subjects, as per the new syllabus, on the recommendation of the Head of the Department concerned.

15. Notwithstanding anything contained in the above pages as Rules and Regulations governing the Two-Year Master's Programmes at Annamalai University, the Syndicate is vested with the powers to revise them from time to time on the recommendations of the Academic Council.

ANNAMALAI UNIVERSITY

FACULTY OF SCIENCE

DEPARTMENT OF MICROBIOLOGY

M. Sc.MICROBIOLOGY TWO YEAR Programme

PROGRAMME CODE: SMIC21

Curricula and Scheme of Examination

(For students admitted from the academic year 2023 - 2024)

CourseCode	Course Title	L	P	C	CIA	ESE	Total
		Hours/ Week					
SEMESTER – I							
23MICC101	1.1 Core I: General Microbiology and Microbial Diversity	7		5	25	75	**100**
23MICC102	1.2 Core II: Microbial Physiology	7		5	25	75	**100**
23MICP103	1.3 Core III: Practical IGeneral Microbiology, Microbial Diversityand Microbial Physiology		6	4	25	75	**100**
23MICE104	**1.4 Elective(Discipline Centric)- I:** Forensic science	5		3	25	75	**100**
23MICE105	Nanobiotechnology						
23MICE106	Microalgal Technology (Among the three choices, anyone can be choosen by the student)						
23MICE107	**1.5 Elective(Generic)- II:** Bioinstrumentation.	5		3	25	75	**100**
23MICE108	Herbal Technology& Cosmetic Microbiology						
23MICE109	Essentials of LaboratoryManagement and Biosafety (Among the three choices, anyone can be choosen by the student)						
	Total credits	30		**20**			**500**
SEMESTER – II							
23MICC201	2.1 Core IV: Medical Bacteriology and Mycology	6		5	25	75	**100**
23MICC202	2.2 Core V: Medical Virology and Parasitology	6		5	25	75	**100**
23MICP203	2.3 Core VI: Practical – II Medical Microbiology		6	4	25	75	**100**
23MICE204	**2.4 Elective(Discipline Centric)- III:** Epidemiology	4		3	25	75	**100**
23MICE205	Clinical Diagnostic Microbiology						
23MICE206	Bioremediation (Among the three choices anyone can be chosen by the student)						
23MICE207	**2.5 Elective(Generic)- IV:** Bioinformatics	4		3	25	75	**100**
23MICE208	Biosafety,Bioethics and IPR						

23MICE209	Clinical Research and Clinical Trials. (Among the three choices anyone can be chosenby the student)						
23MICS210	**2.7 Skill Enhancement Course I: Vermitechnology**	4		2	25	75	**600**
	Totalcredits	30		**22**			**600**
*** Internship during summer vacation. The credits shall be awarded in Semester – III Statement of Marks**							
SEMESTER – III							
23MICC301	3.1 Core VII:Immunology,Immunotechnology and Microbial Genetics.	6		5	25	75	**100**
23MICC302	3.2 Core VIII: Molecular Biology &Recombinant DNA Technology	6		5	25	75	**100**
23MICP303	3.3 Core X: Practical – III Immunology, Microbial Genetics and Molecular Biology		6	5	25	75	**100**
23MICC304	3.3 Core X: Fermentation Technology and Pharmaceutical Microbiology	6		4	25	75	**100**
23MICE305	**3.4 Elective(Discipline Centric)- V:** Soil Microbiology and Microbial Ecology	3		3	25	75	**100**
23MICE306	Microbial Toxicology						
23MICE307	Water conservation and water treatment (Among the three choices anyone can be choosen by the student)						
23MICS308	**3.7 Skill Enhancement Course II :** Organic Farming and Biofertilizer Technology	3		2	25	75	**100**
23MICI309	3.8 Internship / Industrial Activity	-		2	25	75	**100**
	Totalcredits	**30**		**26**			**700**
SEMESTER – IV							
23MICC401	4.1 Core XI: Food & Environmental Microbiology.	6		5	25	75	**100**
23MICP402	4.2 Core XII: Practical IV Applied Microbiology	6		5	25	75	**100**
23MICD403	4.3 Project work (Dissertation & Viva-Voce)	10		7	25	75	**100**
23MICE404	**4.4 Elective (Industry / Entrepreneurship) 20% Theory 80% Practical VI :** Bio energy	4		3	25	75	**100**
23MICE405	Marine Microbiology						
23MICE406	Life science for competitive Examinations (Among the three choices anyone can be choosen by the student)						
23MICS407	**4.5Skill Enhancement Course/Professional Competency Course**: Microbial Quality control and Testing	4		2	25	75	**100**
23MICX408	**4.6 Extension Activity**	-		1	25	75	**100**
	Total Credits	**30**		**23**			**600**
	TOTAL (HOURS/CREDITS/MARKS)	**120**		**91**			**2400**

L- Lectures; P- Practical; C- Credits; CIA- Continuous Internal Assessment; ESE- End-Semester Examination

CREDIT DISTRIBUTION:

S.No	Course Details	Credits
1.	Core Course [9 Courses X 5 Credits] [3 Courses X 4 Credits]	**57**
2.	Elective (Generic / Discipline Centric) (6 Courses X 3 Credits)	18
3.	Skill Enhancement Course [3Course X 2 Credits]	6
4.	Project Work	7
5.	Internship/ Industry	2
6.	Extension Activity	1
	Total Credits	**91**

Discipline Centric/ Generic Elective Courses:

Course Code	Course Title	L	P	C	CIA	ESE	Total
		Hours/Week					
23MICE104	**Elective(Discipline Centric) I :** Forensic science	**5**	**-**	**3**	**25**	**75**	**100**
23MICE105	Nanobiotechnology						
23MICE106	Microalgal Technology						
23MICE107	**Elective (Generic) II :** Bioinstrumentation.	**5**	**-**	**3**	**25**	**75**	**100**
23MICE108	Herbal Technology& Cosmetic Microbiology						
23MICE109	Essentials of LaboratoryManagement and Biosafety						
23MICE204	**Elective(Discipline Centric) III :** Epidemiology	**4**	**-**	**3**	**25**	**75**	**100**
23MICE205	Clinical Diagnostic Microbiology						
23MICE206	Bioremediation						
23MICE207	**Elective(Generic) IV :** Bioinformatics	**4**	**-**	**3**	**25**	**75**	**100**
23MICE208	Biosafety,Bioethics and IPR						
23MICE209	Clinical Research and Clinical Trials						
23MICE305	**Elective(Discipline Centric)V:** Soil Microbiology and Microbial Ecology	**3**	**-**	**3**	**25**	**75**	**100**
23MICE306	Microbial Toxicology						
23MICE307	Water conservation and water treatment						
23MICE404	**Elective (Industry / Entrepreneurship) 20% Theory 80% Practical VI :** Bio energy	3		3	25	75	**100**
23MICE405	Marine Microbiology						
23MICE406	Life science for competitive Examinations						

L- Lectures; P- Practical; C- Credits; CIA- Continuous Internal Assessment; ESE- End-Semester Examination

ANNAMALAI UNIVERSITY
Department of Microbiology

[Question Paper Pattern - INTERNAL TESTS I & II (CIA)]

(Based on Revised Bloom's Taxonomy)

Programme: M.Sc.:Two YearPG **Semester:All**

Time: 2 Hrs **Max.Marks:50**

Part-A (Level-K1)Marks: (6x2=12)

(Answer ALL of the questions)

1. Define /Choose/ Relate……
2. What / Why / How?
3. Multiple Choices a. b. c. d.
4. Multiple Choices a. b. c. d.
5. Match the followingi - a ii- b iii- civ- dv -
6. Match the followingi - a ii- b iii- civ- dv -

Part-B (Level-K2)Marks: (3x5=15)

(Answer any THREE of the questions)

7. Explain….
8. Describe….
9. Select……
10. Compare

Part-C (Level-K3/ Level-K4) Marks: (2x7=14)

(Answer any TWO of the questions)

11. Apply….
12. Calculate….
13. Categorize…

Part-D (Level-K5/ Level-K6)Marks: (1x9=9)

(Answer any ONE of the questions)

14. Discuss….
15. Summarize….

ANNAMALAI UNIVERSITY

Department of Microbiology
Pattern of question paper for END semester examinations
(Based on Revised Bloom's Taxonomy)
Year: I

Programme: M.Sc. Two Year PG Programme **Semester:I / II**

Course Code: **Course Name:**

Time: 3 Hrs **Max.Marks:100**

Part-A (Level-K1/ Level-K2) Marks: (10x2=20)
(Answer ALL of the questions)

1. Define……
2. Multiple Choices a. b. c. d.
3. Multiple Choices a. b. c. d.
4. Match the followingi - a ii- b iii- civ –dv - ….
5. Match the followingi - a ii- b iii- civ –dv - ….
6. Explain…….
7. Select….
8. Describe……
9. Classify….
10. Elucidate….

Part-B (Level-K3/ Level-K4) Marks: (8x5=40)
(Answer any EIGHT of the questions)

11. Prepare….
12. Solve….
13. Apply……
14. Show….
15. Categorize…
16. Analyze…
17. Distinguish….
18. Infer….
19. Compare….
20. Compute

Part-C (Level-K5) Marks: (3x10=30)
(Answer any THREE of the questions)

21. Discuss…
22. Summarize….
23. Evaluate….
24. Disprove….

Part-D (Level-K6)*Marks: (1x10=10)
(Answer any ONE of the questions)

25. Design….
26. Develop…

ANNAMALAI UNIVERSITY
Department of Microbiology
Year: II

Programme: M.Sc. Two Year PGProgrammeSemester:III / IV

Course Code: **Course Name:**
Time: 3 Hrs **Max.Marks:100**

Part-A (Level-K1/ Level-K2)Marks: (10x2=20)
(Answer ALL of thequestions)

1. Define……
2. Multiple Choices a. b. c. d.
3. Multiple Choices a. b. c. d.
4. Match the followingi - a ii- b iii- civ –dv - …..
5. Match the followingi - a ii- b iii- civ –dv - …..
6. Explain…….
7. Select…..
8. Describe…..
9. Classify….
10. Elucidate….

Part-B (Level-K3/ Level-K4)Marks: (6x5=30)
(Answer any SIX of the questions)

11. Apply……
12. Show…..
13. Prepare
14. Make use of….
15. Categorize…
16. Analyze…
17. Distinguish….
18. Simplify…..

Part-C (Level-K5)Marks: (3x10=30)
(Answer any THREE of the questions)

19. Discuss…
20. Recommend with
21. Evaluate…..
22. Justify….
23. Optimize…

Part-D (Level-K6)*Marks: (2x10=20)
(Answer any TWO of the questions)

24. Design….
25. Formulate …
26. Modify …..

M.Sc.Microbiology (TWO YEAR) PROGRAMME									
[End Semester Examinations] Bloom's Taxonomy - Questions Conforming to Levels K1 to K6									
	I Year (Two year PG)					II Year (Two Year PG)			
	Level	Part	Questions & Marks	Total Marks		Level	Part	Questions & Marks	Total Marks
	K1	A	5 x 2	10		K1	A	5 x 2	10
	K2		5 x 2	10		K2		5 x 2	10
	K3	B	4 x5	20		K3	B	2 x 5	10
	K4		4 x5	20		K4		4 x 5	20
	K5	C	3 x 10	30		K5	C	3 x10	30
	K6	D	1 x 10	10		K6	D	2x 10	20
				100					100

Programme Outcomes (POs):

On completion of Two Year M.Sc. Microbiology, students will be able to

PO1: Problem Solving Skill

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

PO2: Decision Making Skill

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

PO3: Ethical Value

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

PO4: Communication Skill

Ability to develop communication, managerial and interpersonal skills.

PO5: Individual and Team Leadership Skill

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

PO6: Employability Skill

Inculcate contemporary business practices to enhance employability skills in the competitive environment.

PO7: Entrepreneurial Skill

Equip with skills and competencies to become an entrepreneur.

PO8: Contribution to Society

Succeed in career endeavors and contribute significantly to society.

PO 9 Multicultural competence

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

PO 10: Moral and ethical awareness/reasoning

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

Programme Specific Outcomes (PSO):

PSO1 – Placement

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

PSO 2 - Entrepreneur

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

PSO3 – Research and Development

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

PSO4 – Contribution to Business World

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

PSO 5 – Contribution to the Society

To contribute to the development of the society by collaborating with stakeholders for mutual benefit.At the end of the programme, the student will be able to

Overall, the Programme is reasoning and applications oriented, equipping the students eligible for higher studies, jobs in various sectors and entrepreneurship abilities.

DEPARTMENT OF MICROBIOLOGY

M.Sc. MICROBIOLOGY [TWO YEAR]

SYLLABUS

Semester	Core Course I	L	P	C
I	23MICC-101:General Microbiology and Microbial Diversity	7	-	5

Course Objectives (CO):

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

Unit – 1:

History and Scope of Microbiology. Microscopy – Principles and applications. Types of Microscopes - Bright field, Dark-field, Phase-contrast, Fluorescence microscope, Transmission electron microscope (TEM) and Scanning electron microscope (SEM). Sample preparation for SEM & TEM. Atomic force, Confocal microscope. Micrometry – Stage, Ocular and its applications.

Unit – 2:

Bacterial Structure, properties and biosynthesis of cellular components – Cell wall. Actinomycetes and Fungi - Distribution, morphology, classification, reproduction and economic importance. Sporulation. Growth and nutrition - Nutritional requirements, Growth curve, Kinetics of growth, Batch culture, Synchronous growth, Measurement of growth and factors affecting growth.

Unit – 3:

Algae - Distribution, morphology, classification, reproduction and economic importance. Isolation of algae from soil and water. Media and methods used for culturing algae, Strain selection and large-scale cultivation. Life cycle - Chlamydomonas, Volvox Spirogyra (Green algae), Nostoc (Cyanobacteria) Ectocarpus, Sargassum (Brown algae), Polysiphonia, Batrachospermum (Red algae).

Unit – 4:

Microbial techniques - Safety guidelines in Microbiology Laboratories. Sterilization, Disinfection and its validation. Staining methods – Simple, Differential and Special staining. Automated Microbial identification systems - Pure cultures techniques – Cultivation of Anaerobic organisms. Maintenance and preservation of pure cultures. Culture collection centres - National and International.

Unit – 5:

Biodiversity - Introduction to microbial biodiversity – Thermophiles - Classification, Thermophilic Archaebacteria and its applications. Methanogens - Classification, Habitats, applications. Alkaliphiles and Acidophiles - Classification, discovery basin, its cell wall and membrane. Barophiles - Classification and its applications. Halophiles - Classification, discovery basin, cell walls and membranes – purple membrane, compatible solutes, Osmoadaptation / halotolerance - Applications of halophiles. Conservation of Biodiversity.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Examine various microbes employing the microscopic techniques learnt. Measure and compare the size of microbes.
CO2:	Differentiate and appreciate the anatomy of various microbes. Plan the growth of microbes for different environmental conditions.
CO3:	Identify and cultivate the algae understanding their habitat. Analyze the morphology, classify and propagate depending on its economic importance.
CO4:	Create aseptic conditions by following good laboratory practices.
CO5:	Categorize and cultivate a variety of extremophiles following standard protocols for industrial applications.

Text Books

1. James G Cappucino and N. Sherman MB(1996). A lab manual Benjamin Cummins, New York 1996.
2. Chan E.C.S., Pelczar M. J. Jr. and Krieg N. R. (2010). Microbiology. (5th Edition). Mc.Graw Hill. Inc, New York.
3. Prescott L. M., Harley J. P. and Klein D. A. (2004). Microbiology. (6th Edition). McGraw - Hill company, New York.
4. White D. Drummond J. and Fuqua C. (2011). The Physiology and Biochemistry of Prokaryotes, Oxford University Press, Oxford, New York.
5. Dubey R.C. and Maheshwari D. K. (2009). Textbook of Microbiology. S. Chand, Limited.

Reference Books:

1. Tortora G. J., Funke B. R. and Case C. L. (2015). Microbiology: An Introduction (12th Edition).Pearson, London, United Kingdom.
2. Webster J. and Weber R.W.S. (2007). Introduction to Fungi. (3rd Edition). Cambridge University Press, Cambridge.
3. Schaechter M. and Leaderberg J. (2004). The Desk encyclopedia of Microbiology. Elsevier Academic Press, California.
4. Ingraham, J.L. and Ingraham, C.A. (2000) Introduction to Microbiology. (2nd Edition). Books / Cole Thomson Learning, UK.
5. Madigan M. T., Bender K.S., Buckley D. H. Sattley W. M. and Stahl (2018) Brock Biology of Microorganisms. (15th Edition). Pearson.

Web Resources:

1. http://sciencenetlinks.com/tools/microbeworld.
2. https://www.microbes.info/.
3. https://www.asmscience.org/VisualLibrary.
4. https://open.umn.edu/opentextbooks/BookDetail.aspx?bookId=404
5. https://www.grsmu.by/files/file/university/cafedry//files/essential_microbiology.pdf

MappingwithProgrammeOutcomes

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

Semester	Core Course II	L	P	C
I	23MICC-102: Microbial Physiology	7	-	5

Course Objectives (CO):

CO1	Illustrate Bacterial nutrition and their utilization
CO2	Discuss cultivation methods and factors related to microbial growth
CO3	Demonstrate concepts of microbial metabolism
CO4	Impart the fundamentals and importance of biosynthetic pathways
CO5	Discuss the methods involved in Photosynthesis

Unit – 1:

Nutrition – Nutritional requirements and types in bacteria Phototrophs,Chemotrophs, Autotrophs and Heterotrophs. Nutrient transport mechanisms- Passive diffusion, Facilitated diffusion, Active transport, Group translocation and Specific transport system

Unit – 2:

Microbial growth – Growth curve and Measurement of Growth – Cell Number and Cell Mass and metabolic activity. Batch, Continuous, Synchronous and Asynchronous cultures, Factors affecting growth

Unit – 3:

Enzymes – properties, functions and regulation. Basic concepts of metabolism, Oxidation – reduction reactions, Energy generation by anaerobic metabolism – Glycolysis, Pentose Phosphate pathway, ED pathway, Fermentation. Energy generation by Aerobic metabolism - TCA cycle, Glycoxylate pathway and Electron Transport chain, Mechanism of ATP synthesis – Chemiosmosis, Pasteur effect. Metabolism of lipids-β oxidation..

Unit – 4:

Anaerobic Respiration. Nitrogen, Sulphur, Iron and Hydrogen Oxidation. Methanogenesis. Biosynthesis – Gluconeogenesis, Peptidoglycan synthesis, Amino acids, Purines, Pyrimidines Fattyacids, Triglycerides, Phospholipids and Sterols.

Unit – 5:

Photosynthesis – process, antenna of light-harvesting pigments, Photochemical reaction centers, Photosynthetic Electron Transport Chain-Cyclic and Non-cyclic. Oxygenic and Anoxygenic Photosynthesis. Calvin-Benson cycle. Bioluminescence - Process and application.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Apply knowledge about nutritional requirement, modes of nutrient transport in microorganisms to various disciplines of Microbiology
CO2:	Analyse microbial growth, factors influencing growth and its measurement techniques for applications in various industries.
CO3:	Compare various metabolic pathways and discuss the properties and functions of enzymes
CO4:	Apply anaerobic respiration and biosynthetic pathways to enhance/control microbial growth
CO5:	Assimilate methods involved in microbial photosynthesis and bioluminescence

Text Books

1.Stanier R.Y., Ingraham, J.L., Wheelis, M.L and Painter, P.R. (2010). General Microbiology. 5th Edn. Macmilan education Ltd. London.

2. Prescott. L.M., Harley. J.P., Klein. D.A. (1993). Microbiology. 2nd edn. Wm. C. Brown publishers, Dubugue.

3. Moat, A.G. and Foster, J.W. (2003). Microbial Physiology.4th Edn. John Wiley and Sons, New York.

4. Doelle, H.W. (1975) Bacterial Metabolism, 2nd Edn. Academic Press, London. 5. Caldwell, D.R (2000) Microbial physiology and metabolism, 2 nd Edn. Star publishing, Belmont, California

Reference Books:

1. Salle. A.J. (1992). Fundamental Principles of Bacteriology. 7th edn. McGraw Hill Inc.New York.
2. Madigan, M.T., Martinko, J.M., & ParkerJ. (2000). Brock Biology of Microorganisms. 9th Edn. Prentice Hall International, Inc, London.
3. Ingraham, J.L., & Ingraham, C.A. (2000). Introduction to Microbiology. 2nd Edn. Brook /Cole. Singapore.
4. Gottschalk, G. (1986). Bacterial Metabolism.2nd Edn. Springer-Verlag, New York. 5. Rose, A.H. (1976). An Introduction to Microbial Physiology. 3 rd Edn. Plenum, New York..

Web Resources

1. https://courses.lumenlearning.com/boundless-Microbiology/chapter/microbialnutrition/
2.https://www.lamission.edu/lifesciences/lecturenote/mic20/Chap06Growth.pdf
3. https://www.tandfonline.com/doi/abs/10.3109/07388558409082583?journalCo de=ibty20
4. https://wew.sciencedirect.com/topics/neuroscience/microbial-respiration.
5.https://www.britannica.com/science/photosynthesis

Mapping with Programme Outcomes

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

Semester	23MICP-103: Core III Practical I General Microbiology,Microbial Diversity and Microbial physiology	L	P	C
I		-	6	4

Course Objectives (CO):

CO1	Gain knowledge on the fundamentals, handling and applications of microscopy,
CO2	Provide fundamental skills in sterilization methods. Identify microbes by different staining methods
CO3	Prepare media for bacterial growth. Analyze microbial enzymes.
CO4	Perform plating techniques and methods involved in microbial preservation.
CO5	Measure bacterial growth, identify optimal growth parameters, cultivate bacteria, and perform antibiotic sensitivity

Unit – 1:

Microscopic Techniques: Light microscopy: Hay infusion broth. Wet mount to show different types of microbes, hanging drop. Micrometry. Dark field microscopy – Motility of Spirochetes. Washing and cleaning of glass wares: Sterilization methods: moist heat, dry heat, and filtration. Quality control check for each method.

Unit – 2:

Staining techniques - Simple staining, Gram's staining, Acid fast staining, Meta chromatic granule staining, Spore, Capsule, Flagella.

Unit – 3:

Media Preparation: Preparation of liquid, solid and semisolid media. Agar deeps, slants, plates. Preparation of basal, enriched, selective and enrichment media. Preparation of Biochemical test media, media to demonstrate enzymatic activities.

Unit – 4:

Purification and maintenance of microbes. Streak plate, pour plate, and slide culture technique. Aseptic transfer. Direct counts – Total cell count, Turbidometry. Viable count - pour plate, spread plate.

Unit – 5:

Bacterial growth curve. Effect of physical and chemical factors on growth. Anaerobic culture methods.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Apply microscopic techniques and staining methods in the identification and differentiation of microbes
CO2:	Apply the knowledge on the sterilization of glass wares and media by different methods and measurement of cell growth.
CO3:	Prepare media for bacterial growth. Analyze microbial enzymes.
CO4:	Pertain plating techniques and methods involved in microbial preservation..
CO5:	Analyze microbial growth, optimal growth parameters, cultivate bacteria, and perform antibiotic sensitivity

Text Books

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

Reference Books:

1. Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi.
2. Gupta P. S. (2003). Clinical Immunology. Oxford University Press.
3. Brown T.A. (2016). Gene Cloning and DNA Analysis. (7th Edition). John Wiley and Jones, Ltd.
4. Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wiley and Sons Ltd. 2012.
5. Maloy S. R., Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2nd Edition). Narosa Publishing Home Pvt Ltd.

Web Resources:

1. http://textbookofbacteriology.net/.
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/
3. https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/
4. [PDF] Lehninger Principles of Biochemistry (8th Edition) By David L. Nelson and Michael M. Cox Book Free Download - StudyMaterialz.in
5. https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/

Mapping with Programme Outcomes

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

Semester	Elective (Discipline Centric) : I	L	P	C
I	23MICE104- Forensic science	5	-	3

Course Objective (CO):

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

Unit – 1:

Forensic Science - Definition, history and development of forensic science. Scope and need of forensic science in present scenario. Branches of forensic science. Tools and techniques of forensic science. Duties of a forensic scientist.

Unit – 2:

Forensic science laboratories - Organizational setup of a forensic science laboratory. Central and State level laboratories in India. Mobile forensic science laboratory and its functions. Forensic microbiology - Types and identification of microbial organisms of forensic significance.

Unit – 3:

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

Unit – 4:

DNA profiling - Introduction, history of DNA typing. Extraction of DNA from blood samples - Organic and Inorganic extraction methods. DNA fingerprinting - RFLP, PCR, STR. DNA testing in disputed paternity.

Unit – 5:

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

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Identify the scope and need of forensic science in the present scenario.
CO2:	Plan for the organizational setup and functioning of forensic science laboratories.
CO3:	Analyze the biological samples found at the crime scene.
CO4:	Perform extraction and identification of DNA obtained from body fluids.
CO5:	Discuss the concept of forensic toxicology.

Text Books:

1. Nanda B. B. and Tewari R. K. (2001) Forensic Science in India: A Vision for the Twenty First Century. Select Publishers, New Delhi. ISBN- 10:8190113526 / ISBN-13:9788190113526.
2. . James S. H. and Nordby, J. J. (2015) Forensic Science: An Introduction to Scientific and Investigative Techniques. (5th Edition). CRC Press. ISBN-10:9781439853832 / ISBN-13:978-1439853832.
3. Li R. (2015) Forensic Biology. (2nd Edition). CRC Press, New York. ISBN-13:978-1-4398-8972-5.
4. Sharma B.R (2020) Forensic science in criminal investigation and trials. (6th Edition)Universal Press.
5. Richard Saferstein (2017). Criminalistics- An introduction to Forensic Science. (12th Edition).Pearson Press.

Reference Books:

1. Nordby J. J. (2000). Dead Reckoning. The Art of Forensic Detection- CRC Press, New York. ISBN:0-8493-8122-3.
2. Saferstein R. and Hall A. B. (2020). Forensic Science Hand book, Vol. I, (3rd Edition). CRC Press, New York. ISBN-10:1498720196.
3. Lincoln, P.J. and Thomson, J. (1998). (2nd Edition). Forensic DNA Profiling Protocols. Vol. 98. Humana Press. ISBN: 978-0-89603-443-3.
4. Val McDermid (2014). Forensics. (2nd Edition). ISBN 9780802125156.
5. Vincent J. DiMaio., Dominick DiMaio. (2001). Forensic Pathology (2nd Edition). CRC Press.

Web Resources:

1. http://clsjournal.ascls.org/content/25/2/114
2. https://www.ncbi.nlm.nih.gov/books/NBK234877/
3. https://www.elsevier.com/books/microbial-forensics/budowle/978-0-12-382006-8
4. https://www.researchgate.net/publication/289542469_Methods_in_microbial_forensics
5. https://cisac.fsi.stanford.edu/events/microbial forensics

Mapping with Programme Outcomes

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

Semester	Elective (Discipline Centric) : I 23MICE105- Nanobiotechnology	L	P	C
I		5	-	3

Course Objectives (CO):

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

Unit – 1:

Introduction to nanobiotechnology, Nano size-changing phenomena at nano scale, Classification of nanomaterials based on their dimensions (0D, 1D, 2D and 3D materials) and based on realization of their applications (The First, second, third and fourth generation materials),Class of nanomaterials and their applications. Need for nanomaterials and the risks associated with the materials.

Unit – 2:

Fabrication of Nanomaterials-Top-down and Bottom-up approaches, Solid phase synthesis-milling, Liquid phase synthesis-Sol-gel synthesis, colloidal synthesis, micro emulsion method, hydrothermal synthesis and solvo thermal synthesis, Vapour/Gas phase synthesis-Inert gas condensation, flame pyrolysis, Laser ablation and plasma synthesis techniques. Microbial synthesis of nanoparticles.

Unit – 3:

Characterization of nanoparticles – Based on particle size/morphology- Dynamic light scattering (DLS),Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy(AFM), Based on surface charge-zeta potential, Based on structure –X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), Energy dispersive X-ray analysis (EDX),Based on optical properties- UV – Spectrophotometer, Based on magnetic properties-Vibrating sample magnetometer(VSM).

Unit – 4:

Nanomaterial based Drug delivery and therapeutics-surface modified nano particles, MEMS/NEMS based devices, peptide/DNA coupled nanoparticles, lipid and inorganic nano particles for drug delivery, Metal/metaloxide nano particles as antibacterial, antifungal and antiviral agents. Toxicity of nanoparticles and Toxicity Evaluation.

Unit – 5:

Nanomaterials in diagnosis-Imaging, nanosensors in detection of pathogens. Treatment of surface water, ground water and waste water contaminated by toxic metal ions, organic and inorganic solutes and microorganisms.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Employ knowledge in the field of nanobiotechnology for development.
CO2:	Identify various applications of nanomaterials in the field of medicine and environment.
CO3:	Examine the prospects and significance of nanobiotechnology.
CO4:	Identify recent advances in this area and create a career or pursue research in the field.
CO5:	Design non-toxic nanoparticles for targeted drug delivery.

Text Books

1. Brydson R. M., Hammond, C. (2005). Generic Methodologies for Nanotechnology: Characterization. In Nanoscale Science and Technology. John Wiley & Sons, Ltd.
2. Leggett G. J., Jones R. A. L. (2005). Bionanotechnology. In Nanoscale Science and Technology. John Wiley & Sons, Ltd.
3. Mohan Kumar G. (2016). Nanotechnology: Nanomaterials and nanodevices. Narosa Publishing House.
4. Goodsell D. S. (2004). Bionanotechnology. John Wiley & Sons, Inc.
5. Pradeep T. (2007). Nano: The Essentials-Understanding nanoscience and nanotechnology. Tata McGraw-Hill.

Reference Books:

1. Nouailhat A. (2008). An Introduction to Nanoscience and Nanotechnology, Wiley.
2. Sharon M. and Maheshwar (2012). Bio-Nanotechnology: Concepts and Applications. New Delhi. Ane books Pvt Ltd.
3. Niemeyer C.M. and Mirkin C. A. (2005). Nanobiotechnology. Wiley Interscience.
4. Rehm, B. (2006). Microbial Bionanotechnology: Biological Self-Assembly Systems and Biopolymer-Based Nanostructures. Horizon Scientific Press.
5. Reisner, D.E. (2009). Bionanotechnology: Global Prospects. CRC Press.

Web Resources:

1. https://www.gale.com/nanotechnology
2. https://www.understandingnano.com/resources.html
3. http://dbtnanobiotech.com/index2.php
4. http://www.istl.org/11-winter/internet1.html
5. https://www.cdc.gov/niosh/topics/nanotech/default.html

Mapping with Programme Outcomes

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

Semester	Elective (Discipline Centric) : I 23MICE106- Microalgal Technology	L	P	C
I		5	-	3

Course Objectives (CO):

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

Unit – 1:

Introduction to Algae - General characteristics. Classification of algae according to Fritsch. Salient features of different groups of algae. Distribution - Freshwater, brackish water and marine algae. Identification methods. An overview of applied Phycology. Economically important microalgae.

Unit – 2:

Cultivation of freshwater and marine microalgae - Growth media. Isolation and enumeration of microalgae. Laboratory cultivation and maintenance. Outdoor cultivation - Photobioreactors - construction, types and operation; raceway ponds - Heterotrophic and mixotrophic cultivation - Harvesting of microalgae biomass.

Unit – 3:

Microalgae in food and nutraceutical applications - Algal single cell proteins. Cultivation of *Spirulina* and*Dunaliella*. Microalgae as aquatic, poultry and cattle feed. Microalgal biofertilizers. Value-added products from microalgae. Pigments - Production of microalgal carotenoids and their uses. Phycobiliproteins - production and commercial applications. Polyunsaturated fatty acids as active nutraceuticals. Microalgal secondary metabolites - Pharmaceutical and cosmetic applications.

Unit – 4:

Microalgae in environmental applications. Phycoremediation - Domestic and industrial waste water treatment. High-rate algal ponds and surface-immobilized systems - Treatment of gaseous wastes by microalgae. Sequestration of carbon dioxide. Scavenging of heavy metals by microalgae. Negative effects of algae. Algal blooms, algicides for algal control.

Unit – 5:

Microalgae as feed stock for production of biofuels - Carbon-neutral fuels. Lipid-rich algal strains - *Botryococcusbraunii*. Drop-in fuels from algae - hydrocarbons and biodiesel, bioethanol, biomethane, biohydrogen and syngas from microalgae biomass. Biocrude synthesis from microalgae. Integrated biorefinery concept. Life cycle analysis of algae biofuels.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Acquire knowledge in the field of microalgal technology and their characteristics.
CO2:	Identify the methods of algal cultivation and harvesting.
CO3:	Recognize and recommend the use of microalgae as food, feed and fodder.
CO4:	Promote microalgae in phycoremediation.
CO5:	Compare and critically evaluate recent applied research in these microalgal applications.

Text Books

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

Reference Books:

1. Andersen R.A. (2005). Algal culturing techniques. Academic Press, Elsevier.
2. Bux F. (2013). Biotechnological Applications of Microalgae: Biodiesel and Value-added Products. CRC Press.
3. Singh B., Bauddh K., Bux, F. (2015). Algae and Environmental Sustainability. Springer.
4. Das D. (2015). An algal biorefinery: An integrated approach. Springer.
5. Bux F. and Chisti Y. (2016). Algae Biotechnology: Products and Processes. Springer.

Web Resources:

1. https://www.classcentral.com/course/algae-10442
2. https://onlinecourses.nptel.ac.in/noc19_bt16/preview
3. https://freevideolectures.com/course/4678/nptel-industrial-biotechnology/46
4. https://nptel.ac.in/courses/103103207
5. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/microalgae

Mapping with Programme Outcomes

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

Semester	Elective(Generic): II 23MICE107-Bioinstrumentation	L	P	C
I		5	-	3

Course Objectives (CO):

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

Unit – 1:

Basic labo-ratory Instruments. Aerobic and anaerobic incubator – Biosafety Cabinets - Fume Hood, pH meter, Lyophilizer, Flow cytometry. Centrifugation techniques: Basic principles of centrifugation - Standard sedimentation coefficient - measurement of sedimentation co-efficient; Principles, methodology and applications of differential, rate zonal and density gradient centrifugation - Applications in determination of molecular weight.

Unit – 2:

General principles of chromatography - Chromatographic Performance parameters; Types- Thin layer chromatography, Paper Chromatography, Liquid chromatography (LPLC &HPLC), Adsorption, ion exchange, Gel filtration, affinity, Gas liquid (GLC). Flash Chromatography and Ultra Performance convergence chromatography. Two dimensional chromatography. Stimulated moving bed chromatography (SEC).

Unit – 3:

Electrophoresis: General principles - moving boundary electrophoresis - electrophoretic mobility – supportive materials – electro endosmosis – types (horizontal, vertical and two dimensional electrophoresis) - Principle and applications - paper electrophoresis, Serum electrophoresis, starch gel electrophoresis, Disc gel, Agarose gel, SDS – PAGE, Immuno electrophoresis. Blotting techniques -Southern, northern and western blotting.

Unit – 4:

Spectroscopic techniques: Principle, simple theory of absorption of light by molecules, electromagnetic spectrum, instrumentation and application of UV- visible, Raman, FTIR spectrophotometer, spectrofluorimetry, Atomic Absorption Spectrophotometer, Flame spectrophotometer, NMR, ESR, Emission Flame Photometry and GC-MS. Detection of molecules in living cells - FISH and GISH. Biophysical methods: Analysis of biomolecules by Spectroscopy UV/visible.

Unit – 5:

Radioisotopic techniques: Principle and applications of tracer techniques in biology. Radioactive isotopes - radioactive decay; Detection and measurement of radioactivity using ionization chamber, proportional chamber, Geiger- Muller and Scintillation counters, auto radiography and its applications. Commonly used isotopes in biology, labeling procedures and safety aspects.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Make use of the laboratory instruments- laminar air flow, pH meter, centrifugation methods, biosafety cabinets following SOP.
CO2:	Apply chromatography techniques in the separation of biomolecules.
CO3:	Perform molecular techniques like mutagenesis and their detection.
CO4:	Estimate molecules in biological samples by adopting UV spectroscopic techniques.
CO5:	Cultivate organisms anaerobically.

Text Books

1. Sharma B. K. (2014). Instrumental Method of Chemical Analysis. Krishna Prakashan Media (P) Ltd.
2. Chatwal G. R and Anand S. K. (2014.) Instrumental Methods of Chemical Analysis. Himalaya Publishing House.
3. Mitchell G. H. (2017). Gel Electrophoresis: Types, Applications and Research. Nova Science Publishers Inc.
4. Holme D. Peck H. (1998). Analytical Biochemistry. (3rd Edition). Prentice Hall.
5. Jayaraman J. (2011). Laboratory Manual in Biochemistry. (2ndEdition). Wiley Eastrn Ltd., New Delhi.

Reference Books:

1. Pavia D. L. (2012) Spectroscopy (4th Edition). Cengage.
2. Skoog A. and West M. (2014). Principles of Instrumental Analysis. (14th Edition). W.B.Saunders Co., Philadephia.
3. Miller J. M. (2007). Chromatography: Concepts and Contrasts (2nd Edition) Wiley-Blackwell.
4. Gurumani N. (2006). Research Methodology for Biological Sciences. (1st Edition) MJP Publishers.
5. Ponmurugan P. and Gangathara P. B. (2012). Biotechniques. (1st Edition). MJP Publishers.

Web Resources:

1. https://norcaloa.com/BMIA.
2. http://www.biologydiscussion.com/biochemistry/centrifugation/centrifuge-introduction- types-uses-and-other-details-with-diagram/12489
3. https://www.watelectrical.com/biosensors-types-its-working-and-applications.
4. http://www.wikiscales.com/articles/electronic-analytical-balance/
5. https://study.com/academy/lesson/what-is-chromatography-definition-types-uses.

Mapping with Programme Outcomes

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

Semester	Elective(Generic): II 23MICE108-Herbal Technology and Cosmetic Microbiology	L	P	C
I		5	-	3

Course Objectives (CO):

CO1	Impart knowledge of Indian Medicinal Plants and their applications in microbiology.
CO2	Promote the technical skills involved in preparation of different types of plant extracts.
CO3	Explain methods to analyze the antimicrobial activity of medicinal plants.
CO4	Acquire knowledge on cosmetic microbiology and role of microorganisms in cosmetics.
CO5	Gain insight into pharmacopeial microbial assays and biosafety.

Unit – 1:

Herbs, Herbal medicine - Indian medicinal plants: Scope and Applications of Indian medicinal plants in treating bacterial, fungal and viral diseases. Basic principles involved in Ayurvedha, Sidha, Unani and Homeopathy.

Unit – 2:

Collection and authentication of selected Indian medicinal plants: *Emblica officinalis, Withaniasomnifera, Phyllanthus amarus, Tinospora cordifolia, Andrographis paniculata, Piper longum, Ocimum sanctum, Azardirchata indica, Terminalia chebula, Allium sativum*. Preparation of extracts- Hot and cold methods. Preparation of stock solutions.

Unit – 3:

Antimicrobial activity of selected Indian medicinal Plants: - In vitro determination of antibacterial and fungal activity of selected whole medicinal plants/ parts – well-diffusion methods. MIC - Macro and micro dilution techniques. Antiviral activity- cell lines- cytotoxicity, cytopathic and non-cytopathic effect.

Unit – 4:

History of Cosmetic Microbiology – Need for cosmetic microbiology, Scope of cosmetic microbiology, - Role of microbes in cosmetic preparation. Preservation of cosmetics. Antimicrobial properties of natural cosmetic products – Garlic, neem, turmeric, aloe vera and tulsi. Sanitary practices in cosmetic manufacturing - HACCP protocols in cosmetic microbiology.

Unit – 5:

Cosmetic microbiology test methods - Antimicrobial preservative efficacy, microbial content testing and biological toxicological testing. Validation methods - bioburden and Pharmacopeial microbial assays. Preservatives of cosmetics - Global regulatory and toxicological aspect of cosmetic preservatives.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Identify the applications of Indian medicinal plants in treating diseases.
CO2:	Identify and authenticate herbal plants.
CO3:	Evaluate the antimicrobial activity of medicinal plants.
CO4:	Describe the role of microorganisms and their metabolites in the preparation of cosmetics.
CO5:	Validate procedures and biosafety measures in the mass production of cosmetics.

Text Books

1. Ayurvedic Formulary of India. (2011). Part 1, 2 & 3. Pharmacopoeia Commission for Indian Medicine and Homeopathy. ISBN-10:8190648977.
2. Panda H. (2004). Handbook on herbal medicines. Asia Pacific Business Press Inc. ISBN:8178330911.
3. Mehra P. S. (2019). A Textbook of Pharmaceutical Microbiology. Dreamtech Press. ISBN 13:9789389307344.
4. Geis P. A. (2020). Cosmetic microbiology: A Practical Approach. (3rd Edition). CRC Press. ISBN:9780429113697.
5. Brannan D. K. (1997). Cosmetic microbiology: A Practical Handbook. CRC Press.ISBN-10:0849337135.

Reference Books:

1. Indian Herbal Pharmacopoeia (2002). Vol. I &II Indian Drug Manufacturers Association, Mumbai.
2. British Herbal Pharmacopoeia.(1990).Vol.I. British Herbal Medicine Association.ISBN: 0903032090.
3. Verpoorte R. and Mukherjee, P. K. (2010). GMP for Botanicals: Regulatory and Quality issues on Phytomedicines. In GMP for botanicals: regulatory and quality issues on phytomedicines. (2nd edition). Saujanya Books, Delhi.ISBN-10:81-900788-5-2/8190078852. ISBN-13:978-81-900788-5-6/9788190078856.
4. Turner R. (2013). Screening methods in Pharmacology. Elsevier. ISBN:9781483264233.
5. Cupp M. J. (2010). Toxicology and Clinical Pharmacology of Herbal Products (pp. 85-93). M. J. Cupp. Humana Press.Totowa, NJ, USA. ISBN-10:1617371904.

Web Resources:

1. https://www.academia.edu/50236711/Modern_Extraction_Methods_for_Preparation_of_Bioactive_Plant_Extracts.
2. https://www.nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl.
3. https://pubmed.ncbi.nlm.nih.gov/17004305/
4. https://www.fda.gov/cosmetics/potential-contaminants-cosmetics/microbiological-safety-and-cosmetics
5. https://pubmed.ncbi.nlm.nih.gov/15156038/

Mapping with Programme Outcomes

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

Semester	Elective (Generic) : II	L	P	C
I	23MICE109 - Essentials of Laboratory Management and Biosafety	5	-	3

Course Objectives (CO):

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

Unit – 1:

Introduction to the laboratory and laboratory hazards - General laboratory facilities – Occupational safety- Lab accidents - Fires, chemical burns, slips and falls, Animal bites. Cuts from broken glass. Toxic fume inhalation. General laboratory rules, Good laboratory practice (GLP). Laboratory plan.

Unit – 2:

Common hazards in laboratory: Chemical hazards- Safe handling of chemicals and gases, hazard labels and symbols. Material safety datasheet (MSDS), Chemical handling - Fume hood, Storage of chemicals. Chemical Waste Disposal Guideline. Physical hazards - Physical agent data sheets (PADS), Electric hazards- Electrical shock, Electrical explosions, Electrical burns. Safe work practices. Potential ignition sources in the lab. Stages of Fire. Fire Extinguishers. Fire Response.

Unit – 3:

Prevention and First aid for laboratory accidents. Personal protective equipment (PPE), Proper attire (Eye/Face Protection, laboratory coats, gloves, respirators. Disposal/Removal of PPE. Emergency equipment safety - Showers/ Eye Washes. Laboratory security and emergency response. First aid for - Injuries caused by broken glass, Acid/Alkali splashes on the skin, swallowing acid/alkali, burns caused by heat, electric shock.

Unit – 4:

Biosafety - Historical background. Blood borne pathogens (BBP) and laboratory - acquired infections. Introduction to biological safety cabinets. Primary containment for biohazards. Biosafety levels of specific microorganisms. Recommended biosafety. Levels for infectious agents and infected animals. Risk groups with examples - Risk assessment. Safety levels. Case studies - Safe working, hand hygiene. Laboratory instruments, packing, sending, transport, import and export of biological agents. Hygiene, disinfection, decontamination, sterilization.

Unit – 5:

Biosafety regulations and guidelines. Centers for disease control and prevention and the National institutes of health. Occupational safety and health administration. Recombinant DNA advisory committee(RDAC), Institutional biosafety committee(IBSC), Review committee on genetic manipulation(RCGM), Genetic engineering approval committee (GEAC). Implementation of biosafety guidelines.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Employ skills on laboratory safety and avoid laboratory accidents.
CO2:	Prevent laboratory hazards by practicing safety strategies.
CO3:	Practice various first aid procedures during common laboratory accidents.
CO4:	Ensure biosafety strategies in laboratory.
CO5:	Recognize the importance of biosafety guidelines.

Text Books

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

Reference Books:

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

Web Resources:

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

Mapping with Programme Outcomes

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

Semester	Core Course IV	L	P	C
II	23MICC201: Medical Bacteriology and Mycology	6	-	5

Course Objectives (CO):

CO1	Acquire Knowledge on collection, transportation and processing of various kinds of clinical specimens.
CO2	Explain morphology, characteristics and pathogenesis of bacteria.
CO3	Discuss various factors leading to pathogenesis of bacteria.
CO4	Acquire knowledge on antifungal agents and their importance.
CO5	Describe various diagnostic methods available for fungal disease diagnosis.

Unit – 1:

Classification of medically important bacteria, Normal flora of human body, Collection, transport, storage and processing of clinical specimens, Microbiological examination of clinical specimens, antimicrobial susceptibility testing. Handling and maintenance of laboratory animals – Rabbits, guinea pigs and mice.

Unit – 2:

Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of Staphylococci, Streptococci, Pneumococci, Neisseriae., Bacillus, Corynebacteria, Mycobacteria and Clostridium.

Unit – 3:

Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by Enterobacteriaceae members, Yersinia, Pseudomonas, Vibrio, Mycoplasma, Helicobacter, Rickettsiae, Chlamydiae, Bordetella, Francisella., Spirochaetes- Leptospira, Treponema and Borrelia. Nosocomial, zoonotic and opportunistic infections - prevention and control.

Unit – 4:

Morphology, taxonomy and classification of fungi. Detection and recovery of fungi from clinical specimens. Dermatophytes and agents of superficial mycoses. Trichophyton, Epidermophyton &Microsporum. Yeasts of medical importance – Candida, Cryptococcus. Mycotoxins. Antifungal agents, testing methods and quality control.

Unit – 5:

Dimorphic fungi causing Systemic mycoses, Histoplasma, Coccidioides, Sporothrix, Blastomyces. Fungi causing Eumycotic Mycetoma, Opportunistic fungi- Fungi causing secondary infections in immunocompromised patients. Immunodiagnostic methods in mycology- Recent advancements in diagnosis. Antifungal agents.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Collect, transport and process of various kinds of clinical specimens.
CO2:	Analyze various bacteria based on morphology and pathogenesis.
CO3:	Discuss various treatment methods for bacterial disease.
CO4:	Employ various methods detect fungi in clinical samples and apply knowledge on antifungal agents.
CO5:	Apply various immunodiagnostic method to detect fungal infections.

Text Books

1. Kanunga R. (2017). Ananthanarayanan and Panicker's Text book of Microbiology. (2017).Orient Longman, Hyderabad.
2. Greenwood, D., Slack, R. B. and Peutherer, J. F. (2012) Medical Microbiology, (18th Edition). Churchill Livingstone, London.
3. Finegold, S. M. (2000) Diagnostic Microbiology, (10th Edition). C.V. Mosby Company, St. Louis.
4. Alexopoulos C. J., Mims C. W. and Blackwell M. (2007). Introductory Mycology, (4th Edition). Wiley Publishers.
5. Chander J. (2018). Textbook of Medical Mycology. (4th Edition). Jaypee brothers Medical Publishers.

Reference Books:

1. Salle A. J. (2007). Fundamental Principles of Bacteriology. (4th Edition). Tata McGraw-Hill Publications.
2. Collee J.C. Duguid J.P. Foraser, A.C, Marimon B.P, (1996). Mackie & McCartney Practical Medical Microbiology. 14thedn, Churchill Livingston.
3. Cheesbrough M. (2006). District Laboratory Practice in Tropical countries.- Part 22ndedn.Cambridge University Press.
4. Topley and Wilson's. (1998). Principles of Bacteriology.9th edn. Edward Arnold, London.
5. Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7th edn. Elsevier, Mosby Saunders.

Web Resources:

1. http://textbookofbacteriology.net/nd
2. https://microbiologysociety.org/members-outreach-resources/links.html
3. https://www.pathelective.com/micro-resources
4. http://mycology.cornell.edu/fteach.html
5. https://www.adelaide.edu.au/mycology/

Mapping with Programme Outcomes

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

Semester	Core Course V	L	P	C
II	23MICC202-Medical Virology and Parasitology	6	-	5

Course Objectives (CO):

CO1	Describe the replication strategy and cultivation methods of viruses.
CO2	Acquire knowledge about oncogenic virus and human viral infections.
CO3	Develop diagnostic skills, in the identification of virus infections.
CO4	Impart knowledge about parasitic infections.
CO5	Develop diagnostic skills, in the identification of parasitic infections.

Unit – 1:

General properties of viruses - Structure and Classification - viroids, prions, satellite RNAs and virusoids. Cultivation of viruses - embryonated eggs, experimental animals and cell cultures. Purification and Assay of viruses – Physical and Chemical methods (Electron Microscopy, Protein and Nucleic acids studies.) Infectivity Assays (Plaque and end-point).

Unit – 2:

Virus Entry, Host Defenses Against Viral Infections, Epidemiology, pathogenic mechanisms, Pathogenesis, laboratory diagnosis, treatment for the following viruses: DNA Viruses- Pox, Herpes, Adeno, Papova and Hepadna, RNA Viruses- Picorna, Orthomyxo, Paramyxo, Rhabdo, Rota, HIV and other Hepatitis viruses, Arbo – Dengue virus, Ebola virus, Emerging and reemerging viral infections

Unit – 3:

Bacterial viruses - ΦX 174, M13, MU, T4, lambda, Pi; Structural organization, life cycle and phage production. Lysogenic cycle-typing and application in bacterial genetics. Diagnosis of viral infections –conventional serological and molecular methods. Antiviral agents and viral vaccines.

Unit – 4:

Introduction to Medical Parasitology – Classification, host-parasite relationships. Epidemiology, life cycle, pathogenic mechanisms, laboratory diagnosis, treatment for the following: Protozoa causing human infections – *Entamoeba*, Aerobic and Anaerobic amoebae, *Giardia, Trichomonas, Balantidium. Toxoplasma, Cryptosporidium, Leishmania,* and *Trypanosoma.*

Unit – 5:

Classification, life cycle, pathogenicity, laboratory diagnosis and treatment for parasites – Helminthes - Cestodes – *Taenia Solium, T. Saginata, T. Echinococcus*. Trematodes – *Fasciola Hepatica, FasciolopsisBuski, Paragonimus, Schistosomes*. Nematodes - *Ascaris, Ankylostoma, Trichuris, Trichinella, Enterobius, Strongyloides*and*Wuchereria*. Other parasites causing infections in immune compromised hosts and AIDS. Cultivation of parasites. Diagnosis of parasitic infections – Serological and molecular diagnosis. Anti-protozoan drugs.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Cultivate viruses by different methods and aid in diagnosis. Perform purification and viral assay.
CO2:	Investigate the symptoms of viral infections and presumptively identify the viral disease.
CO3:	Diagnose various viral diseases by different methods.(serological, conventional and molecular)
CO4:	Educate public about the spread, control and prevention of parasitic diseases.
CO5:	Identify the protozoans and helminths present in stool and blood specimens. Perform serological and molecular diagnosis of parasitic infections.

Text Books

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

Reference Books:

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

Web Resources:

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

Mapping with Programme Outcomes

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

Semester	23MICP203-Core Course VI -Practical II Medical Microbiology	L	P	C
II		-	6	4

Course Objectives (CO):

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

Practicals:

Unit – 1:

Staining of clinical specimens - Wet mount, Differential and Special staining methods.

Isolation and identification of bacterial pathogens from clinical specimens - cultivation in basal, differential, enriched, selective and special media – Biochemical identification tests.

Enumeration of bacteria in urine to detect significant bacteriuria.Antimicrobial sensitivity testing - Kirby Bauer method and Stokes method.Minimum inhibitory concentration (MIC) test. Minimum bactericidal concentration (MBC) test.

Unit – 2:

Identification and Classification of common fungi.Mounting and staining of VAM spores.

Examination of different fungi by Lactophenol cotton blue staining.Examination of different fungi by KOH staining.Cultivation of fungi and their identification - *Mucor, Rhizopus, Aspergillus, Penicillium.*Microscopic observation of different asexual fungal spores.

Microscopic observation of fungal fruiting bodies.Identification of Dermatophytes.

Unit – 3:

Isolation and characterization of bacteriophage from natural sources by phage titration.

Cultivation of viruses –Egg Inoculation methods.Diagnosis of Viral Infections –ELISA – HIA.Spotters of viral inclusions and CPE-stained smears.

Unit – 4:

Examination of parasites in clinical specimens - Ova/cysts in faeces.Concentration: methods – Floatation methods-simple Saturated salt solution method – Zinc sulphate methods - Sedimentation methods- Formal ether method.

Unit – 5:

Blood smear examination for malarial parasites. Thin smear by Leishman's stain – Thick smear by J.B. stain.Identification of common arthropods of medical importance - spotters of *Anopheles, Glossina, Phlebotomus, Aedes,* Ticks and mites.

Course Outcomes (CO)

On completion of this course, students will;

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

Text Books

1. Cullimore D. R. (2010). Practical Atlas for Bacterial Identification, 2nd Edition. Publisher-Taylor and Francis.
2. Abbott A.C. (2010). The Principles of Bacteriology. Nabu Press.
3. Parija S. C. (2012). Textbook of Practical Microbiology. Ahuja Publishing House.
4. Cappuccimo, J. and Sherman, N. (2002) Microbiology: A Laboratory Manual, (6thEdition). Pearson Education, Publication, New Delhi.
5. Morag C. and Timbury M.C. (1994).Medical Virology. 4th edn. Blackwell Scientific Publishers.

Reference Books:

1. Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi.
2. Chart H. (2018). Practical Laboratory Bacteriology. CRC Press.
3. Moore V. A. (2017). Laboratory Directions for Beginners in Bacteriology. Triste Publishing Ltd.
4. Cheesbrough M. (2006). District Laboratory Practice in Tropical countries.- Part 22nd Edition.Cambridge University Press.
5. Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7th Edition. Elsevier, Mosby Saunders

Web Resources:

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

Mapping with Programme Outcomes

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

Semester	Elective (Discipline Centric) : III 23MICE 204- Epidemiology	L	P	C
II		4	-	3

Course Objectives (CO):

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

Unit – 1:

Fundamentals of epidemiology - Definitions of epidemiology – Epidemiology of infectious diseases in Public Health. Natural history of disease - Historical aspects of epidemiology. Common risk factors - Epidemiologic Triad - Agent factors, host factors and environmental factors. Transmission basics - Chain of infection, portal of entry. Modes of transmission -Direct and indirect. Stages of infectious diseases. Agents and vectors of communicable diseases of public health importance and dynamics of disease transmission. Epidemiology of Zoonosis - Factors, routes of transmission of bacterial, viral, parasitic and fungal zoonotic agents. Control of zoonosis.

Unit – 2:

Tools of Epidemiology - Measures of Disease - Prevalence, incidence. Index case. Risk rates. Descriptive Epidemiology - Cohort studies, measuring infectivity, survey methodology including census procedures. Surveillance strategies - Disease surveillance, geographical indication system, outbreak investigation in public health and contact investigation.

Unit – 3:

Epidemiological aspects of diseases of national importance - Background to communicable and non-communicable diseases. Vector borne diseases in India. Diarrhoeal diseases. Zoonoses. Viral haemorrhagic fevers. Mycobacterial infections. Sexually transmitted diseases. Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS). Emerging disease threats - Severe Acute Respiratory Syndrome (SARS), Covid-19, Ebola, MDR-TB, Malaria, Mucor mycosis, Avian flu. Dengue, Swine Flu, Chikungunya. Epidemiology, prevention, and control of non-communicable diseases - Asthma, Coronary heart disease, Malignancy, diabetes mellitus, respiratory diseases, eye diseases, Dental disorders. Emerging and Re-emerging Diseases.

Unit – 4:

Mechanisms of Antimicrobial resistance - Multidrug Efflux pumps, Extended Spectrum β-lactamases (ESBL). Hospital acquired infections - Factors, infection sites, mechanisms, Role of Multidrug resistant pathogens. Role of *Pseudomonas, Acinetobacter, Clostridium difficile,* HBV, HCV, Rotavirus, *Cryptosporidium* and *Aspergillus* in Nosocomial infections. Prevention and management of nosocomial infections.

Unit – 5:

National Programmes related to Communicable and Non-Communicable diseases - National Malaria Eradication Programme, Revised National Tuberculosis Control Programme, Vector Borne Disease Control Programme, National AIDS Control Programme, National Cancer Control Programme and National Diabetes Control Programme. Biochemical and immunological tools in epidemiology - Biotyping, Serotyping, Phage typing, FAME (Fatty acid methyl ester analysis), Curie Point PyMS (Pyrolysis Mass spectrometry), Protein profiling, Molecular typing methods.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Apply the knowledge acquired on concepts of epidemiology to clinical and public health environment.
CO2:	Plan various strategies to trace the epidemiology.
CO3:	Plan the control of communicable and non-communicable diseases.
CO4:	Analyze the implications of drug resistance in the society and design the control of antimicrobial resistance and its management.
CO5:	Employ National control programs related to Communicable and Non-Communicable diseases with the public.

Text Books

1. Dicker R., Coronado F., Koo. D. and Parrish. R. G. (2012). Principles of Epidemiology in Public Health Practice., (3rd Edition). CDC.
2. Gerstman B. (2013). Epidemiology Kept Simple: An Introduction to Classic and Modern Epidemiology. (3rd Edition). Wiley Blackwell.
3. Greenwood, D., Slack, R. B. and Peutherer, J. F. (2012) Medical Microbiology, (18th Edition). Churchill Livingstone, London.
4. Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A.
5. Dimmok N. J. and Primrose S. B. (1994). Introduction to Modern Virology.5th edn. Blackwell Scientific Publishers.

Reference Books:

1. Bhopal R. S. (2016).Concepts of Epidemiology - An Integrated Introduction to the Ideas, Theories, Principles and Methods of Epidemiology. (3rd Edition). Oxford University Press, New York.
2. Celentano D. D. and Szklo M. (2018). Gordis Epidemiology. (6th Edition). Elseiver, USA.
3. Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2nd Edition). Cambridge University Press.
4. Ryan K. J. and Ray C. G. (2004). Sherris Medical Microbiology. (4th Edition), McGraw Hill, New York.
5. Topley W.W. C., Wilson, G. S., Parker M. T. and Collier L. H. (1998). Principles of Bacteriology. (9th Edition). Edward Arnold, London.

Web Resources:

1. https://www.scielo.br/j/rbca/a/mjDFGTtfWtBm786ZmR9TG9d/?lang=en
2. https://hal.archives-ouvertes.fr/hal-00902711/document
3. https://www.who.int/csr/resources/publications/whocdscsreph200212.pdf
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7187955/
5. https://www.who.int/diseasecontrol_emergencies/publications/idhe_2009_london_outbreaks.pdf

Mapping with Program Outcomes

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

Semester	Elective (Discipline Centric) : III	L	P	C
II	23MICE-205- Clinical and Diagnostic Microbiology	4	-	3

Course Objectives (CO):

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

Unit – 1:

Microbiology Laboratory Safety Practices -General Safety Guidelines, Handling of Biological Hazards, Infectious health care waste disposal - Biomedical waste management, Emerging and Re-emerging infections.

Unit – 2:

Diagnostic procedures - General concept of Clinical specimen collection, transport, storage and general processing in Microbiology laboratory - Specimen acceptance and rejection criteria.

Unit – 3:

Diagnosis of microbial diseases - Clinical, differential, Microbiological, immunological and molecular diagnosis of microbial diseases. Modern and novel microbial diagnostic methods. Automation in Microbial diagnosis.

Unit – 4:

Antibiotic sensitivity tests - Disc diffusion - Stokes and Kirby Bauer methods, E test - Dilution - Agar dilution & broth dilution - MBC/MIC - Quality control for antibiotics and standard strains.

Unit – 5:

Nosocomial infections – common types, sources, reservoir and mode of transmission, pathogenesis and control measures. Hospital Infection Control Committee (HICC) – Functions.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Apply Laboratory safety procedures and hospital waste disposal strategies.
CO2:	Collect various clinical specimens, handle, preserve and process safely.
CO3:	Identify the causative agents of diseases by conventional and molecular methods following standard protocols.
CO4:	Assess the antimicrobial susceptibility pattern of pathogens.
CO5:	Trace the sources of nosocomial infection and recommend control measures.

Text Books

1. Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi. ISBN-10:0443047219 / ISBN-13-978-0443047213.
2. Tille P. M. (2021). Bailey and Scott's Diagnostic Microbiology. (15th Edition). Elsevier. ISBN:9780323681056.
3. Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A.
4. Mukherjee K.L. (2000). Medical Laboratory Technology.Vol. 1-3. (2nd Edition). Tata McGraw-Hill Education. ISBN-10:0074632604.
5. Sood R. (2009). Medical Laboratory Technology – Methods and Interpretations. (6th Edition). Jaypee Brothers Medical Publishers (P) Ltd. New Delhi. ISBN:9788184484496.

Reference Books:

1. Murray P. R., Baron E. J., Jorgenson J. H., Pfaller M. A. and Yolken R.H. (2003). Manual of Clinical Microbiology. (8th Edition). American Society for Microbiology, Washington, DC. ISBN:1-555810255-4.
2. Bennett J. E., Dolin R. and Blaser M. J. (2019). Principles and Practice of Infectious Diseases. (9th Edition). Elsevier. EBook ISBN:9780323550277. Hardcover ISBN:9780323482554.
3. Ridgway G. L., Stokes E. J. and Wren M. W. D. (1987). Clinical Microbiology 7th Edition. Hodder Arnold Publication. ISBN-10:0340554231 / ISBN-13:9780340554234.
4. Koneman E.W., Allen S. D., Schreckenberg P. C. and Winn W. C. (2020). Koneman's Color Atlas and Textbook of Diagnostic Microbiology. (7th Edition). Jones & Bartlett Learning. ISBN:1284322378 9781284322378.
5. Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2nd Edition). Cambridge University Press. ISBN-13:978-0-521-67631-1 / ISBN-10:0-521-67631-2.

Web Resources:

1. https://www.ncbi.nlm.nih.gov/books/NBK20370/
2. https://www.msdmanuals.com/en-in/home/infections/diagnosis-of-infectious3disease/diagnosis-of-infectious-disease
3. https://journals.asm.org/doi/10.1128/JCM.02592-20
4. https://www.sciencedirect.com/science/article/pii/S2221169116309509
5. http://www.textbookofbacteriology.net/normalflora_3.html

Mapping with Programme Outcomes

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

Semester	Elective (Discipline Centric) : III	L	P	C
II	23MICE206- Bioremediation	4	-	3

Course Objectives (CO):

CO1	Describe the nature and importance of bioremediation and use in real world applications.
CO2	Describe the typical composition of waste water and application of efficient technologies for water treatment.
CO3	Explain the fundamentals of treatment technologies and the considerations for its design and implementation in treatment plants.
CO4	Explain the potential of microbes in ore extraction and acquaint students with methods of reducing health risks caused by xenobiotics.
CO5	Familiarize the role of plants and their associated microbes in remediation and management of environmental pollution.

Unit – 1:

Bioremediation - process and organisms involved. Bioaugmentation - Ex-situ and in-situ processes; Intrinsic and engineered bioremediation. Major pollutants and associated risks; organic pollutant degradation. Microbial aspects and metabolic aspects. Factors affecting the process. Recent developments and significance.

Unit – 2:

Microbes involved in aerobic and anaerobic processes in nature. Water treatment - BOD, COD, dissolved gases, removal of heavy metals, total organic carbon removal. Secondary waste water treatments - use of membrane bioreactor. Aquaculture effluent treatment. Aerobic sludge and landfill leachate process. Aerobic digestion.

Unit – 3:

Composting of solid wastes, anaerobic digestion - methane production and important factors involved, Pros and cons of anaerobic process, sulphur, iron and nitrate reduction, hydrocarbon degradation, degradation of nitroaromatic compounds. Bioremediation of dyes, bioremediation in paper and pulp industries. Aerobic and anaerobic digesters – design. Various types of digester for bioremediation of industrial effluents.

Unit – 4:

Microbial leaching of ores - process, microorganisms involved and metal recovery with special reference to copper and iron. Biotransformation of heavy metals and xenobiotics. Petroleum biodegradation - reductive and oxidative. Dechlorination. Biodegradable of plastics and super bug.

Unit – 5:

Phytoremediation of heavy metals in soil - Basic principles of phytoremediation - Uptake and transport, Accumulation and sequestration. Phytoextraction. Phytodegradation. Phytovolatilization. Rhizodegradation. Phytostabilization – Organic and synthetic amendments in multi metal contaminated mine sites. Role of Arbuscular mycorrhizal fungi and plant growth promoting rhizobacteria in phytoremediation.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Differentiate Ex-situ bioremediation and In-situ bioremediation. Assess the roles of organisms in bioremediation.
CO2:	Distinguish microbial processes necessary for the design and optimization of biological processing unit operations.
CO3:	Identify, formulate and design engineered solutions to environmental problems.
CO4:	Explore microbes in degradation of toxic wastes and playing role on biological mechanisms.
CO5:	Establish the mechanisms of Arbuscular mycorrhizal fungi and Plant growth promoting Rhizobacteria in phytoremediation.

Text Books

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

Reference Books:

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

Web Resources:

1. Bioremediation- Objective, Principle, Categories, Types, Methods, Applications (microbenotes.com)
2. https://agris.fao.org › agris-search
3. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/bioremediation
4. https://www.intechopen.com/chapters/70661
5. https://microbiologysociety.org/blog/bioremediation-the-pollution-solution.html

Mapping with Programme Outcomes

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

Semester	Elective (Generic) :IV 23MICE207-Bioinformatics	L	P	C
II		4	-	3

Course Objectives (CO):

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

Unit – 1:

Biological Data Mining – Exploration of Data Mining Tools. Cluster Analysis Methods. Data Visualization. Biological Data Management. Biological Algorithms – Biological Primary and Derived Databases. Concept of Alignment, Pairwise Sequence Alignment (PSA), Multiple Sequence Alignment (MSA), BLAST, CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

Unit – 2:

Phylogenetic Tree Construction - Concept of Dendrograms. Evolutionary Trees - Distance Based Tree Reconstruction - Ultrametric trees and Ultrametric distances – Reconstructing Trees from Additive Matrices - Evolutionary Trees and Hierarchical Clustering - Character Based Tree Reconstruction - Maximum Parsimony Method, Maximum likelihood method - Reliability of Trees – Substitution matrices – Evolutionary models.

Unit – 3:

Computational Protein Structure prediction – Secondary structure – Homology modelling-Fold recognition and ab initio 3D structure prediction – Structure comparison and alignment – Prediction of function from structure. Geometrical parameters – Potential energy surfaces – Hardware and Software requirements-Molecular graphics – Molecular file formats- Molecular visualization tools.

Unit – 4:

Prediction of Properties of Ligand Compounds – 3D Autocorrelation -3D Morse Code-Conformation Dependent and Independent Chirality Codes –Comparative Molecular Field Analysis – 4 D QSAR –HYBOT Descriptors – Structure Descriptors – Applications – Linear Free Energy Relationships – Quantity Structure - Property Relationships –Prediction of the Toxicity of Compounds

Unit – 5:

Molecular Docking- Flexible - Rigid docking- Target- Ligand preparation- Solvent accessibility- Surface volume calculation, Active site prediction- Docking algorithms- Genetic, Lamarckian - Docking analyses- Molecular interactions, bonded and nonbonded - Molecular Docking Software and Working Methods. Genome to drug discovery – Subtractive Genomics – Principles of Immunoinformatics and Vaccine Development.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Access to databases that provides information on nucleic acids and proteins.
CO2:	Invent algorithms for sequence alignment.
CO3:	Construct phylogenetic tree.
CO4:	Predict the structure of proteins.
CO5:	Design drugs by predicting drug ligand interactions and molecular docking.

Text Books

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

Reference Books:

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

Web Resources:

1. https://www.hsls.pitt.edu/obrc/
2. https://www.hsls.pitt.edu/obrc/index.php?page=dna
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1669712/
4. https://www.ebi.ac.uk/
5. https://www.kegg.jp/kegg/kegg2.html

Mapping with Programme Outcomes

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

Semester	Elective (Generic) : IV	L	P	C
II	23MICE208- Biosafety, Bioethics and IPR	4	-	3

Course Objectives (CO):

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

Unit – 1:

Intellectual Property Rights: Different forms of Intellectual Property Rights – their relevance, importance to industry, Academia. Role of IPR's in Biotechnology, Patent Terminology - Patents, trademarks, copyrights, industrial designs, geographical indications, trade secrets, non-disclosure agreements. Patent life and geographical boundaries. International organizations and IPR - Overview of WTO, TRIPS, WIPO, GATT, International conventions, Trade agreements, Implication of TRIPS for developing countries.

Unit – 2:

Process involved in patenting. Patent Search - Procedural steps in patenting, process of filing, PCT application, pre-grant & post-grant opposition, PCT and patent harmonization including Sui-generis system, patent search methods, patent databases and libraries, online tools, Country-wise patent searches (USPTO, EPO, India etc.), patent mapping.

Unit – 3:

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

Unit – 4:

Introduction to bioethics - need of bioethics, applications and issues related to bioethics, social and cultural issues. Bioethics and biodiversity - conserving natural biodiversity, convention on protecting biodiversity, protocols in exchanging biological material across borders. Bioethics & GMO's - issues and concerns pertaining to genetically modified foods and food crops, organisms and their possible health implications and mixing up with the gene-pool.

Unit – 5:

Bioethics in medicine - Protocols of ethical concerns related to prenatal diagnosis, gene therapy, organ transplantation, xeno transplantation, ethics in patient care, informed consent. bioethics and cloning - permissions and procedures in animal cloning, human cloning, risks and hopes. Bioethics in research: stem cell research, human genome project, use of animals in research, human volunteers for clinical research, studies on ethnic races. he Nuremberg code.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Execute the role of IPR, Patent, Trademarks and its importance.
CO2:	Develop patent procedure, patent filling and its mapping.
CO3:	Become Patent attorneys and Patent officers.
CO4:	Applybioethics in GMO, food crops and its biodiversity.
CO5:	Analyze the importance of bioethics in research associated with HGP, clinical research, stem cell therapy.

Text Books

1. Usharani B., Anbazhagi S. and Vidya C. K. (2019). Biosafety in Microbiological Laboratories. (1st Edition). Notion Press. ISBN-101645878856.
2. Satheesh M. K. (2009). Bioethics and Biosafety. (1st Edition). J. K International Publishing House Pvt. Ltd: Delhi. ISBN: 9788190675703.
3. Goel D. and Parashar S. (2013). IPR, Biosaftey and Bioethics. (1st Edition). Pearson education: Chennai. ISBN-13: 978-8131774700.
4. Raj Mohan joshi. Biosafety and Bioethics. Wiley Publications.
5. Sibi. GIntellectual, Property Rights, Bioethics, Biosafety and Entreepreneurship in biotechnology. (2021). Wiley Publications.

Reference Books:

1. Nithyananda K. V. (2019). Intellectual Property Rights: Protection and Management, India, IN: Cengage Learning India Private Limited.
2. Neeraj, P. and Khusdeep, D. (2014). Intellectual Property Rights, India, IN: PHI learning Private Limited.
3. Ahuja, V K. (2017). Law relating to Intellectual Property Rights, India, IN: Lexis Nexis.
4. Tony Hope (2004). Medical Ethics: A very Short introduction, Oxford Publication.
5. Goel Parashar. IPR, Biosafety and Bioethics (2013). Pearson Publications.

Web Resources:

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

Mapping with Programme Outcomes

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

Semester	Elective (Generic) : IV 23MICE209-Clinical Research And Clinical Trials	L	P	C
II		4	-	3

Course Objectives (CO):

CO1	Provide an overview of history and methods involved in conducting clinical research.
CO2	Design the principles involved in ethical, legal, and regulatory issues in clinical research on human subjects.
CO3	Describe principles and issues involved in monitoring patient-oriented research.
CO4	Formulate a well- defined quality assurance and quality control plans.
CO5	Acquire business development skills in the area of clinical research.

Unit – 1:

Introduction to Clinical Research: Clinical Research: An Overview, Different types of Clinical Research. Clinical Pharmacology: Pharmacokinetics, Pharmacodynamics, Pharmacoepidemiology, Bioavailability, Bioequivalence, Terminologies and definition in Clinical Research. Drug Development Process: Drug Discovery Pipeline, Drug Discovery Process. Preclinical trail, Human Pharmacology (Phase-I), Therapeutic Exploratory trail (Phase-II), Therapeutic Confirmatory Trail (Phase-III) and Post marketing surveillance (Phase-IV).

Unit – 2:

Ethical Considerations and Guideline in Clinical Research: Historical guidelines in Clinical Research-Nuremberg code, Declaration of Helsinki, Belmont report. International Conference on Harmonization (ICH)-Brief history of ICH, Structure of ICH & ICH Harmonization Process, Guidelines for Good Clinical Practice. Regulation in Clinical Research-Drug and cosmetic act, FDA, Schedule-Y- Ethics Committee and their responsibilities. Clinical Research Regulatory Submission & approval Process- IND, NDA and ANDA submission Procedure. DCGI submission procedure. Other Regulatory authorities- EMEA, MHRA, PhRMA.

Unit – 3:

Clinical Trial Management: Key Stakeholders in Clinical Research, Ethics Committees and Institutional Review Board, Responsibilities of Sponsor. Responsibilities of Investigator, Protocol in Clinical Research Clinical Trial Design, Project Planning Project Managements - Informed Consent, Investigator's Brochure (IB), Selection of an Investigator and Site, Patient screening, Inclusion and exclusion criteria, Randomization, Blinding. Essential Documents in clinical research -IB, ICF, PIS, TMF, ISF, CDA & CTA.

Unit – 4:

Quality Assurance, Quality Control & Clinical Monitoring: Defining the terminology-Quality, Quality system, Quality Assurance & Quality Control-QA audit plan. 21 CRF Part 11, Site Auditing, Sponsor Compliance and Auditing, SOP For Clinical Research-CRF Review & Source Data Verification, Drug Safety Reporting Corrective and preventative action process.

Unit – 5:

Business Development in the Clinical Research Industry: Introduction & Stages of Business Development-Start-up Phase, Growth Phase, Maturity Phase, Decline Phase. Outsourcing in Clinical Research, Reasons for outsourcing to contract research organizations, The India Advantage, Scope and Future of CRO, List of Clinical Research Organizations in India, List of IT companies offering services in Clinical Research. Role of business development manager.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Apprehend the Drug Development process and different phases of clinical trials.
CO2:	Recognize the ethics and regulatory perspectives on clinical research trials activities.
CO3:	Accentuate about clinical trials management concepts and documentation process.
CO4:	Accomplish quality assurance and quality control to ensure the protection of human subjects and the reliability of clinical trial results.
CO5:	To nurture skills recitation to commercial start up and industriousness.

Text Books

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

Reference Books:

1. Friedman L.M., Fuberge C.D., DeMets D. and Reboussen, D.M. (2015). Fundamentals of Clinical Trials, Springer.
2. Browner W. S., (2012). Publishing and Presenting Clinical Research. (3rd Edition). Lippincott Williams and Wilkins.
3. Rondel R. K., Varley S. A. and Webb C. F. (2008). Clinical Data Management. (2nd Edition). Wiley.
4. Peppler, H.J. and Pearl Man, D. (1979). Fermentation Technology, Vol 1 & 2, 2ndEdition. Academic Press, London.
5. E1-Mansi, E.M.T., Bryce, C.F.A., Demain, A.L. and Allman,A.R. (2007). Fermentation Microbiology and Biotechnology. 2ndEdition, CRC press, Taylor and Francis Group.

Web Resources:

1. https://www.hzu.edu.in/uploads/2020/10/Textbook-of-Clinical-Trials-Wiley-(2004).pdf
2. https://www.routledge.com/A-Practical-Guide-to-Managing-Clinical-Trials/Pfeiffer-Wells/p/book/9780367497828
3. https://www.auctoresonline.org/journals/clinical-research-and-clinical-trials
4. https://www.who.int/health-topics/clinical-trials#tab=tab_1
5. https://www.cancerresearchuk.org/about-cancer/find-a-clinical-trial/what-clinical-trials-are/types-of-clinical-trials

Mapping with Programme Outcomes

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

Semester	Skill Enhancement Course I	L	P	C
II	**23MICS210** - Vermitechnology	4	-	2

Course Objectives (CO):

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

Unit – 1:

Introduction to Vermiculture - Definition, classification, history, economic importance- In sustainable agriculture, organic farming, earthworm activities, soil fertility & texture, soil aeration, water impercolation, decomposition & moisture, bait & food and their value in maintenance of soil structure. Its role in the bio transformation of the residues generated by human activity and production of organic fertilizers. Choosing the right worm. Useful species of earthworms. Local species of earthworms. Exotic species of earthworms. Factors affecting distribution of earthworms in soil.

Unit – 2:

Earthworm Biology and Rearing - Key to identify the species of earthworms. Biology of *Eisenia fetida.* a) Taxonomy Anatomy, physiology and reproduction of Lumbricidae. b) Vital cycle of *Eisenia fetida*: alimentation, fecundity, annual reproducer potential and limiting factors (gases, diet, humidity, temperature, PH, light, and climatic factors). Biology of *Eudrilus eugeniae*. c) Taxonomy Anatomy, physiology and reproduction of Eudrilidae. d) Vital cycle of *Eudrilus eugeniae*: alimentation, fecundity, annual reproducer potential and limit factors (gases, diet, humidity, temperature, PH, light, and climatic factors)..

Unit – 3:

Vermicomposting Process - Feeds for Vermitech systems- Animal manures- Kitchen Waste and Urban waste- Paper pulp and card board solids- Compost and waste products- Industrial Wastes. Vermicomposting Basic process- Initial pre-composting phase- Mesophilic phase- Maturing and stabilization phase- Mechanism of Earthworm action. Methods of vermicomposting- a) windrows system; b) wedge system; c) container system-pits, tanks & cement rings; commercial model; beds or bins-top fed type, stacked type, d) Continuous flow system

Unit – 4:

Vermicomposting - Trouble Shooting-Temperature-Aeration- Acidity- Pests and Diseases- Ants, rodents, Birds, Centipedes, sour crop, Mite pests. Odour problems. Separation techniques- Light Separation-Sideways Separation-Vertical Separation-Gradual transfer. Harvesting Earthworms- manual method- migration method. Packing & Nutritional analysis of vermicompost.

Unit – 5:

Applications of Vermiculture - Vermiculture Bio-technology, use of vermi castings in organic farming/horticulture, as feed/bait for capture/culture fisheries; forest regeneration. Application quantity of vermicompost in Agricultural fields- crops, fruits, vegetables & flowers. By-products and value-added products- Verm wash- vermicompost tea-vermi meal-enriched vermicompost-pelleted vermicompost.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Compare and contrast the uses of vermicompost to the soil.
CO2:	Recommend different species of earthworms after acquiring knowledge on its biology.
CO3:	Design the vermicomposting process.
CO4:	Assess the Best Practices of Vermicomposting
CO5:	Recommend the applications of vermicompost to different soils and for different crops.

Text Books

1. Ismail S. A. (2005). The Earthworm Book, Second Revised Edition. Other India Press, Goa, India.
2. Rathoure A. K., Bharati P. K. and Ray J. (2020). Vermitechnology, Farm and Fertilizer. Vermitechnology, Farm and Fertilizer Discovery Publishing House Pvt Ltd.
3. Christy M. V. 2008. Vermitechnology, (1st Edition), MJP Publishers.
4. The complete technology book on Vermiculture and Vermicompost with manufacturing Process, machinery equipment details and Plant Layout. AB Press.
5. Keshav Singh (2014). A Textbook of vermicompost: Vermiwash and Biopesticide.

References Books

1. Roy D. (2018). Handbook of Vermitechnology. Lambert Academic Publishing.
2. Kumar A. (2005). Verms and Vermitechnology, A.P.H. Publishing Corporation, New Delhi.
3. Lekshmy M. S., Santhi R. (2012). Vermitechnology, Sara Publications, New Delhi, India.
4. Edwards CA, Arancon NQ ShermanRL. (2011) Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management 1st edn.CRC Press.
5. Ismail, S.A. (1997). Vermicology-The Biology of Earthworm.1st edn. Orient longman.

Web Resources

1. https://en.wikipedia.org/wiki/Vermicompost
2. http://stjosephs.edu.in/upload/papers/9567411a78c63d4ccfbbe85e6aa22840.pdf
3. https://www.kngac.ac.in/elearning-portal/ec/admin/contents/4_18K4ZEL02_2021012803204629.pdf
4. https://composting.ces.ncsu.edu/vermicomposting-2/
5. https://rodaleinstitute.org/science/articles/vermicomposting-for-beginners/

Mapping with Programme Outcomes

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

Semester	Core Course II	L	P	C
III	23MICC-301:Immunology ,Immunotechnology and Microbial Genetics	6	-	5

Course Objectives (CO):

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

Unit – 1:

Introduction to biology of the immune system – Cells and organs of Immune System. T and B lymphocytes – Origin, development, differentiation, lymphocyte subpopulation in humans. Innate immunity- Complement, Toll-like receptors and other components. Acquired immunity – Active and Passive immunity. Antigens - features associated with antigenicity and immunogenicity. Basis of antigen specificity. MHC genes and products, Structure of MHC molecules, Genetics of HLA Systems – Antigens and HLA typing. Antigen processing and presentation to T- lymphocytes.

Unit – 2:

Immunoglobulins. Theories of antibody production. Class switching and generation of antibody diversity. Monoclonal and polyclonal antibodies. Complement system – mode of activation- Classical, Alternate and Lectin pathways, biological functions. Antigen recognition – TCR, Diversity of TCR, T cell surface alloantigens, lymphocyte activation, clonal proliferation and differentiation. Physiology of acquired immune response – various phases of HI, CMI – Cell mediated cytotoxicity, DTH response.

Unit – 3:

Hypersensitivity – Types and mechanisms, Autoimmunity, Tumor Immunity and Transplantation immunology. Immunodeficiency-Primary immunodeficiency and Secondary immunodeficiencies. Genetics of Immunohematology – Genetic basis and significance of ABO and other minor blood groups in humans, Bombay blood group, Secretors and Non-secretors, Rh System and genetic basis of D- antigens. Diagnostic Immunology - Precipitation reaction, Immunodiffusion methods - SRID, ODD. Immunoelectrophoresis - Rocket and Counter current electrophoresis. Agglutination - Hemagglutination - Hemagglutination inhibition. Labeled Assay- Immunofluorescence assay, Radio immunoassay, FISH, ELISA. Flow cytometry. Immune regulation mechanisms – immuno-induction, immuno- suppression, immuno-tolerance, immuno-potentiation, Immunomodulation. Role of cytokines, lymphokines and chemokines. Introduction to Vaccines and Adjuvants - Types of vaccines. Development of vaccines and antibodies in plants. Immunomics - Introduction and Applications. Antigen engineering for better immunogenicity and use for vaccine development-multiepitope vaccines. Reverse vaccinology.

Unit – 4:

Structural of prokaryotic and eukaryotic genome. Introduction to prokaryotic genomic structure, Eukaryotic Genome - Structure of chromatin, chromosome, centromere, telomere, nucleosome. Modifications- methylation, acetylation, phosphorylation and its effect on structure and function of chromatin, DNA methylation and gene imprinting, organelle genome.

Unit – 5:

Gene Transfer Mechanisms- Conjugation and its uses. Transduction, Generalized and Specialized, Transformation– Natural Competence and Transformation. Transposition and Types of Transposition reactions. Insertion sequences, complex and compound transposons – T10, T5, and Retroposon. Mechanism – Transposons of *E. coli*, Bacteriophage and Yeast. Importance of transposable elements in horizontal transfer of genes and evolution.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Categorize the immune response to a variety of antigens. Identify different immune cells involved in immunity.
CO2:	Justify the significance of MHC molecules in immune response and antibody production.
CO3:	Design antibodies and evaluate immunological assays in patient samples.
CO4:	Analyze genomic DNA of prokaryotes and eukaryotes.
CO5:	Summarize gene transfer mechanisms for experimental study.

Text Books

1. Coico R., Sunshine G. and Benjamini E. (2003). Immunology – A Short Course. (5th Edition). Wiley-Blackwell, New York.
2. Owen J. A., Punt J., Stranford S. A. and Kuby J. (2013). Immunology, (7th Edition). W. H. Freeman and Company, New York.
3. Abbas A. K., Lichtman A. H. and Pillai S. (2021). Cellular and Molecular Immunology. (10thEdition).Elsevier.
4. Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi.
5. Gardner E. J. Simmons M. J. and Snusted D.P. (2006). Principles of Genetics. (8th Edition). Wiley India Pvt. Ltd.

Reference Books:

5. Travers J. (1997). Immunobiology - The Immune System in Health and Disease. (3rd Edition). Current Biology Ltd. New York.
6. Delves P.J., Martin S., Burton D. R. and Roitt I. M. (2006). Roitt's Essential Immunology. (11th Edition). Wiley-Blackwell.
7. Hay F. C. and Westwood O. M. R. (2002). Practical Immunology (4thEdition). Wiley-Blackwell.
8. Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press.
9. Russell P.J. (2010). Genetics - A Molecular Approach. (3rd Edition). Pearson New International Edition.

Web Resources:

1. https://www.ncbi.nlm.nih.gov/books/NBK279395/
2. https://med.stanford.edu/immunol/phd-program/ebook.html
3. https://ocw.mit.edu/courses/hst-176-cellular-and-molecular-immunology-fall-2005/pages/lecture-notes/
4. [PDF] Lehninger Principles of Biochemistry (8th Edition) By David L. Nelson and Michael M. Cox Book Free Download - StudyMaterialz.in
5. https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/

Mapping with Programme Outcomes

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

Semester	Core Course VIII	L	P	C
III	23MICC302 - **Molecular Biology &**Recombinant DNA Technology	6	-	5

Course Objectives (CO):

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

Unit – 1:

DNA replication – modes and enzymes involved. Detailed mechanism of semi-conservative replication. Prokaryotic and eukaryotic transcription. Structure and processing of m-RNA, r-RNA and t-RNA. Ribosomes. Genetic Code and Wobble hypothesis, Translation in prokaryotes and eukaryotes, post translational modifications.

Unit – 2:

Gene regulation and expression – Lac operon, arabinose and tryptophan operons. Gene regulation in eukaryotic systems - repetitive DNA, gene rearrangement, promoters, enhancer elements. Molecular basis of gene mutation - Types of mutations - base substitutions, frame shift, deletion insertion, duplication, inversion. Silent, conditional and lethal mutation. Chemical mutagenesis. Repair of DNA damage. Photoreactivation. SOS repair mechanism. Base excision repair. Nucleotide excision repair. Detection and analysis of mutations (Replica plating, Antibiotic enrichment, Ames test).

Unit – 3:

Tools and methods in gene cloning. Restriction endonucleases – nomenclature, classification and characteristics - DNA methylases, DNA polymerases, Ligases. Adapters, linkers and homopolymer tailing. Artificial gene transfer techniques - electroporation, microinjection, protoplast fusion and microparticle bombardment. Screening for recombinants. Gene cloning vectors for prokaryotes and eukaryotes - cloning properties and types of plasmids vectors (pBR322 and derivatives, pUC vectors and pGEM3Z) - Phage Vectors(M13 and Lambda), cosmids, phasmids, phagemids and BACs - Eukaryotic vectors - Yeast vectors – Animal and plant vectors – expression vectors. Shuttle vectors - Expression of foreign genes in bacteria, animal, plant, algae and fungi – merits and demerits.

Unit – 4:

Genomic DNA and cDNA library - Construction and Screening. Substrative hybridization for tissue specific DNA libraries. Techniques in genetic engineering Characterization of cloned DNA: Hybrid arrested translation (HAT) - Restriction mapping - restriction fragment length polymorphism (RFLP) - Polymerase chain reaction (PCR) – Principles, types and their applications. DNA sequencing - Primer walking, Sanger's method and automated sequencing methods. Pyrosequencing – DNA chips and micro array. Protein engineering and techniques Site directed mutagenesis – methods - Design and construction of novel proteins and enzymes, Basic concepts in enzyme engineering, engineering for kinetic properties of enzymes. protein folding, protein sequencing, protein crystallization. Applications of protein engineering.

Unit – 5:

Plant biotechnology - constituents and concepts of sterilization - preparation, isolation and selection of explant. Suspension cell culture, callus culture, protoplast isolation, culture & fusion. Anther and pollen culture for production. Animal biotechnology – equipment and media used for animal cell culture technology. Primary and established cell line culture and culture media. Applications of animal cell cultures. Serum protein media viability and cytotoxicity. Applications of Genetic Engineering - transgenic animals, Recombinant Cytokines and their use in the treatment of animal infections. Monoclonal Antibodies in Therapy- Vaccines and their Applications in Animal Infections - Human Gene Therapy - Germline and Somatic Cell Therapy - Ex-vivo Gene Therapy. In-vivoGene Therapy. Vectors in Gene Therapy-Viral and Non-Viral Vectors. Transgenic Plants.

Course Outcomes (CO)

On completion of this course, students will;

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

Text Books

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

Reference Books:

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

Web Resources:

1. https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/
2. https://geneticeducation.co.in/what-is-transcriptomics
3. https://www.molbiotools.com/usefullinks.html
4. https://geneticeducation.co.in/what-is-transcriptomics
5. https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/

Mapping with Programme Outcomes

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

Semester	Core IX- 23MICP-303: Practical III Immunology,Microbial Genetics and Molecular Biology	L	P	C
III		-	6	5

Course Objectives (CO):

CO1	Acquire adequate skills to perform blood grouping and serological reactions.
CO2	Provide fundamental skills in preparation, separation and purification of immunoglobulin.
CO3	Illustrate the significance of artificial transformation and mutations.
CO4	Familiarize with routine molecular biological techniques
CO5	Discuss blotting techniques and PCR

Unit – 1:

Hematological reactions - Blood Grouping – forward and reverse, Rh Typing Identification of various immune cells by morphology – Leishman staining, Giemsa staining. Agglutination Reactions- Latex Agglutination reactions- RF, ASO, CRP.Detection of HBs Ag by ELISA. Precipitation reactions in gels– Ouchterlony double immunodiffusion (ODD) and Mancini's single radial immunodiffusion (SRID) Immuno-electrophoresis and staining of precipitin linesRocket immuno electrophoresis and counter current immuno electrophoresis

Unit – 2:

Preparation of lymphocytes from peripheral blood by density gradient centrifugation. Purification of immunoglobulin– Ammonium Sulphate Precipitation. Separation of IgG by chromatography using DEAE cellulose or Sephade

Unit – 3:

Artificial Transformation Detection of Antibiotic resistant mutants Identification of mutants by replica plating method

Unit – 4:

Isolation of genomic DNA from E. coli and analysis by agarose gel electrophoresis Separation of proteins by polyacrylamide gel electrophoresis (SDS-PAGE) Plasmid DNA isolation from E.coli

Unit – 5:

Amplification of DNA by PCR .Western blotting – Demonstration. Southern blotting – Demonstration

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Perform and evaluate immunological reactions to aid diagnosis
CO2:	Assess the level of lymphocytes in a blood sample and purify immunoglobulin employing appropriate techniques
CO3:	Perform DNA extraction and gene transfer mechanisms, analyze and identify by gel electrophoresis
CO4:	Utilize various molecular techniques for gene manipulation and detection of mutants.
CO5:	Undertake novel research with techniques like PCR and blotting analysis.

Text Books

1.Roitt R.I.M (2001). Essential Immunology.10th Edn. Blackwell Scientific Publishers.

2. Glick B. R. and Patten C. L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA (5th Edition). ASM Press.

3. Gunasekaran P. (2007). Laboratory Manual in Microbiology. New Age International.

4. James G Cappucino. and Natalie Sherman. (2016). Microbiology – A laboratory manual. (5th Edition). The Benjamin publishing company. New York. 5. Russell P. J. (2019). Genetics – A Molecular Approach (3rd Edition). Pearson Education, Inc.

Reference Books:

1. Stites D.P., Abba I.Terr, Parslow T.G.(1997). Medical Immunology. 9thedn, PrenticeHall Inc.

2. Tizard, R.I.(2000) Immunology- An Introduction. 4thedn. Saunders College Publishing, Philadelphia.

3. Dale J. W., Schantz M. V. and Plant N. (2012). From Gene to Genomes –Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd.

4. Sambrook J. and Russell D.W. (2001). Molecular Cloning: A Laboratory Manual. (7th Edition). Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press.

5. Brown T.A. (2016). Gene Cloning and DNA Analysis. (7th Edition). John Wiley and Jones, Ltd.

Web Resources

1.https://www.molbiotools.com/usefullinks.html

2.https://geneticgenie.org3.

3.https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5

4.https://vlab.amrita.edu/index.php?sub=3&brch=272

5. https://nptel.ac.in/courses/102105087 .

Mapping with Programme Outcomes

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

Semester	Core Course :X	L	P	C
III	23MICC304- Fermentation technology & Pharmaceutical Microbiology	6	-	4

Course Objectives(CO):

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

Unit – 1:

Bioprocesses - concepts and design. Industrially important microorganisms – Isolation, primary and secondary screening, preservation and improvement of industrially important strains. Upstream processing - Development of inoculums for fermentation process. Media for industrial fermentation - Formulation, optimization. Sterilization. Stages of upstream - Growth of inoculums, fermenter pre-culture and production fermentation. Types of fermentation - Batch, continuous, dual or multiple, surface, submerged, aerobic and anaerobic.

Unit – 2:

Fermenter – Design, types and construction, Instrumentation and control. Productivity. Yield coefficients. Heat production. Aeration and agitation. Gas exchange and mass transfer. Computer Applications in fermentation technology. Fermentation Economics.

Unit – 3:

Downstream Processing - Recovery and purification of intracellular and extracellular products. Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration - Physical, chemical and enzymatic methods. Extraction - Solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction. Purification by different methods. Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization.

Unit – 4:

Overview of pharmaceutical microbiology - Ecology of microorganisms - Atmosphere, water, skin, respiratory flora of workers, raw materials, packaging, building equipment and their control measures. Design and layout of sterile manufacturing unit. Contamination and Spoilage of Pharmaceutical products - sterile injectable and non-injectable, ophthalmologic preparation, implants.

Unit – 5:

Production of pharmaceutical products and quality assurance – Vaccines, immunodiagnostics, immuno-sera, immunoglobulin. Antibiotics - Penicillin, Griseofulvin, Metronidazole. Enzymes - Streptokinase, Streptodornase. Quality assurance and quality management in pharmaceuticals – In-Process, Final-Product Control and sterility tests. Regulatory aspects - BIS (IS), ISI, ISO, WHO and US certification.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Develop microbial strains, carry out fermentation and recover the products of the process.
CO2:	Design fermenters according to needs for various products.
CO3:	Recover the end products of the fermentation process economically.
CO4:	Utilize the knowledge on pharmaceutical microbiology for industrial production of products.
CO5:	Produce therapeutic products from microbes employing technology and analyze the quality the products.

Text Books

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

References Books

1. Stanbury P. T. and Whitaker. (2016). Principles of Fermentation Technology. (3rd Edition). Pergamon Press. NY.
2. Handa S. S. and Kapoor V. K. (2022). Pharamcognosy, (4th Edition). Vallabh Prakashan Publishers, New Delhi.
3. Kokate C. K., Durohit A. P. and Gokhale S. R. Pharmacognosy. (2002). (12th Edition). Nirali Prakasham Publishers, Pune.
4. Hugo W. B. and Russell A. D. (2004). Pharmaceutical Microbiology. (7th Edition). Blackwell Scientific Publication, Oxford.
5. Wallis, T.E. (2005). Text book of Pharmacognosy. (5th Edition). CBS publishers and distributors, New Delhi.

Web Resources

1. https://ib.bioninja.com.au/options/untitled/b1-microbiology organisms/fermenters.html
2. https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/penicillin.html
3. https://www.sciencedirect.com/topics/biochemistry-genetics-andmolecular-biology/ethanol-fermentation
4. https://www.usp.org/sites/default/files/usp/document/harmonization/genmethod/q05b_pf_ira_34_6_2008.pdf
5. http://www.simbhq.org/

Mapping with Programme Outcomes

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

Semester	Elective (Discipline Centric) V:	L	P	C
III	**23MICE305** - Soil and Microbial Ecology	3	-	3

Course Objectives (CO):

CO1	Explain the role of microorganisms in soil fertility.
CO2	Discuss the harmful effects of micro organisms in soil
CO3	Create awareness. about microbial interactions.
CO4	Acquire in depth knowledge about microbial communities and ecosystem..
CO5	Develop knowledge about quantitative ecology

Unit – 1:

Soil Microbiology– Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity, and distribution of major group of microorganisms in soil. Quantification of soil microflora, role of microorganism in soil fertility. Mineralization of Organic & Inorganic matter in soil. Biological nitrogen fixationChemistry and Genetics of BN

Unit – 2:

Phytopathology and Disease cycle of Plant pathogens - Tikka and Citrus canker, Types of disease symptoms, Structural and Inducible biochemical defenses - Systemic Acquired Resistance (SAR), pathogenesis related (PR) proteins, Plantibodies, Phenolics, Phytoalexins

Unit – 3:

Interactions among microbial populations- Single microbial populations, positive and negative interactions. Interaction between diverse microbialpopulations. Population within biofilms. Interaction between microbes and plants – Rhizosphere and mycorhizae. Interactions with animals – contribution of microbes in animal nutrition and diseases.

Unit – 4:

Microbial Communities and Ecosystems – Development of microbial community. Microbial community and dynamics and nature. .Succession within biofilm communities.

Unit – 5:

Quantitative Microbial Ecology – Sample collection, detection of microbial populations, determination of microbial numbers, detecting non culturable bacteria and determination of microbial biomass.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Depict diversity and significance of soil microbes and predict the role of microbes in biological nitrogen fixation..
CO2:	Apply the knowledge on plant pathology in agriculture
CO3:	Utilize the knowledge of microbial interactions in various fields.
CO4:	Predict community ecosystem and their dynamics.
CO5:	Apply quantitative microbial ecology for the benefit of mankind.

Text Books:

1.Subba Rao. N. S. (2017). Soil Microbiology. (5th Edition). MedTech Publishers. 2. Rangaswami. G. and Mahadevan. A. (2006). Diseases of Crop Plants in India. (4th Edition). Prentice–Hall of India Pvt. Ltd .

3. Larry.L. Barton and Diana .E. Northup. (2011). Microbial Ecology. Wiley Publishers.

4. McArthur. (2006). MicrobialEcology – An Evolutionary Approach AP Publishers.

5. Subba Rao. N.S. (2005). Soil microorganisms and Plant Growth. (4th Edition). Oxford and IBH Publishing Pvt. Ltd.

Reference Books:

1.Bartha .A (2009). Microbial Ecology- Fundamentals and applications. 4 th Edn. Pearson Education.

2. Robert. LTate. (2003).Soil Science – An inter-disciplinary approach to soil research. Lipincott Williams and Wilkins.

3. Terry J. Gentry and Jeffry. J. Fuhrmann, David A Zuberer. (2021). Principle and application of soil Microbiology. 3rd Edn. Elsiver publications.

4. Shrivastava A.K. (2003). Environment Auditing. A. P. H. Publishing Corporation.

5. Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Org

Web Resources:

1. https://staff.oouagoiwoye.edu.ng
2. http://www.scribd.com
3. www.environmentshumail.blogspot.in/
4. https://www.soinc.org
5. https://www.onlinebiologynotes.com

Mapping with Programme Outcomes

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

Semester	Elective (Discipline Centric) :V 23MICE306– Microbial Toxicology	L	P	C
III		3	-	3

Course Objectives (CO):

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

Unit – 1:

General Introduction - Definition of toxins, different categories of toxins and venoms, recent trends in venom and toxin research.

Unit – 2:

Bacterial toxins - Bacterial toxins Bacterial toxinogenesis, endotoxins, exotoxins, exotoxins, bacterial protein toxins with special reference to cholera, diphtheria and tetanus toxins, molecular mechanism of action of endotoxins, exotoxins, enterotoxins, neurotoxins and mycotoxins.

Unit – 3:

Plant toxins & Toxins from snake venom - Natural toxins in plants, Plant toxic proteins, impact of plant toxin on human, natural toxins in food, plants, allelopathy. Toxins from snake venom Snakes and Biological significance of their venoms, composition of snake venom, evolution of venom, 3D structure of some important venom constituents and their mechanism of action (phospholipase A2, cardiotoxin, neurotoxin) three-finger toxins, anti-venom and medicinal plants in treatment of snakebite patients.

Unit – 4:

Tools for isolation and characterization of toxins - Multidimensional chromatographic techniques (gel-filtration, ion-exchange reverse-phase HPLC, SDS-PAGE, 2-dimensional gel electrophoresis), toxin mass fingerprinting, N-terminal peptide sequencing, analysis of protein data by using proteomics software.

Unit – 5:

Medicinal and industrial applications of venoms and toxins. Use of toxin in neurobiology and muscular research, anticancer drug, diagnosis of haemostatic disorders, antibacterial agents, bioinsecticides and other industrial applications.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Perceive the adverse effects of toxin and its potential role in research.
CO2:	Assess the toxicity, properties and mode of actions of microbial toxins.
CO3:	Explicate the mode of actions and their biological significance.
CO4:	Evaluate the toxicity level with the help of advanced techniques.
CO5:	Elucidate the various natures of application of toxic substances.

Text Books

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

Reference Books:

1. Reilly M. J. (2018). Bioinstrumentation. CBS Publishers and Distributors Pvt Ltd. ISBN 13 978-8123928395.
2. Greenberg M., Hamilton R., Phillips S. and McCluskey G. J. (2003). Occupational, Industrial and Environmental Toxicology. St Louis: C.V. Mosby.
3. Wiley-Vch. (2005). Ullmann's Industrial Toxicology. New York: John Wiley & Sons.
4. Winder C. and Stacey N.H. and Boca Raton F. L. (2004). Occupational Toxicology. (2nd Edition). CRC Press.
5. Gopalakrishnakone(2015). Biological Toxins and Bioterrorism. Springer.

Web Resources:

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

Mapping with Programme Outcomes

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

Semester	Elective (Discipline Centric) :V	L	P	C
III	23MICE307 - Water Conservation and Water Treatment	3	-	3

Course Objectives (CO):

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

Unit – 1:

Water Scarcity; Major Causes of Water Scarcity, Types of Water Scarcity, Water Footprint- Effects of Water Scarcity Across the Globe-, Water Scarcity in India; Effects of Water Scarcity in India - Social and Political Effects and Economic Risks of Water Scarcity in India.

Unit – 2:

Multi-pronged approach to Prevent Water Scarcity; Aquifer Recharging, Water reuse and Zero-Liquid Discharge Technology, Coastal Reservoir, Desalination Plants-Measures for Preventing Water Scarcity in India - Jal Shakti Abhiyan Campaign, Atal Bhujal Yojana, Adoption of Composite Water Management Index (CWMI), Water conservation resource management, Rain Water Harvesting.

Unit – 3:

Water Quality and Pollution; Impurities in the water, Characteristics of different water sources Vulnerability of the water sources to contamination, Water quality criteria - Quality of surface waters, flowing waters, impounded waters, Groundwater, Water quality standards, Microbiological quality of drinking Water, Chemical quality of drinking water.

Unit – 4:

Water Treatment Technologies; Sedimentation, Filtration, Coagulation and flocculation, Water softening and adsorption processes, Membrane filtration, Microfiltration, Ultrafiltration and Nanofiltration,Water disinfection, Activated carbon filtration, Household Water Treatment and Safe Storage (HWTS). Methods for household water treatment Safe water storage, Household water treatment and safe storage decision tree, Assessing the impact of HWTS, Government policies for HWTS.

Unit – 5:

New and Emerging Drinking Water Treatment Technologies; Nanotechnology, Acoustic nanotube technology, Photocatalytic water purification technology, Aquaporin Inside™ technology, Automatic Variable Filtration (AVF) technology, Sun Spring System, Desalination.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Appraise issues of water scarcity, stress, and conflict on global population.
CO2:	Apprehend the multiple approaches against water scarcity and to understand various government schemes for water conservation.
CO3:	Relate the connection between water quality and public health.
CO4:	Design and execute standard strategy for successful HWTS implementation.
CO5:	Cogitate the purpose, principles, operation, and limitation of various modern water treatment technologies.

Text Books

1. Vasileios A., Tzanakakis N. Paranychianakis V. and Angelakis A. N. (2020). Water Supply and Water Scarcity. MDPI, ISBN 978-3-03943-306-3 (Hbk). ISBN 978-3-03943-3070.
2. Pannirselvam M., Shu Li.,Griffin G., Philip L., Natarajan A. and Hussain S. (2019). Water Scarcity and Ways to Reduce the Impact. ISBN: 978-3-319-75199-3.
3. Tiwari A., Kumar A., Singh A., Singh T.N., Suozzi E., Matta G. and Russo S. (2022). Water Scarcity, Contamination and Management. Elsevier. ISBN: 9780323853781.
4. Daniel, C.J. (1996). Environmental Aspects of Microbiology, 1st edn. Bright Sun Publications.
5. Maier RM, Pepper IL, Gerba CP (2008). Environmental Microbiology, 2nd edn. Academic Press.

Reference Books:

1. Fujita K. and Mizushima T. (2021). Sustainable Development in India -Groundwater Irrigation, Energy Use, and Food Production. ISBN 9780367460976.
2. Gupta R. (2008). Water Crisis in India. Atlantic Publishers. ISBN: 9788126909582, 9788126909582.
3. Ahuja S. (2013). Monitoring Water Quality-Pollution Assessment, Analysis, and Remediation. Elsevier. Book ISBN: 9780444594044. Hardcover ISBN: 9780444593955.
4. Saeid Eslamian ., Faezeh Eslamian ., (2021) Water harvesting and conservation – Basic Concepts and fundamentals, Wiley Publications.
5. Buckley RG. (2016) Environmental Microbiology 1st edn. CBS Publishing.

Web Resources:

1. https://link.springer.com/book/10.1007/978-1-59745-278-6
2. https://apps.who.int/iris/handle/10665/206916?show=full
3. https://www.acs.org/content/acs/en/policy/publicpolicies/sustainability/water-statement.html
4. https://www.toftigers.org/best-practice/water-conservation-and-treatment/
5. https://doh.wa.gov/community-and-environment/wastewater-management/site-sewage-systems-oss

Mapping with Programme Outcomes

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

Semester	Skill Enhancement Course II	L	P	C
III	22MICS308-Organic Farming and Biofertilizer Technology	3		2

Course Objectives(CO):

CO1	Impart knowledge on the importance, types and advantages of organic farming thereby creating awareness on conserving environment and natural resources, encouraging sustainable agriculture.
CO2	Familiarize with the basic concepts of farm development and relate the development of organic farming in their countries to meet global trends.
CO3	Explain the various types of biofertilizer and the scope in its production.
CO4	Discuss about biofertilizer production and its field application, promoting economy.
CO5	Develop the skill to analyze the quality of packaging, storage, assess the shelf life and bioefficacy of biofertilizers

Unit – 1:

Organic farming – Definition, relevance. Biological nutrient management - Organic manures, vermicompost, green manure, organic residue, biofertilizer soil amendments. Integrated pest and weed management - Use of biocontrol agents, bio pesticides etc. Organic and Conventional farming. Organic and Chemical farming – Comparison.

Unit – 2:

Certification and Schemes - Certification and Schemes. Organic certification in brief. Integrated farming system- definition, goal, components. Factors affecting ecological balance. Land degradation. Soil health management. Models of IFS for rainfed and irrigated conditions and different categories of farmers. Government schemes - NPOF, NPOF, NHM, HMNEH, NPMSH&F and RKVY.

Unit – 3:

Biofertilizers - Introduction, types, advantages and future perspective. Introduction, status and scope. Structure and characteristic features of bacterial biofertilizers- *Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium* and *Frankia*.

Unit – 4:

Cyanobacterial biofertilizers- Anabaena, Nostoc, *Hapalosiphon*and fungal biofertilizers- AM mycorrhiza and ectomycorhiza. Nitrogen fixation -Free living and symbiotic nitrogen fixation. Mechanism of phosphate solubilization and phosphate mobilization, potassium solubilization.

Unit – 5:

Production technology - Strain selection, sterilization, growth and fermentation, mass production of carrier based and liquid bio-fertilizers. FCO specifications and quality control of biofertilizers. Application technology for seeds, seedlings, tubers. Biofertilizers - Storage, shelf life, quality control and marketing. Factors influencing the efficacy of biofertilizers.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	On completion of this course, students will;
CO2:	Produce biofertilizers and distinguish between organic and conventional farming.
CO3:	Plan a Complete Farm Business including marketing, operation and financial outline.
CO4:	Practice the application of microbial bio-fertilizers in large scales, thereby increasing soil fertility.
CO5:	Develop integrated farming for sustainable agriculture.

Text Books

1. Sharma A. K. (2001). Hand book of Organic Farming. Agrobios.
2. Gaur A. C. (2006). Hand book of Organic Farming and Biofertilizers. Ambika Book Agency.
3. Subba Rao N.S. (2017). Bio-fertilizers in Agriculture and Forestry. (4th Edition). Med Tech publisher.
4. Subba Rao N. S. (2002). Soil Microbiology. Soil Microorganisms and Plant Growth. (4th Edition). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Sathe T.V. (2004). Vermiculture and Organic Farming. Daya Publishers.

References Books

1. Rakshit A. and Singh H. B. (2015). ABC of Organic Farming. (1st Edition). Jain Brothers.
2. Dubey R. C. (2008). A Textbook of Biotechnology. S. Chand & Co., New Delhi.
3. Bansal M. (2019). Basics of Organic Farming. CBS Publisher.
4. Bhoopander G., Ram Prasad., (2019) Biofertilizer for sustainable agriculture and Environment, Springer
5. Niir Board., (2012) (1st Edition) Biofertiliser and organic farming

Web Resources

1. https://agritech.tnau.ac.in/org_farm/orgfarm_introduction.html
2. https://www.fao.org/organicag/oa-faq/oa-faq6/en/
3. https://www.india.gov.in/topics/agriculture/organic-farming
4. https://agriculture.nagaland.gov.in/bio-fertilizer/
5. https://www.ccd.ngo/sustainable-agriculture.html?gclid=EAIaIQobChMI5a-KndCo-wIV2ZZLBR1ozQj9EAAYAiAAEgJW2_D_BwE

Mapping with Programme Outcomes

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

Semester	23MICI309- Internship/Industrial Activity	L	P	C
III		-	-	2

Students are provided with an opportunity to learn about the application of microbiology in various industries by visiting, food and dairy industries, biofertilizer production units, blood banks, clinical laboratories, and different industries

Semester	Core Course XI	L	P	C
IV	**23MICC401** - Food and Environmental Microbiology	6	-	5

Course Objectives (CO):

CO1	Discuss microorganisms involved in food spoilage..
CO2	Illustrate bacterial and nonbacterial food borne infections important in public health. Familiarize various national and international aspects of food safety and quality assurance.
CO3	Create awareness. about components of environment, environmental pollution, and detection methods
CO4	Acquire in depth knowledge about solid and liquid waste treatments
CO5	Develop knowledge about organic matter degradation, bioremediation, and the environment risk assessment

Unit – 1:

Microorganisms of food- Scope of food Microbiology. Contamination and spoilage of food –vegetables, fruits, poultry, fish, eggs, meat and milk products and canned foods. Food Preservation - Temperature (low and high), drying, radiation and chemicals.

Unit – 2:

Food microbiology and public health. Food hazards. Food Bacterial infections. Nonbacterial food borne illness - Helminthes, nematodes, protozoa, toxigenic fungi and food borne virus. Microbiological quality standards for food. Government regulatory practices and policies - FDA, HACCP, BIS (IS), FSSAI-2014. Food adulteration and common food additives

Unit – 3:

Components of Environment: Hydrosphere, lithosphere, atmosphere, and biosphere – definitions with examples; Energy flow in the ecosystem- Carbon, Nitrogen, Sulfur and Phosphorous cycles. Physical factors affecting distribution of microorganisms in various environments. Predisposing factors for Environmental diseases – infectious (water and air borne) and pollution related, spread and control of these diseases. Treatment and safety of drinking (potable) water, methods to detect potability of water samples. Space microbiology - Microbiological research in space environment..

Unit – 4:

Waste management – Solid waste - Types - management - Factors affecting solid waste generation rates. Industrial effluent treatment, primary, secondary, tertiary, and advanced treatment process. Quality assessment of decontaminated matters and other biological effluents. Biological reference standards. Utilization of Solid Waste as Food, Feed and Fuel- Composting, Vermicomposting, Bio manure and Biogas production. E waste management..

Unit – 5:

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

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Utilize the knowledge on process of food contamination and spoilage to preserve food. Utilize the knowledge on process of food contamination and spoilage to preserve food
CO2:	Use the knowledge on food borne disease to protect public health.
CO3:	Explain the different types of microorganisms in water. Identify the causes of water pollution and the methods for quality assessment of water and control of water borne diseases.
CO4:	Apply knowledge about waste treatments and microbial decomposition and bio-remediation process in environmental cleanup.
CO5:	Plan a clear approach on environmental issues. Control pollution and explain protection laws to public

Text Books

1. Adams M. R. and Moss M. O. (1996). Food Microbiology, New Age International (P) Limited Publishers, New Delhi.

2. Frazier W.C., Westhoff. D. C. and Vanitha K.N. (2013). Food Microbiology. (6th Edition). McGraw Hill Education.

3. Jay J. M., Loessner M. J. and Golden D.A. (2006). Modern Food Microbiology. (7th Edition). Springer.

4. Shrivastava A.K. (2003). Environment Auditing. A. P. H. Publishing Corporation.

5. Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan.

Reference Books:

1.Robinson R. K. (2000). Dairy Microbiology3 rdEdn, Elsevier Applied Science, London.

2. Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7 th Edn. Edward Arnold: London.

3. Banwarst. G.J. (2003). Basic Food Microbiology 2 nd Edn, CBS Publishers and distributors.

4. Bitton, G. (2011). Wastewater Microbiology. (4th Edition). WileyBlackwell. 5. Bridgewater L. (2012). Standard Methods for the Examination of Water and Wastewater. American Public Health Association.

Web Resources:

1. https://www.fssai.gov.in

2.https://www.who.int/news-room/fact-sheets/detail/food-safety

3. https://egyankosh.ac.in

Mapping with Programme Outcomes

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

Semester	Core Course XII	L	P	C
IV	**23MICP402**–Practical IV Applied Microbiology	6	-	5

Course Objectives (CO):

CO1	Enumerate bacteria in milk for quality analysis
CO2	Analyze methods for microbes from spoiled food
CO3	Gain knowledge on microbes present in water
CO4	Identification and characterization of nitrogen fixers.
CO5	Gain knowledge on biofertilizer production.and field application.

Unit -1

Breed count, Direct microscopic count and Standard plate count of Milk, Methylene blue reductase test, Resazurin test and alkaline phosphatase test of milk

Unit -2

Isolation of bacteria, fungi and yeast from spoiled and canned food. Production and detection of aflatoxins from spoiled food

Unit -3

Microbial Analysis of water – MPN, Membrane filtration. Chemical - BOD.

Unit-4

Enumeration of bacteria and fungi from air – Air sampler Isolation of free-living nitrogen fixers from soil and Rhizobium from root nodules of leguminous plants. Isolation and enumeration of phosphate-solubilizing bacteria from soil.

Unit -5

Preparation of Biofertilizers and testing the efficiency of prepared biofertilizers, R:S ratio of soil microbes Study of phylloplane microflora by leaf impression method Isolation of cellulose degrading bacteria Isolation of plant pathogen – Alternaria, Curvularia, Cultivation of mushroom from solid waste

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Check the quality of milk
CO2:	Identify bacteria and fungi in spoiled food
CO3:	Analyze potability of wate
CO4:	Check the microbial population in air
CO5:	Prepare, apply and check the efficiency of biofertilizers.

Text Books:

1.Ray B. and Bhunia A. (2013). Fundamentals of Food Microbiology. (5th Edition). CRC Press.
2. Garg N., Garg K. and Mukerji K. G. (2013). I K. International Pvt. Ltd.
3. Pepper I., Gerba C. and Brendecke J. (2004). Environmental Microbiology - A Laboratory Manual. (2nd Edition). Academic Press, Elsevier.
4. Yates M.V., Nakatsu C.H., Miller R.V. and Pillai, S.D. (2016). Manual of Environmental Microbiology. (4th Edition). Wiley.
5. Adams M.R, and Moss M.D, (2005). Food Microbiology 4 th Edition, New Age International Pvt. Ltd., Publishers.First edition.

Reference Books:

1.Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7 thEdition Edward Arnold: London. 115
2. Vijaya R K, (2004). Food Microbiology 1 st Edition. MJP Publishers, Chennai.
3. Banwarst. G.J. (2003). Basic Food Microbiology 2 nd Edition, CBS Publishers and distributors.
4. James G Cappucino. and Natalie Sherman. (2016). Microbiology – A laboratory manual. (5th Edition). The Benjamin publishing company. New York.
5. Hurst, C.J., Crawford R.L., Garland J.L., Lipson D.A., Mills A.L. and Stetzenbach L.D. (2007). Manual of Environmental Microbiology. (3rd Edition). American Society for Microbiology.

Web Resources:

1. https://www.fssai.gov.in
2. https://www.who.int/news-room/fact-sheets/detail/food-safety
3. https://academic.oup.com/bioscience/article/65/8/758/240222
4. https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5
5. https://vlab.amrita.edu/index.php?sub=3&brch=27

Mapping with Programme Outcomes

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

Semester	23MICD403 - Project work (Dissertation & Viva-voce)	L	P	C
IV		-	10	7

OBJECTIVES OF THE COURSE

To impart advanced practical knowledge to conduct a research project. To plan and design statistically, retrieve relevant literature, organize and conduct, process the data, photograph relevant observations, evaluate by statistical programmes. Present the project in any regional/national conference/seminar during the second year of the course and submit for final semester examinations. The work has to be conducted in department under the guidance of the project supervisor. Interdisciplinary collaborations from external departments / institutions can be organized only for essential areas of the project. Industrial visit has been included along with the project work as a report (minimum of 10 pages) possibly with geo-tagged photographs. The method of valuation of the project and Industrial visit report submitted by the candidate is outlined as follows:

Internal (2 out of 3 presentations)	-	25 Marks
Viva	-	15 Marks
Project Report	-	60 Marks

Semester	Elective(Industry/Entrepreneurship): VI	L	P	C
IV	23MICE404 - Bioenergy	4	-	3

Course Objectives(CO):

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

Unit – 1:

Bioenergy – Biomass Energy Resources. Biomass conversion methods. Microbes as bioresources for bioenergy products (Bacteria, fungi, yeast and microalgae) - Bioprospecting of microbial strains for biofuel production.

Unit – 2:

Biodiesel − Microbes and Biodiesel. Production and feed stock. Techniques of lipid extraction and conversion to biodiesel. Biodiesel quality and its assessment. Strategies of genetic engineering of organisms for biodiesel production. Biodiesel production from single cell organisms (*Cryptococcus, Cunninghamella, Mortierella*).

Unit – 3:

Alcoholic Fuels from microorganisms: Biochemical conversion to ethanol: Biomass pre-treatment, Starch to sucrose conversion and Sucrose to ethanol fermentation. Role of enzymes and their applications in ethanol production. Distillation and Quantification of ethanol. Production and Estimation of biobutanol, biomethanol, biopropanol and bioglycerol.

Unit – 4:

Biogas - Microbes and Biogas production, Biogas plants – types – design – construction– Biogas Bottling Technology and Development in India, Biogas appliances – burner, luminaries and power generation – effect on engine performance. Application of Biogas slurry in agriculture.

Unit – 5:

Biohydrogen– Production from bacteria and algae. Commercialized microalgae (*Spirulina, Dunaliella, Hematococcus*and *Chlorella*) and their production. Economics of microalgae production. Cultivation of seaweeds. Microbial fuel cells.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Evaluate the various aspects of biomass production and their implementation.
CO2:	Design and construct a biodiesel plant.
CO3:	Carry out the process of fermentation for bio – alcohol fuels.
CO4:	Identify the nature of biogas as a biofuel and their technologies and applications.
CO5:	Design, execute and extract biohydrogen from algae.

Text Books

1. Dahiya A. (2014). Bioenergy- Biomass to Biofuel. (1st Edition). Academic Press Editor.
2. Brown R. C. (2003). Biorenewable Resources: Engineering New Products from Agriculture. (1st Edition). Wiley Blackwell Publishing.
3. Jawaid M., Hakeem K. R. and Rashid U. (2014). Biomass and Bioenergy: Processing and Properties. (1st Edition). Springer Cham.
4. Caye M. Drapcho, Tery H. Walker (Biofuels EngineeringProcess Technology. McGraw Hill.
5. Teri. Bio energy Powering the Future. Pearson Longman Publications.

References Books

1. Konur O. (2018). Bioenergy and Biofuels. (1st Edition). CRC Press.
2. Lee J. W.(2012). Advanced Biofuels and Bioproducts. (13th Edition), Springer.
3. Khanal S. (2008). Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. (8th Edition). Wiley-Blackwell Publishing.
4. Pradeep Chaturvedi.(1995). Bioenergy Resources. Concept Publishing Company.
5. Lee S. (2018).Biofuel and Bioenergy. Taylor and Francis

Web Resources

1. https://www.elsevier.com Biofuels and Bioenergy
2. https://www.sciencedirect.com › book › bioenergy
3. https://www.un.org/en/climatechange/what-is-renewable-energy?gclid=EAIaIQobChMIqriN2Nao-wIV2HwrCh2pfA5mEAAYASAAEgI-p_D_BwE
4. https://www.energy.gov/eere/bioenergy/bioenergy-basics
5. https://www.iea.org/fuels-and-technologies/bioenergy

Mapping with Programme Outcomes

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

Semester	Elective Elective(Industry/Entrepreneurship): VI	L	P	C
IV	23MICE405 – Marine Microbiology	4		3

Course Objectives(CO):

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

Unit – 1:

Marine microbial environment - Benthic & littoral zone, salt pan, mangroves and estuarine microbes, microbial loop. Marine microbial communities – Bacteria, fungi, protozoa. Microbial interactions – Endosymbionts and Ectosymbionts.

Unit – 2:

Dynamics of Marine Microbes - Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming – Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization – phosphorus cycle. Decomposition of organic matter. Bioleaching and biodeterioration of natural and synthetic materials.

Unit – 3:

Marine extremophiles: Mechanism of survival at extreme environments – Adaptive mechanisms in thermophilic, alkalophilic, osmophilic, barophilic, psychrophilic hyperthermophilic and halophilic microorganisms – Importance in biotechnology.

Unit – 4:

Marine Microbial Diseases:Aqua culture pathogens & Water borne pathogens - *Aeromonas, Vibrio,Salmonella, Pseudomonas, Leptospira, Corynebacteria*and viral diseases. Rapid diagnosis of contamination in sea foods and aquaculture products.

Unit – 5:

Applications of Marine Microbial Biotechnology: Production and applications of marine microbial products – Enzymes, Antibiotics, Organic acids, Toxins, Biosurfactants and Pigments. Sea food preservation methods. Probiotic bacteria and their importance in aquaculture.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Apply the knowledge on marine microbial communities and their interactions.
CO2:	Illustrate the role of marine microorganisms in biogeochemical cycles.
CO3:	Categorize the extreme environments in the oceans and the survival mechanisms adapted by the microorganisms living in these environments.
CO4:	Identify the diseases affecting marine organisms and its diagnosis.
CO5:	Evaluate the marine microorganisms as a resource for novel microbial products.

Text Books

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

References Books

1. Maier R. M., Pepper I. L. and Gerba C. P. (2006). Environmental Microbiology. (2nd Edition). Academic Press. ISBN:978-0-12-370519-8.
2. Belkin S. and Colwell R. R. (2005). Oceans and Health: Pathogens in the Marine Environment. Springer. ISBN:978-0-387-23708-4.
3. Scheper T. (2009). Advances in Biochemical Engineering/Biotechnology-Marine Biotechnology. Springer. ISBN:978-3-540-69356-7. E-ISBN:978-3-540-69357-4.
4. Gasol J. M. and Kirchman D. L. (Eds.). (2018). Microbial Ecology of the Oceans. (3rd Edition). Wiley-Blackwell. ISBN:978-1-119-10718-7.
5. Kim S. K. (2019). Essentials of Marine Biotechnology. Springer.

Web Resources

1. https://link.springer.com/content/pdf/bfm%3A978-0-387-23709-1%2F1
2. https://www.researchgate.net/publication/285931262_Bioactive_Marine_Natural_Products
3. http://link.springer.com/content/pdf/bfm%3A978-3-642-03470-1%2F1.pdf
4. https://link.springer.com/book/10.1007/b102184
5. https://www.wiley.com/en-bs/Microbial+Ecology+of+the+Oceans%2C+3rd+Edition-p-9781119107187

Mapping with Programme Outcomes

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

Semester	Elective Elective(Industry/Entrepreneurship) : VI	L	P	C
IV	23MICE406 – Life science for Competitive Examinations	4		3

Course Objectives(CO):

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

Unit – 1:

Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Metabolism of carbohydrates, lipids, amino acids, nucleotides and vitamins. Structure of atoms, molecules and chemical bonds.Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.).Bioenergetics.

Unit – 2:

Cellular Organisation,Cell division and cell cycle,Membrane structure and function,Organization of genes and chromosomes,Structural organization and function of intracellular organelles,DNA replication, repair and recombination,Protein synthesis and processing.

Unit – 3:

Inheritance Biology,Mendelian principles- Dominance, segregation, independent assortment,Linkage and Gene mapping, Karyotyping,Extrachromosomal inheritance - Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. Human genetics-Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

Unit – 4:

Ecology-Habitat and Niche,biotic and abiotic interactions, Biome- biogeographical zones of India.Ecological Succession,Population Ecology- Characteristics of a population; population growth curves,Environmental pollution-global environmental change, Biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.Biodiversity Management approaches. Indian case studies on Conservation/Management strategy (Project Tiger, Biosphere Reserves).

Unit – 5:

Evolution and Behaviour- Evolution - Theories- Darwin's, Lamarck's, Oparin Haldane. Paleontological, Embryological and Molecular evidences. Hardy Weinberg's Law. Speciation; Allopatricity and Sympatricity. Adaptive radiation and Convergent evolution; Sexual selection; Co-evolution. Altruism, Biological clocks, Migration and Parental care. Molecular Evolution-Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Define, classify and assess the structure, biological functions and interactions of Biomolecules.
CO2:	Validate the knowledge of collective and progressive notions of cellular organization.
CO3:	Assess and describe the importance of inheritance biology.
CO4:	Establish acquaintance and understanding of ecology & Biodiversity in a broader sense.
CO5:	Understand the processes of evolution, relate with natural selection, adaptation and speciation.

Text Books

1. Nelson D. L. and Cox M. M. (2008). Lehningers Principles of Biochemistry. (5th Edition). W.H. Freeman and Company.
2. Chapman J. L. (1998).Ecology: Principles and Applications. (2nd Edition). Cambridge University Press.
3. Krishnamurthy V. K. (2003). Textbook of Biodiversity. Science Publishers.
4. Rogers A. L. (2011). Evidence of Evolution. University of Chicago Press. Chicago.
5. Stites D.P.,Abba I.Terr, Parslow T.G.(1997). Medical Immunology. 9thEdn, ntice-Hall Inc.

References Books

1. Pontarotti P. (2018). Origin and Evolution of biodiversity. (1st Edition). Springer.
2. Verma P. S. and Agarwal V. K. (2004). Cell biology, Genetics, Molecular Biology, Evolution and Ecology. (2nd Edition). S Chand publication.
3. Lewin R. and Foley R. (2004). Principles of Human Evolution. (2nd Edition). Black well Publishing Company.
4. Boyer R.F. (2002) Modern Experimental Biochemistry 3rd Edition. Pearson Education.
5. Wilson K., Walker J., Clokie S and Hofmann A. (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8t Edition. Cambridge University Press.

Web Resources

1. https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_
2. https://www.livescience.com/474-controversy-evolution-works.html.
3. https://www.examrace.com/Study-Material/Life-Sciences/
4. https://www.kopykitab.com/Methods-In-Biology-Life-Science-Study-Material-For-CSIR-NET-Exam-by-Panel-Of-Experts
5. https://www.erforum.net/2017/01/life-science-biology-handwritten-notes-for-competitive-exams.html

Mapping with Programme Outcomes

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

Semester	23MICS407 – Skill Enhancement Course/Professional Competency Skill	L	P	C
IV	Microbial Quality Control and Testing	2		1

Course Objectives (CO):

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

Unit – 1:

Concepts of quality control techniques - quality assurance, Total Quality Management (TQM) Continuous Quality Improvement (CQI) Quality Assurance (QA) pre analytical and post analytical techniques, ATCC, MTCC, microbial based assay.

Unit – 2:

Waste water microbiology – types and sources of contamination, prevention of water borne diseases. Water management, water harvesting, water recycling. Characteristics of waste water from industries - Sugar factory, Pulp & Paper mill, Distillery, Textile, Engineering, Food Industry, Domestic waste. Waste water treatment plant types and quality control. Water pollution causes and remedies.

Unit – 3:

Microflora of water. Microbiological analysis of water sample. Microbiological analysis of water sample collection, drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests Control of microbes in water: Water borne pathogens, water borne diseases. Control of water borne pathogens - Precipitation, chemical disinfection, filtration, high temperature, UV light.

Unit – 4:

Microflora of air - Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres. Collection of air samples and analysis. Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, isolation and Identification. Control Measures of Bioaerosols - UV light, HEPA filters, desiccation, Incineration.

Unit – 5:

Quality control in food - Food X ray inspection, PPE Equipment, IoT sensors, preventive quality control and reality quality control. Quality control of pharma products. Quality assurance framework, assessment of pharmaceutical quality, determinants of pharmaceutical quality, practical approaches to quality assurance.

Course Outcomes (CO)

On completion of this course, students will;

CO1:	Apply knowledge in quality analysis techniques suitable for industries.
CO2:	Perform water managements, water harvesting and treat sewage, water pollutions and remedies.
CO3:	Detect portability of water. Test water quality.
CO4:	Impart knowledge on bioaerosols, impact and prevention
CO5:	Apply quality control techniques for food and pharma products

Text Books

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

Reference Books:

1. Cullimore D. R. (2010). Practical Atlas for Bacterial Identification. (2nd Edition). -Taylor &Francis.
2. Sundararaj T. (2003). Microbiology Laboratory Manual. (2nd Edition). Published by A. Sundararaj
3. Hoges N. A., Denyer S P. and Baird R.M. (2003). Handbook of microbiological quality control. Microbial Quality Assurance in Pharmaceutcals, cosmetics & Toiletries. by Sally F. Bloomfield
4. Amitava Mitra. Fundamentals of Quality control and Improvement. (3rd Edition). Wiley Publications
5. David Roesti, Marcel Goverde (2019). Pharmaceutical Microbiological Quality Assurance and control: Practical guide for non- sterile Manufacturing. Wiley Publishers.

Web Resources:

1. https://www.researchgate.net › publication › 320730681
2. https://www.fssai.gov.in
3. https://mofpi.nic.in/Schemes/implementation-haccp-iso-22000-iso-9000-ghp-gmp-etc
4. https://www.who.int/news-room/fact-sheets/detail/food-safety
5. https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

Mapping with Programme Outcomes:

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

Semester	23MICX 408 –Extension Activity	L	P	C
IV		-	-	1

Students are insisted to join NSS/ NCC/ YRC/ RRC or any other service organizations in our University. The Students should visit the nearby communities to disseminate knowledge regarding importance of personal and public hygiene, awareness about communicable diseases and importance of blood donation. They have to educate farmers about the importance of microbes in agriculture, income generation through mushroom cultivation, SCP and biofertilizer production. Students should involve in activities to increase scientific temper among public.