PONDICHERRY UNIVERSITY
(A CENTRAL UNIVERSITY)

REGULATIONS, CURRICULUM AND SYLLABUS
For Affiliated Colleges

B.Sc./B.Sc. (Hons.) Microbiology

(Under the National Education Policy 2020)

Effective from the Academic Year 2023 -24

Department of Microbiology

Revised June 2024

PONDICHERRY UNIVERSITY

B.Sc. /B.Sc. (Hons.) MICROBIOLOGY

NEP - REGULATIONS

(Effective from the academic year 2023-24)

PREAMBLE

The Bachelor of Science (B.Sc.) in Microbiology programme is a dynamic and comprehensive academic journey designed to equip students with a strong foundation in the principles and practices of microbiology. Rooted in the ever-evolving field of biological sciences, this programme is crafted to cultivate a deep understanding of microbial life, including its diversity, physiology, genetics, and role in the environment and human health.

The curriculum encompasses a balanced blend of foundational courses and specialized courses, focusing on experiential learning. Core subjects include microbial physiology, immunology, molecular biology, and environmental microbiology, ensuring a solid theoretical foundation. These courses allow students to delve deeper into areas such as medical microbiology, industrial microbiology, microbial genetics, and biotechnology.

Experiential learning is a key component of the programme, offering opportunities for internships, research projects, and participation in scientific conferences. Students will engage in practical applications of their knowledge, honing their skills through hands-on experiences that mirror the challenges and demands of the rapidly evolving field of microbiology.

Recognizing the global nature of microbiology, the B.Sc. in Microbiology programme integrates a comprehensive international perspective. Students will examine global microbial challenges, including emerging infectious diseases, antimicrobial resistance, and environmental sustainability. The curriculum emphasizes the importance of multicultural influences and ethical considerations in scientific research and practice, in line with the National Education Policy (NEP) 2020. This approach prepares students to contribute responsibly and effectively to the global scientific community, addressing critical issues that transcend national boundaries.

The B.Sc. in Microbiology is a transformative educational experience that empowers students to become adept problem solvers, innovators, and leaders in the field of microbiology. By fostering a passion for continuous learning and providing a solid foundation in both theory and application, the programme sets the stage for a successful and fulfilling career in the dynamic world of biological sciences.

Overall, this programme aims to develop well-rounded microbiology professionals who are equipped to navigate and thrive in the complex, fast-paced world of biological research and applications.

PROGRAMME OBJECTIVES

- To provide students with a strong foundation in the principles and concepts of microbiology, including the study of microorganisms, their structure, function, and interactions.
- To develop practical laboratory skills, ensuring students can proficiently use modern techniques and equipment for microbial analysis, cultivation, and identification.
- To foster an understanding of the diversity of microorganisms, including bacteria, viruses, fungi, and parasites, and their roles in various ecosystems, industries, and human health.
- To enable students to apply microbiological knowledge in various fields, such as medicine, agriculture, environmental science and biotechnology.

- To instil a sense of ethics and professionalism in the practice of microbiology, emphasizing responsible conduct in research, safety protocols, and ethical considerations in the field.
- To foster an interdisciplinary approach by integrating microbiology with other scientific disciplines, recognizing its interconnectedness with fields such as genetics, biochemistry, and immunology.
- To provide opportunities for specialization in specific areas of microbiology, allowing students to develop a deeper understanding of particular aspects of the field.
- To encourage students to critically analyse scientific literature, synthesize information, and contribute to the development of new knowledge in microbiology.
- To prepare students for advanced studies, such as postgraduate research or professional degrees, by offering a rigorous academic curriculum and research-focused experiences.

These objectives collectively aim to produce well-rounded graduates with a comprehensive understanding of microbiology, equipped with the skills and knowledge needed for successful careers or advanced studies in the field.

PROGRAMME OUTCOMES

- Demonstrate a solid understanding of the fundamental principles and concepts of microbiology, including the morphology, physiology, and genetics of microorganisms.
- Exhibit competence in performing standard microbiological laboratory techniques, including the cultivation, isolation, and identification of microorganisms.
- Demonstrate awareness of ethical considerations in microbiological research and adhere to professional standards in laboratory practices and scientific inquiry.
- Apply microbiological knowledge to address real-world issues in areas such as healthcare, agriculture, industry, and environmental science.
- Recognize the interdisciplinary nature of microbiology and integrate knowledge from related fields such as genetics, biochemistry, and immunology.
- Develop expertise in a specific area of microbiology through coursework and research, showcasing a deep understanding of specialized topics.
- Engage in critical analysis of scientific literature, synthesizing information from various sources to contribute to the advancement of microbiological knowledge.
- Demonstrate readiness for advanced studies or professional careers through a comprehensive academic background, research experiences, and exposure to advanced topics in microbiology.

These outcomes collectively aim to produce graduates who are well-equipped with the knowledge, skills, and ethical grounding necessary to excel in diverse microbiological careers or pursue advanced studies in the field.

DEFINITIONS

Terms used in the NEP Regulations shall have the meaning assigned to them as given below unless the context otherwise requires:

A. **Credit**: A credit is the number of hours of instruction required per week for the given subject in a given semester of 16-18 weeks. One credit is equivalent to 15 hours of teaching (lecture or tutorial) or 30 hours of practice/field work/community engagement and service per Semester.

B. **Academic Year:** Means the year starting on 1st day of July and ends on the 30th day of June in the succeeding year.

C. **Residence time**: Means the time a student spends for attending classes in the College/Institution (either Online/Offline) as a full-time student and enrolled in any Academic programme of the Institution.

D. **Semester**: Means 18 weeks (90 Working days) of teaching-learning sessions of which two weeks shall be set apart for examinations and evaluation;

E. **Grade**: Means a letter grade assigned to a student in a Course for his/her performance at academic sessions as denoted in symbols of: O(Outstanding), A+(Excellent), A (Very good), B+ (Good), B (Above average), C (average), P (Pass) F (Fail) and Ab (Absent) with a numeric value of O=10, A+=9, A=8, B+=7, B=6, C=5 P=4, and F=0, Ab=0;

F. **Grade Point Average (GPA):** Means an average of the Grades secured by a student in all courses in a given academic session duly weighted by the number of credits associated to each of the courses.

G. **Cumulative GPA (CGPA):** is the weighted average of all courses the student has taken in a given Programme.

H. **A common Course**: Means the set of courses that all students who are admitted to any Programme of the University are required to study; these courses include, Languages (English-modern Indian languages), NEP specific courses- viz. Understanding India, Environmental sciences/Education, Health and wellbeing/Yoga, Digital & Technological solutions;

I. **Major Discipline:** Means the core subjects mandatory for the programme, Major discipline may be a single discipline or interdisciplinary/ multidisciplinary courses. Eg. B.Sc. (Physics) or B.Sc. (Physics, Maths and Chemistry)

J. **Minor Discipline**: Means allied or elective subjects to major discipline, Microbiology.

J.i. **Minor discipline Cognate**: Refers to a pool of courses offered by the parent department / cognate (allied) departments. Eg.B.Com (General) may have minors streams leading in 2/3 to B.Com (Accounting & Taxation), B.Com (Banking & Finance), B.Com (Company Law & Corporate Secretaryship) or B.Com (Computer Applications and Data Analytics).

J.ii. **Minor discipline Generic**: Refers to the subsidiary/elective subjects chosen from a basket of courses offered by different departments other than the minors offered by the parent department. Eg.B.Com (Corporate Economics).

K. **Credit Requirement**: For a Degree/Diploma/Certificate Programme means the minimum number of credits that a student shall accumulate to achieve the status of being qualified to receive the said Degree, Diploma/Certificate as the case may be.

L. **Exit option:** Means the option exercised by the students, to leave the Programme at the end of any given Academic year.

M. **Lateral entry:** Means a student being admitted into an ongoing Programme of the University otherwise than in the 1st year of the programme.

N. **Vocational Studies/Education**: This refers to set of activities for participation in an approved project or practical or lab, practices of application of scientific theories, studio activities involving students in creative artistic activities, workshop-based activities, field-based shop-floor learning, and Community engagement services, etc. (These courses are expected to enable students to incorporate the learned skills in daily life and start up entrepreneurship.)

O. **Skill-based learning/project**: This refers to activities designed to understand the different socio-economic contexts, first-hand understanding of the policies, regulations, organizational structures, processes, and programmes that guide the development process.

P. **Work-based internship:** Means structured internships with Software Companies, Research and Higher Educational Institution Laboratories, Corporate offices, etc. which will further improve employability.

AWARD OF UG DEGREE/DIPLOMA/CERTIFICATE

Four years B.Sc. Degree Programme shall have options for earning a UG Certificate / Diploma / Degree / Degree (Honors) / UG Degree (Honors with Research) based on the exit option exercised by the candidates

DURATION OF THE COURSE

The Curriculum Framework designed by UGC for implementing NEP 2020 specifies that all Undergraduate(UG) degree programmes are to be for a period of either 3 years or 4 years leading to the award of UG Degree or UG (Hons.) Degrees.

All UG courses shall focus on conceptual understanding and development of critical thinking in a given field of Study, incidentally the skills such as communication, teamwork, and leadership shall be embodied in Teaching-learning process to facilitate for career option in the given field of specialization.

AGE LIMIT

The rules as applicable to other Under Graduate courses as prevailing in Pondicherry University.

ELIGIBILITY FOR ADMISSION

Candidates for admission to B.Sc./B.Sc. (Hons.) Microbiology shall require to have passed H.Sc. (or +2) or its equivalent with Botany/Zoology/Biology as one of the subjects of study, conducted by the Government of Tamil Nadu or any other equivalent system recognized by the Government of Puducherry based on the admission criteria laid down by Pondicherry University are eligible to apply.

LATERAL ENTRY

As per NEP, students have a choice of entry into the Programme of study. UGC specifies that about 10% of seats over and above the sanctioned strength shall be allocated to accommodate the Lateral Entry students. The guidelines for lateral Entry are as follows:

1. Lateral Entry for II Year B.Sc. /B.Sc. (Hons.) Microbiology:

Student should complete **UG certificate in Microbiology** from any University.

2. Lateral Entry for III Year B.Sc. /B.Sc. (Hons.) Microbiology:

Student should complete **UG Diploma course in Microbiology** from any University.

3. Lateral Entry for IV Year B.Sc. (Hons.) Microbiology:

Student should complete **B.Sc. Microbiology** from any University

ACADEMIC AUDIT OF COURSES

Internal Quality Assurance Cell at every institution is expected to supervise the implementation of NEP Regulations in these programmes. Availability of required number of Classrooms, Faculty rooms, Labs, Library facilities, Computer Centre and recruitment of Faculty members, allocation of funds for running the Science Labs/Computer Centre etc., is the responsibility of the College Administration.

PEDAGOGICAL APPROACHES

a) Lecture Courses	Regular classroom lectures by qualified / experienced Expert Teachers • These Lectures may also include classroom discussion, demonstrations, case analysis • Use of Models, Audio-Visual contents, Documentaries, PPTs may supplement
b) Tutorial Courses	Problem solving Exercise, classes guided discussion, supplementary readings vocational training, etc.
c) Practical / Lab work	Practical Lab activity with Theoretical support, Mini projects, Activity based engagement, Program executions, Data processing and presentation exercise.
d) Seminar Course	A course requiring student to design and participate in discussions, Group Discussions, Elocution and Debate, Oral Communication Paper presentations, Poster Presentation, Role play participation, Quiz competitions, Business plan preparation/presentation, etc.
e) Internship course	Courses requiring students to Learn by Doing in the workplace external to the educational Institutions. Internships involve working in Software Companies, Research and Higher Educational Institution Laboratories, Corporate Offices, etc. All Internships should be properly guided and inducted for focused learning.
f) Research Project	Students need to study and analyze the recent research publications from indexed/peer reviewed journals in their area of specialization. Outcome of the study and analysis need to be presented as a thesis or research report with necessary experimental results.

COURSE STRUCTURE

All Academic Programmes offered under NEP shall be offered in terms of credits. Each course/subject in a given Programme of study shall carry certain number of credits which will be awarded on completion of the said course.

EXIT OF THE COURSE:

NEP 2020 introduces the facility to breakdown the Programme of study at Undergraduate (UG) level after completion of every year of study. The students will be awarded the following:

1. Students who opt to exit after completion of first year will be awarded **UG Certificate in Microbiology** provided they have earned a minimum of 42 credits and in addition, they have to complete work based vocational course/internship of 4 credits during the summer vacation of the first year.
2. Students who opt to exit after completion of second year will be awarded **UG Diploma in Microbiology** provided they have earned a minimum of 84 credits and in addition, they have to complete work based vocational course/internship of 4 credits during the summer vacation of the Second year.
3. Students who opt to exit after completion of third year will be awarded **UG degree (B.Sc. Microbiology)** provided they have earned a minimum of 124 credits.
4. Students who exit after completion of fourth year will be awarded either **B.Sc. (Hons.) Microbiology)** provided they have earned a minimum of 164 credits or **B.Sc. (Hons. with Research) Microbiology**, provided they have earned a minimum of 164 credits with Research Project.

MEDIUM OF INSTRUCTION

The medium of instruction for B.Sc. Microbiology **shall be in English**.

BREAK UP OF CREDITS AND COURSES

NEP Framework has specified the minimum number of credits that a Bachelor student has to earn in ¾ year period. Table I specifies the number of credits and number of courses that a 3year UG student and a four year UG (Hons.) Degree student is expected to complete in 3 and 4 year duration respectively.

TABLE I
BREAK UP OF CREDITS AND COURSES

Sl.No.	Component	3 Year Degree	4 Year Hons Degree
1.	Major Disciplinary Courses	60 Credits (15Courses of 4 credits each)	80 Credits (20 Courses of 4 credits each)
2.	Minor Disciplinary Courses	24 Credits (6 Courses of 4 Credits each)	32 Credits (8 Courses of 4 credits each)
3.	Multi Disciplinary Courses	9 Credits (3 Courses of 3 credits each)	9 Credits (3 courses of 3 credits each)
4.	Ability Enhancement Courses	12 Credits (4 Courses of 3credits each)	12 Credits (4 courses of 3credits each)
5.	Skill Enhancement Courses	9 Credits (3 Courses of 3 credits each)	9 Credits (3courses of 3 credits each)
6.	Common Value-added courses	8 Credits (4Courses of 2 credits each)	8 Credits (4 courses of 2 credits each)
7.	Winter Project / Internship Community Engagement	2 Credits (1 field-based course)	2 Credits (1 field-based course)
8.	Research Dissertation Project	-	12 Credits (Project report & background subjects)
9.	Total credits required	124 Credits	164 Credits

Every Undergraduate (UG) programme offered by a College shall confirm to the Structure specified by the UGC's Framework, 2023. A student of 3 year UG programme is mandated to complete a minimum of 124 credits and the student of 4 year Honors degree shall complete 164 credits. An UG student shall complete the following courses under different heads as listed below:

1. Major Disciplinary Courses
2. Minor Disciplinary Courses
3. Multi Disciplinary Courses
4. Ability Enhancement Courses
5. Skill Enhancement Courses
6. Value added/Common Courses
7. Internships and Community Service based projects

NEP CLASSIFICATION OF COURSES

i) Major Disciplinary courses (MJD):

Major disciplinary courses are subject specific compulsory subjects that a student has to complete to obtain the UG / UG (Hons.) Degree in the given discipline. Major disciplinary courses shall constitute 50% of the total credits.

All discipline specific major courses shall be designed for 4 credits each with one/two additional hours or guidance of teaching at Tutorials / Practicals.

UG programmes may be offered in a single major discipline or in Multiple Major disciplines giving equal weightage in credits. For example a B.Sc. course may be in a single discipline like B.Sc. (Maths) or with multiple major disciplines like B.Sc. (Maths, Physics & Chemistry).

ii) Minor Disciplinary Course (MID): (24/32 Credits)

Minor disciplinary courses refer to those subjects which are Allied / Specialisation / Elective subjects to the Major discipline. These allied courses are expected to provide additional understanding of the subject in a specific focused area. For example, a B.A. (Political Science) student shall study allied subjects like Public Administration, Sociology as these subjects have inter linkages with the Major Disciplinary subjects.

iii) Multi-Disciplinary Courses (MLD): (9 Credits)

All undergraduate students are mandated to pursue 9 credits worth of courses in such Multi-disciplinary areas / Courses out of 9/10 NEP defined subjects. Colleges may identify any 3 multiple disciplinary streams listed below based on availability of resources and manpower.

a) Natural Sciences
b) Physical Sciences
c) Humanities / Social Sciences

Students are expected to learn basic/introductory courses designed by other departments for this purpose. Colleges may list any 3 introductory courses(one each in Natural Sciences, Physical Sciences, Humanities) for uniform adoption of all UG students.

iv) Ability Enhancement (AEC) courses: (8 Credits)

All Undergraduate (UG) students are mandated to complete at least 8 Credits worth of Courses which focus on Communication and Linguistic skills, Critical reading, and writing skills. These courses are expected to enhance the ability in articulation and presentation of their thoughts at workplace. Colleges may design these ability enhancement courses tuned to the requirements of given major discipline. E.g. A course in Business Communication is more appropriate in place of literature/prose/poetry.

a) English Language

Ability Enhancement Course	
I. English Language a) English Language &Literature - 1 and 2 b) Functional English–1 and 2 c) Communicative English–1 and 2	II. Indian Language (two courses) a) Indian language & Literature –1 and 2 b) Functional language–2 c) Communicative language –1 and 2

v) Skill Enhancement Course: (9 Credits)

These courses focus at imparting practical skills with hands-on Training. In order to enhance the employability of students, Colleges are expected to design such courses that they deem fit for their students for better employment/entrepreneurship/career development, etc. Colleges may also outsource the Skill Enhancement Courses to AICTE approved agencies for conducting short term Training Workshops, Skill India initiatives of GOI and approved Trades by Skill development of corporation are to be considered. Short term courses.

vi) Value Added Common courses (VAC): (8 Credits)

Under NEP, the UGC has proposed for 6 to 8 credits worth of common courses which are likely to add value to overall knowledge base of the students. These courses include:

a) Understanding India
b) Environmental Sciences/Education
c) Digital Technologies
d) Health, Wellness, Yoga Education, Sports & Fitness

The course structure and coverage of topics are suggested by UGC in its draft documents, colleges/UG Boards of Studies may design the methodology for conducting these value-added courses.

vii) Summer Internship (2 to 4 Credits)

As per the UGC guidelines all UG students should be exposed to 4 to 6-week Summer Internship in an industrial organizations / Training Centres / Research Institution, etc. Such Summer Internship is to be conducted in between 4th Semester and 5th Semester. A review of report and award of grade based on Work based learning by students is to be recorded during the 5th Semester.

a) Community Engagement and Service (CES) (2 Credits)

All UG students are also mandated to participate in a 15 days community engagement activity during their winter vacation between 5th and 6th Semesters. This Community engagement activity is expected to expose the students to social problems of neighbourhood village students may prepare a report on the activities carried out for a award of 2 credits.

EVALUATION:

Total Marks:100

All Credit courses are evaluated for 100 marks. Internal Assessment component is for 25 marks and the End Semester University exam is for 75 marks. In case of Practicals, Project work, etc., it is 50:50 marks for Internal and End-Semester Exams.

Category of the Course:

There are three categories of courses as shown.

Category A	Theory Courses with Lecture hours and hours allotted for tutorials wherever required.
Category B	Practical Courses with only Practical hours or Laboratory hours. Laboratory Courses, Internships, Research Project Works and other courses allotted only with practical hours in the curriculum shall be under this category.
Category C	Theory & Practice combined Courses where Lecture and Practical hours allotted.

Learning Assessment:

<table>
<tr><th>Course Types</th><th colspan="2">Internal Assessment</th><th>End Semester Assessment</th></tr>
<tr><td rowspan="5">Category A

IA:25Marks
EA:75Marks</td><td colspan="2">25 Marks</td><td rowspan="5">75 Marks</td></tr>
<tr><td>Evaluation Component</td><td>Marks</td></tr>
<tr><td>I. Mid Semester Exam (one)</td><td>20</td></tr>
<tr><td>II. Percentage of Attendance</td><td>05</td></tr>
<tr><td>Total</td><td>25</td></tr>
<tr><td rowspan="15">Category B

IA:50Marks
EA:50Marks</td><td colspan="2">50 Marks</td><td></td></tr>
<tr><td colspan="2">Practical/Internship Courses</td><td rowspan="14">50 Marks</td></tr>
<tr><td>Evaluation Component</td><td>Marks</td></tr>
<tr><td>I. Weekly Observation Note / Report</td><td>20</td></tr>
<tr><td>II. Practical Record/ Internship Report</td><td>10</td></tr>
<tr><td>III. Model Practical Exam</td><td>20</td></tr>
<tr><td>IV. Percentage of Attendance</td><td>05</td></tr>
<tr><td>Total</td><td>50</td></tr>
<tr><td colspan="2">Research Project Work Course</td></tr>
<tr><td>Evaluation Component</td><td>Marks</td></tr>
<tr><td>I. Monthly Review (3 Reviews – 10 Marks each)</td><td>30</td></tr>
<tr><td>II. Project Report</td><td>10</td></tr>
<tr><td>III. Project Work</td><td>10</td></tr>
<tr><td>Total</td><td>50</td></tr>
<tr><td></td><td colspan="2">25 Marks</td><td></td></tr>
<tr><td rowspan="6">Category C

IA: 25 Marks
EA:75 Marks
(Theory: 50 + Practical: 25 = 75 Marks)</td><td>Evaluation Component</td><td>Marks</td><td rowspan="6">75 Marks
(Theory:50 Marks and Practical:25 Marks)</td></tr>
<tr><td>Theory</td><td></td></tr>
<tr><td>I. Mid Semester Exam (one) - Theory</td><td>10</td></tr>
<tr><td>II. Model Practical Exam</td><td>10</td></tr>
<tr><td>III. Percentage of Attendance</td><td>05</td></tr>
<tr><td>Total</td><td>25</td></tr>
</table>

Marks for Attendance:

Attendance %	Marks
Below75%	0
75%-80%	1
80%-85%	2
85%-90%	3
90%-95%	4
95%-100%	5

Internal Test Scheme:

Principal of the College schedules the Mid-Semester Exam for all courses during 8/9th week of start of classes. All faculty members are expected to conduct this Mid-Semester exam for 1.30 hr duration and evaluate, upload the marks to Controller of Examinations of University. Colleges are also requested to preserve the answer books of Mid-Semester exams until declaration of results by the University.

End-Semester University Exam:

Controller of Examinations (COE) of Pondicherry University schedules the End-Semester exams for all theory and practical subjects based on University calendar. **For Category C courses, theory and practical exams will be conducted separately by the Controller of Examinations of Pondicherry University.**

A detailed Exam Time Table shall be circulated to all Colleges at least 15 days before the start of exams mostly during 15/16th week of the Semester. Question Papers shall be set externally based on BOS approved syllabus. All students who have a minimum of 70% attendance are eligible to attend the end-semester exams. The breakup of end semester marks is as given below.

CATEGORY A: Theory Subjects

Total Marks:100 (Internal: 25 Marks & External :75 Marks)

End Semester Examination : **Maximum Marks -75, Duration - 3 Hours**

QUESTION PAPER PATTERN FOR END SEMESTER EXAMINATION

Section – A: (10 x 2 Marks = 20 Marks)

- It is of short answer type. Each question carries 2 marks.
- 10 questions to be given by selecting 2 questions from each unit.
- Candidate should Answer all the questions.

Section – B: (5 x 5 Marks = 25 Marks)

- It is of short answer type. Each question carries 5 marks.
- 5 questions to be given with either or choice, 1 question from each unit.
- Candidate should answer all 5 questions.

Section – C: (3 x 10 Marks = 30 Marks)

- It is of essay answer type. Each question carries 10 Marks.
- 5 questions to be given. One question from each unit.
- Candidate should answer 3 out of 5 questions.

CATEGORY B: Practical Courses

Based on Practical Examinations conducted by COE of University.

Total Marks:100 (Internal:50 Marks & External :50 Marks)

End Semester Examination: Maximum Marks-50, Duration -3 Hours

Practical Exam/ Internship /Project Work: Presentation of Work/ Report/ Viva-voce examinations.

(Submission of practical record/ report for the End Semester Practical Examination is mandatory)

CATEGORY C: Theory Subjects with Practical Components

Total Marks:100 (Internal : 25 Marks , End Semester Theory: 50 Marks and End Semester Practical : 25 Marks)

1. QUESTION PAPER PATTERN FOR END SEMESTER EXAMINATION (THEORY)

End Semester Theory Examination: **Maximum Marks - 50, Duration - 3 Hours**

Section – A: (5 x 1 Mark = 5 Marks)

- It is of short answer type. Each question carries 1marks.
- 5 questions to be given by selecting 1 question from each unit.
- Candidate should answer all the questions.

Section – B: (5 x 3 Marks = 15 Marks)

- It is of short answer type. Each question carries 3 marks.
- 5 questions to be given with either or choice, 1 question from each unit.
- Candidate should answer all 5 questions.

Section – C: (3 x 10 Marks = 30 Marks)

- It is of essay answer type. Each question carries 10 Marks.
- 5 questions to be given. One question from each unit.
- Candidate should answer 3 out of 5 questions.

End Semester Assessment for courses under Category C (Theory Examinations with practical component) will be conducted with Theory 50 Marks and Practical 25 Marks.

2. QUESTION PAPER PATTERN FOR END SEMESTER EXAMINATION (PRACTICAL COMPONENT)

End Semester Practical Examination :**Maximum Marks - 25, Duration - 3 Hours**

1. **Question 1**(15 marks)
2. **Question 2 - Spotters** (5 marks)
3. **Record** (5 marks)

(Submission of practical record for the End Semester Practical Examination is mandatory)

Practical Component is based on Practical Exams/Viva-voce with External Examiner appointed by the University Controller of Examinations and schedules exclusively prepared for such practical examinations by the University Examination Section.

Total Marks for End Semester Assessment: 75Marks (Theory : 50 Marks + Practical : 25 Marks)

*A minimum passing score of **20 out of 50 Marks** is required for the theory component, and **10 out of 25 Marks** for the practical component. If a candidate fails either in the theory or the practical component, they must retake both components in the subsequent exams.*

For the Major Disciplinary Course, MJD 18: Microbes and their Applications (Credit Seminar), it is classified as a Category B course. The End Semester Examination, carrying 50 marks, will be internally conducted and evaluated by the Department of Microbiology.

CONSOLIDATION OF MARKS AND PASSING MINIMUM

Controller of Examinations of the University consolidates the Internal Assessment marks uploaded by the Colleges and marks secured by students in end-semester examination. The total marks will be converted into letter grades as shown in the following Table 2. As per NEP Regulations, the passing minimum is 50% marks (IA + End semester put together) However, Pondicherry University considers 40% marks as pass during first 3 years of study and students who secured less than 50 will be awarded 'P' (Pass Grade)

ARREAR EXAM

A student who failed to secure 40% marks in aggregate is declared as Failed and he is eligible to take up supplementary examination by registering to the failed course in the following Semester. All other candidates who failed due to shortage of attendance, those who are seeking to improve the grade shall repeat the course.

LETTER GRADES AND CALCULATION OF CGPA

Total Marks Secured by a student in each subject shall be converted into a letter grade. UGC Framework has suggested a Country wide uniform letter grades for all UG courses. The following Table shows the seven letter grades and corresponding meaning and the grade points for calculation of CGPA.

TABLE–2

Equivalent Letter Grade	Meaning	Grade Points for Calculation of CGPA
O	Outstanding	10
A+	Excellent	9
A	Very Good	8
B+	Good	7
B	Above Average	6
C	Average	5
P	Pass	4
F	Fail	0
Ab	Absent	0

In order to work out the above letter grades, the marks secured by a student (Total of IA and Semester End) would be categorized for relative grading. The ranges of marks for each grade would be worked as follows:

Highest marks in the given subject = X
Cut of marks for grading purpose =50marks
Passing mark (for 3 year of UG) =40
Number of grades (excepting P grade) (O, A+,A,B+,B,C) =6
Range of marks =K

$$K = \frac{x - 50}{G}$$

The following table given the range of marks and letter grades. According to K value, one of the following grading schemes will be followed.

(i) If $K \geq 5$, then the grades shall be awarded as given in Table II.

Table II		
Range of Marks in%	**Letter Grade Points for**	**Letter Grade Points for**
X to (X-K)+1	O	10
(X-K) to(X-2K)+1	A+	9
(X-2K)to(X-3K)+1	A	8
(X-3K)to(X-4K)+1	B+	7
(X-4K)to(X-5K)+1	B	6
(X-5K) to 50	C	5
40 –49	P	4
Below40	F	0
Absent(Lack of Attendance)	Ab	0

(ii) If K < 5,thenthegradesshallbeawardedasgiveninTable III.

Table III		
Range of Marks in%	**Letter Grade Points for**	**Letter Grade Points for**
80-100	O	10
71-79	A+	9
66-70	A	8
61-65	B+	7
56-60	B	6
50-55	C	5
40-49	P	4
Below40	F	0
Absent (lack of attendance)	Ab	0

CALCULATION OF SEMESTER GRADE POINT AVERAGE (SGPA) AND CGPA:

Semester Grade Point Average (SGPA) is calculated by taking a weighted average of all grade points secured by a candidate from all subjects registered by him/her in the given Semester. The weights being the number of credits that each subject carry.

Cumulative Grade Point Average (CGPA) CGPA shall be calculated as the weighted average of credits that course carries and the value of Grade points averaged for all subjects.

Computation of SGPA and CGPA

The following procedure shall be followed to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

The SGPA is the ratio of the sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student,

i.e. **SGPA**$(Si)=\Sigma(CixGi)/\Sigma Ci$

Where Ci is the number of credits of the i^{th}course and Gi is the grade point scored by the student in the i^{th}course.

(i) **Example for Computation of SGPA where candidate has not failed in any course.**

Semester	**Course**	**Credit**	**Letter Grade**	**Grade point**	**Credit Point** (Credit x Grade)
I	Course1	3	A	8	3X8=24
I	Course2	4	B+	7	4X7=28
I	Course3	3	B	6	3X6=18
I	Course4	3	O	10	3X10=30
I	Course5	3	C	5	3X5=15
I	Course6	4	B	6	4X6=24
		20			139
	SGPA				139/20=6.95

(ii) Example for Computation of SGPA where candidate has failed in one course.

Semester	**Course**	**Credits**	**Letter Grade**	**Grade point**	**Credit Point** (Credit x Grade)
I	Course1	3	A	8	3X8=24
I	Course2	4	B+	7	4X7=28
I	Course3	3	B	6	3X6=18
I	Course4	3	O	10	3X10=30
I	Course5	3	C	5	3X5=15
I	Course6	4	F	0	4X0=00
		20			115
	SGPA				115/20=5.75

(ii) **Example for Computation of SGPA where candidate has failed in two courses.**

Semester	**Course**	**Credit**	**Letter Grade**	**Grade point**	**Credit Point** (Credit x Grade)
I	Course1	3	A	8	3X8=24
I	Course2	4	B+	7	4X7=28
I	Course3	3	F	0	3X0=00
I	Course4	3	B	6	3X6=18
I	Course5	3	C	5	3X5=15
I	Course6	4	F	0	4X0=00
		20			85
	SGPA				85/20=4.25

The CGPA shall also be calculated in similar way as shown in examples (i), (ii) and (iii) of SGPA for all subjects taken by the students in all the semesters. However, if any student fails more than once in the same subject, then while calculating CGPA, the credit and grade point related to the subject in which the student fails in multiple attempts will be restricted to one time only. The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

In case of audit courses offered, the students may be given (P) or (F) grade without any credits. This may be indicated in the mark sheet. Audit courses will not be considered towards the calculation of CGPA.

DECLARATION OF RESULTS

Controller of Examinations (COE) of the University shall declare the results of given UG programme following the CGPA secured by students by the end of 6^{th} Semester.

Pass Classes

Range of CGPA	**Result**
9.0 above	First Class with distinction
6.0 above	First Class
5.0 Below5.99	Second Class
4.0 4.99	Pass Class

B.Sc./B.Sc. (Honors) Microbiology

The Semester-wise and Broad Course Category-wise Distribution of credits of the Undergraduate Programme:

Semester	Major	Minor	Multi-disciplinary	Language	Skill Enhancement Course	Value Added	Community Engagement	Summer Internship	Research Project	Total Credits
I	1. Fundamentals of Microbiology	1. Biomolecules and Cell Biology	1. Natural Sciences	English /MIL	1. Mushroom and *Spirulina* Cultivation/ 2. Management of Microbiology Laboratory/ 3. Haematology and Blood Banking **(Any one)**	Two courses		Nil	Nil	
Credits	**4**	**4**	**3**	**3**	**3**	**4**				**21**
II	2. Immunology	2. Clinical Biochemistry	2. Physical Sciences	English /MIL	4. Quality Control and Assurance in Microbiology/ 5. Bioremediation/ 6. Vermitechnology **(Any one)**	Two courses		Nil	Nil	
Credits	**4**	**4**	**3**	**3**	**3**	**4**				**21**
III	3. Molecular Biology 4. Food Microbiology	3. Economic and Medical Entomology	3.Humanities/ Social Sciences	English /MIL	7. Bioinoculants production/ 8. Diagnostic Microbiology/ 9. Microbial Food Safety **(Any one)**	Nil		Nil	Nil	
Credits	**8**	**4**	**3**	**3**	**3**					**21**

IV	5. Bacterial Physiology and Metabolism 6. Virology 7. Recombinant DNA Technology	4. Plant Pathology	Nil	English /MIL	Nil	Nil	Community Engagement	Nil	Nil	
Credits	**12**	**4**		**3**			**2**			**21**
V	8. Pharmaceutical Microbiology 9. Microbial Diversity and Bacterial Phylogeny 10. Medical Mycology and Parasitology	5. Microbes in Human Welfare	Nil	Nil	Nil	Nil		Summer Internship	Nil	
Credits	**12**	**4**						**4**		**20**
VI	11. Microbial Process and Products Technology 12. Agricultural Microbiology 13. Environmental Microbiology 14. Medical Bacteriology	6. Microbial Culture and Control	Nil	Nil	Nil	Nil		Nil	Nil	
Credits	**16**	**4**								**20**
VII	15. Microbiome Biology 16. Dairy Microbiology 17. Research Methodology	7. Public Health Microbiology 8. Bioinformatics	Nil	Nil	Nil	Nil		Nil	Nil	
Credits	**12**	**8**								**20**

VIII	18. Microbes and their applications (Credit Seminar) 19. Industrial Microbiology 20. Research Project **or** 21. Soil Microbiology 22. Techniques in Microbiology 23. Entrepreneurial Microbiology	Nil	Nil	Nil	Nil	Nil		Nil	Project	
Credits	**8** (With project) **or** **20** (Without Project)								**12**	**20**
Total Credits	**76** (With project) **or** **88** (Without project)	**32**	**9**	**12**	**9**	**8**	**2**	**4**	**12** (With project) **or** **0** (Without project)	**164**

UG Certificate in Microbiology: Students exiting the programme after two semesters and securing **42 credits** will be awarded UG Certificate provided they secure 4 credits in work based vocational courses offered during summer term or internship / Apprenticeship in addition to 6 credits from skill-based courses earned during first and second semester.

UG Diploma in Microbiology: Students exiting the programme after four semesters and securing **84 credits** will be awarded UG Diploma provided they secure additional 4 credits in work based vocational courses offered during summer term or internship / Apprenticeship in addition to 9 credits from skill-based courses earned during first year and second year.

B.Sc. Microbiology: Students who want to undertake 3-year UG programme will be awarded UG Degree (B.Sc. Microbiology) after six semesters upon securing **124 credits**.

B.Sc. (Honors) in Microbiology: Students will be awarded B.Sc. (Honors) in Microbiology after eight semesters and securing minimum **164 credits.**

B.Sc. (Honors with Research) in Microbiology: Students will be awarded B.Sc., (Honors with Research) in Microbiology after eight semesters and securing minimum **164 credits** with Research Project.

ANNEXURE II

SEMESTER WISE CREDITS AND HOURS OF WORK AS PER NEP

SEMESTER I				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Hours of Teacher**
MJD 1	Major Disciplinary course (compulsory)	MJD-1:**Fundamentals of Microbiology**	3+1	3+2 P
MID1	Minor Disciplinary Courses	MID-1: **Biomolecules and Cell Biology**	3+1	3+2 P
MLD 1	Multi-Disciplinary Course (Any one)	MLD-1:**Natural Sciences:** 1. Herbal Nutrition 2. Basic Botany 3. Basic Zoology 4. Basic Microbiology 5. Fundamentals of Biotechnology	3	4
AEC I & II	Ability Enhancement courses I & II English or Indian Language	AEC-1(A): Basic Language and Literature	2+1	4
		AEC-1(B): Functional Language		
		AEC-1(C): Spoken communication		
		AEC-2(A): Basic Language and Literature		
		AEC-2(B): Functional Language		
		AEC-2(C): Spoken communication		
SEC	Skill Enhancement Course (Anyone)	SEC-1(A): **Mushroom and *Spirulina* Cultivation**	3	4
		SEC-1(B): **Management of Microbiology Laboratory**		
		SEC-1(C): **Haematology and Blood Banking**		
VAC	NEP Value Added common courses I & II (compulsory)	VAC-1: Environmental Studies	2	4
		VAC-2: Understanding India	2	4
		Total Credits / Total Hours of Work	**21 Credits**	**30 Hours**

P denotes Practical hours and conducted in batches if student strength exceeds 25.

SEMESTER II				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Hours of Teacher**
MJD 2	Major Disciplinary courses (compulsory)	MJD-2:**Immunology**	3+1	3+2 P
MID2	Minor Disciplinary courses	MID-2: **Clinical Biochemistry**	3+1	3+2 P
MLD2	Multi-Disciplinary courses (Any one)	MLD-2: **Physical Sciences** 1. Electronics in Everyday Life 2. Chemistry in Everyday Life 3. Science and Society 4. Energy in Everyday Life 5. Basic Mathematics	3	4
AEC III &IV	Ability Enhancement courses III & IV English or Indian Language	AEC-3(A): Basic Language and Literature	2+1	4
		AEC-3(B): Functional Language		
		AEC-3(C): Spoken communication		
		AEC-4(A): Basic Language and Literature		
		AEC-4(B): Functional Language		
		AEC-4(C): Spoken communication		
SEC	Skill Enhancement Course (Any one)	SEC-2(A): **Quality Control and Assurance in Microbiology**	3	4
		SEC-2(B): **Bioremediation**		
		SEC-2(C): **Vermitechnology**		
VAC	NEP Value added common courses I & II (compulsory)	VAC-3: Health & Wellness / Yoga Education	2	4
		VAC-4: Digital Technologies	2	4
		Total Credits / Total Hours of Work	**21 Credits**	**30 Hours**

P denotes Practical hours and conducted in batches if student strength exceeds 25.

UG Certificate in Microbiology: Students exiting the programme after two semesters and securing **42 credits** will be awarded UG Certificate provided they secure 4 credits in work based vocational courses offered during summer term or internship / Apprenticeship in addition to 6 credits from skill-based courses earned during first and second semester.

SEMESTER III

Code No	Nature of Course	Title of the Course	Credits	Hours of Teacher
MJD3 MJD4	Major Disciplinary courses (compulsory)	MJD3: **Molecular Biology** MJD4: **Food Microbiology**	3+1 3+1	4+2 P 4+2 P
MID3	Minor Disciplinary courses	MID-3: **Economic and Medical Entomology**	3+1	4+2 P
MLD3	Multi-Disciplinary Course (Any one)	MLD-3: **Humanities / Social Sciences:** 1. Basic Economic Concepts and Measurement 2. Basics of Accounting 3. French for Beginners 4. Commercial Geography 5. Introduction to Public Administration	3	4
AEC V & VI	Ability Enhancement courses V&VI English or Indian Language	AEC-5(A): Basic Language and Literature AEC-5(B): Functional Language AEC-5(C): Spoken communication AEC-6(A): Basic Language and Literature AEC-6(B): Functional Language AEC-6(C): Spoken communication	2+1	4
SEC	Skill Enhancement Course (Anyone)	SEC-3(A): **Bioinoculants production** SEC-3(B): **Diagnostic Microbiology** SEC-3(C): **Microbial Food Safety**	3	4
		Total Credits / Total Hours of Work	**21 Credits**	**30 Hours**

P denotes Practical hours and conducted in batches if student strength exceeds 25.

SEMESTER IV				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Hours of Teacher**
MJD5 MJD6 MJD7	Major Disciplinary courses (compulsory)	MJD5:**Bacterial Physiology and Metabolism** MJD6: **Virology** MJD7:**Recombinant DNA Technology**	3+1 3+1 3+1	3+2 P 3+2 P 3+2 P
MID4	Minor Disciplinary courses	MID-4: **Plant Pathology**	3+1	3+2 P
AEC VII &VIII	Ability Enhancement courses VII & VIII English or Indian Language	AEC-7(A): Basic Language and Literature AEC-7(B): Functional Language AEC-7(C): Spoken communication AEC-8(A): Basic Language and Literature AEC-8(B): Functional Language AEC-8(C): Spoken communication	2+1	4
Project	WP/Internship	Community Engagement	2	6 P
		Total Credits / Total Hours of Work	**21 Credits**	**30 Hours**

P denotes Practical hours and conducted in batches if student strength exceeds 25.

UG Diploma in Microbiology: Students exiting the programme after four semesters and securing **84 credits** will be awarded UG Diploma provided they secure additional 4 credits in work based vocational courses offered during summer term or internship / Apprenticeship in addition to 9 credits from skill-based courses earned during first year and second year.

SEMESTER V

Code No	Nature of Course	Title of the Course	Credits	Hours of Teacher
MJD 8	Major Disciplinary courses (compulsory)	MJD8:**Pharmaceutical Microbiology**	3+1	4+2 P
MJD 9		MJD9: **Microbial Diversity and Bacterial Phylogeny**	3+1	4+2 P
MJD10		MJD10:**Medical Mycology and Parasitology**	3+1	4+2 P
MID5	Minor Disciplinary courses	MID-5: **Microbes in Human Welfare**	3+1	4+2 P
SKD	Skill Development Course	Summer Internship	4	6 P
		Total Credits / Total Hours of Work	**20 Credits**	**30 Hours**

P denotes Practical hours and conducted in batches if student strength exceeds 25.

SEMESTER VI

Code No	Nature of Course	Title of the Course	Credits	Hours of Teacher
MJD11	Major Disciplinary courses (compulsory)	MJD11:**Microbial Process and Products Technology**	3+1	4+2 P
MJD12		MJD12:**Agricultural Microbiology**	3+1	4+2 P
MJD13		MJD13:**Environmental Microbiology**	3+1	4+2 P
MJD14		MJD14: **Medical Bacteriology**	3+1	4+2 P
MID6	Minor Disciplinary courses	MID-6: **Microbial Culture and Control**	3+1	4+2 P
		Total Credits / Total Hours of Work	**20 Credits**	**30Hours**

P denotes Practical hours and conducted in batches if student strength exceeds 25.

B.Sc. Microbiology: Students who want to undertake 3-year UG programme will be awarded UG Degree (B.Sc.in Microbiology) after six semesters upon securing **124 credits**.

SEMESTER VII				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Hours of Teacher**
MJD15	Major Disciplinary courses (compulsory)	MJD15: **Microbiome Biology**	3+1	4+2 P
MJD16		MJD16: **Dairy Microbiology**	3+1	4+2 P
MJD17		MJD17: **Research Methodology**	3+1	4+2 P
MID7	Minor Disciplinary courses	MID-7:**Public Health Microbiology**	3+1	4+2 P
MID8		MID-8: **Bioinformatics**	3+1	4+2 P
		Total Credits / Total Hours of Work	**20 Credits**	**30 Hours**

P denotes Practical hours and conducted in batches if student strength exceeds 25.

SEMESTER VIII				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Hours of Teacher**
MJD18	Major Disciplinary courses (compulsory)	MJD18: **Microbes and their applications (Credit Seminar)**	2+2	2+4 P
MJD19		MJD19:**Industrial Microbiology**	3+1	4+2 P
MJD 20	Research Project or Major Disciplinary Course (Choose one)	MJD 20: R**esearch Project** (Alternatively)	12	18
	or	**Or**	**or**	**or**
MJD 21	**3** Major Disciplinary Courses	MJD 21:**Soil Microbiology**	3+1	4+2 P
MJD 22		MJD 22:**Techniques in Microbiology**	3+1	4+2 P
MJD 23		MJD 23:**Entrepreneurial Microbiology**	3+1	4+2 P
		Total Credits / Total Hours of Work	**20 Credits**	**30 Hours**

P denotes Practical hours and conducted in batches if student strength exceeds 25.

For the Major Disciplinary Course, MJD 18: Microbes and their Applications (Credit Seminar), it is classified as a Category B course. The End Semester Examination, carrying 50 marks, will be internally conducted and evaluated by the Department of Microbiology.

B.Sc.(Honors) in Microbiology: Students will be awarded B.Sc. (Honors) in Microbiology after eight semesters and securing minimum **164 credits.**

B.Sc.(Honors with Research) in Microbiology: Students will be awarded B.Sc. (Honors with Research) in Microbiology after eight semesters and securing minimum **164 credits** with Research Project.

Major courses for B.Sc. /B.Sc.(Honors) in Microbiology- semester wise distribution.

SEMESTER	COURSE	TOTAL CREDIT
I	Fundamentals of Microbiology	3+1 (P)
II	Immunology	3+1 (P)
III	Molecular Biology	3+1 (P)
	Food Microbiology	3+1 (P)
IV	Bacterial Physiology and Metabolism	3+1 (P)
	Virology	3+1 (P)
	Recombinant DNA Technology	3+1 (P)
V	Pharmaceutical Microbiology	3+1 (P)
	Microbial Diversity and Bacterial Phylogeny	3+1 (P)
	Medical Mycology and Parasitology	3+1 (P)
VI	Microbial Process and Products Technology	3+1 (P)
	Agricultural Microbiology	3+1 (P)
	Environmental Microbiology	3+1 (P)
	Medical Bacteriology	3+1 (P)
VII	Microbiome Biology	3+1 (P)
	Dairy Microbiology	3+1 (P)
	Research Methodology	3+1 (P)
VIII	Microbes and their Applications (Credit Seminar)	2+2 (P)
	Industrial Microbiology	3+1 (P)
	Soil Microbiology	3+1 (P)
	Techniques in Microbiology	3+1 (P)
	Entrepreneurial Microbiology	3+1 (P)
	Total Credits	**88**

Courses offered under minor stream in Microbiology

SEMESTER	COURSE	TOTAL CREDIT
I	Biomolecules and Cell Biology	3+1 (P)
II	Clinical Biochemistry	3+1 (P)
III	Economic and Medical Entomology	3+1 (P)
IV	Plant Pathology	3+1 (P)
V	Microbes in Human Welfare	3+1 (P)
VI	Microbial Culture and Control	3+1 (P)
VII	Public Health Microbiology	3+1 (P)
VIII	Bioinformatics	3+1 (P)
	Total Credits	**32**

Multidisciplinary courses

SEMESTER	COURSE	TOTAL CREDIT
I (Any one)	**Natural Sciences:** 1. Herbal Nutrition 2. Basic Botany 3. Basic Zoology 4. Basic Microbiology 5. Fundamentals of Biotechnology	3
II (Any one)	**Physical Sciences;** 1. Electronics in Everyday Life 2. Chemistry in Everyday Life 3. Science and Society 4. Energy in Everyday Life 5. Basic Mathematics	3
III (Any one)	**Humanities/Social Sciences** 1. Basic Economic Concepts and Measurement 2. Basics of Accounting 3. French for Beginners 4. Commercial Geography 5. Introduction to Public Administration	3
	Total Credits	**9**

Skill Enhancement Course offered in Department of Microbiology

SEMESTER	COURSE	TOTAL CREDIT
I (Any one)	1.Mushroom and *Spirulina* Cultivation	**3**
	2.Management of Microbiology Laboratory	
	3. Haematology and Blood Banking	
II (Any one)	4.Quality Control and Assurance in Microbiology	**3**
	5.Bioremediation	
	6.Vermitechnology	
III (Any one)	7. Bioinoculants Production	**3**
	8. Diagnostic Microbiology	
	9. Microbial Food Safety	
	Total Credits	**9**

SEMESTER – I

Major Disciplinary Course
MJD1

FUNDAMENTALS OF MICROBIOLOGY

Credits: 3+1(P)

Total hours:75

Course Objectives:

The objectives of the course include (i) to learn the basics of microbiology including, historical events (ii) to understand about the types of microscopy and intricate details of the bacterial cell. (iii) to appreciate various methods of sterilization employed to ensure aseptic conditions in microbiology works and (iv) lastly to know about the types of culture media employed to isolate the microorganisms.

Unit - I **5 hours**

History and scope of microbiology, spontaneous generation – biogenesis theory – contributions of Leeuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Paul Ehrlich and Fleming.

Unit – II **10 hours**

Microscope– principles and application – simple and compound microscope – dark field – phase contrast, fluorescent microscope, SEM and TEM. Types of staining – simple, differential (Gram's, AFB), special – capsular staining (negative), spore, LPCB, KOH mount.

Unit - III **10 hours**

Ultrastructure of bacteria, cell envelope, cell wall– Gram positive and Gram negative bacterial cell wall, slime, flagella, capsule, pili.

Unit – IV **10 hours**

Sterilization and disinfection – principles – methods of sterilization – physical methods – dry heat –moist heat – radiation– filtration (membrane and HEPA)– chemical sterilization – chemical agents – mode of action. Preservation and maintenance of culture.

Unit - V **10 hours**

Culture and media preparation – solid and liquid. Types of media –semi synthetic, synthetic, enriched, enrichment, selective and differential media. Pure culture techniques – tube dilution, pour, spread, streak plate. Anaerobic cultivation of bacteria.

Unit – VI **30 hours**

Practical- Microbiology Good Laboratory Practices and Biosafety- Preparation of culture media and cultivation of bacteria & fungi- microscopic observation of bacteria and fungi - Microbial preservation techniques - Isolation and Identification of bacteria and fungi.

Text Books

1. Willey J.M., Sandman K.M. and Wood D.H. (2023). Prescott's Microbiology, 12thEdn., McGraw Hill, p. 1024.
2. Madigan, M.T., Bender K.S. Buckley D.H., Sattley W.M. and Stahl D.A (2021). Brock Biology of Microorganisms, 16th Global Edn., Pearson Education Ltd., p.1129.

Reference Books

1. Chess B. (2024). Talaro's Foundations in Microbiology, 12th Edn., McGraw Hill, p.993.
2. Tortora G.J., Funke B.R., Chase C.L., Bair W.B. and Weber D. (2024). Microbiology: An Introduction, 14th Edn. Pearson-Benjamin Cummings.
3. Brown A. and Smith H. (2016). Benson's Microbiological Applications: Laboratory Manual concise version, 14th Edn. McGraw-Hill Companies.

Course Outcome:

Upon successful completion of the course the candidate will

- *be familiar with the history and development of Microbiology with the broad perspective of the scope of Microbiology.*
- *understand the principles and applications of the different microscopes and staining methods.*
- *have gained knowledge on the ultrastructure of bacteria.*
- *be acquainted with different methods of sterilization and preservation of cultures.*
- *understand the different types of media used for the cultivation of microbes.*

SEMESTER – I

Minor Disciplinary Course
MID1
BIOMOLECULES AND CELL BIOLOGY

Credits: 3+1(P)

Total hours:75

Course Objectives:

The objectives of this course is to understand the basics of cell biology which is an essential part of any life science programme, it includes (i) to know about the biomolecules of the cell (ii) to appreciate the structural and functional roles of the cells in the daily life such as appreciating the role of the organelles and to value the life processes such as respiration and photosynthesis (iii) finally to comprehend the role of cell communication in life systems.

Unit – I **10 hours**

Biomacromolecules of the cell: Carbohydrates – definition, classification, and functions, Amino acids and proteins – classification and function, primary, secondary, tertiary and quaternary structure of proteins, Lipids – classification and their function; Nucleic acids – classification and their function.

Unit – II **9 hours**

Structure and functions of cell wall: bacterial cell wall – plant cell wall and fungal cell wall, plasma membrane – exocytosis, endocytosis, phagocytosis – vesicles and their importance in transport. Cytoskeleton structure – microtubules, microfilaments, intermediate filament.

Unit – III **9hours**

Structure and functions of cell organelles – endoplasmic reticulum (rough endoplasmic reticulum and smooth endoplasmic reticulum), golgi apparatus, lysosomes, microbodies (peroxysomes and glyoxysomes), vacuoles, ribosomes, centriole and basal bodies.

Unit - IV **9 hours**

Mitochondria – organization of respiratory chain, chloroplasts – photophosphorylation, nucleus, nucleolus, nuclear membrane and organization of chromosomes, cell cycle and its check points, cell division (mitosis and meiosis).

Unit – V **8 hours**

Cell communication – overview – types of cell signaling – signal molecules – signal amplification – receptor types – quorum sensing.

Unit – VI **30 hours**

Practical: Preparation of Molar, Normal solutions and buffers – Determination of pH using pH meter – Qualitative analysis of carbohydrates, protein and fats – Estimation of glucose by Benedict's test – Estimation of ascorbic acid – Preparation of starch from potatoes, Understand about the cell types of prokaryotes and eukaryotes, by observing their structure, the cell division and function – Observing the internal structures of the cells, their importance and functioning.

Text Books

1. Verma P.S. and Agarwal V.K. (2016). Cell Biology (Cytology, Biomolecules, Molecular Biology), Paperback, S. Chand and Company Ltd**.**
2. Hardin J. and Lodolce J.P. (2022). Becker's World of the Cell, 10th Edn (Global Edition). Pearson Education Ltd., p.929.
3. Satyanarayana T. (2005). Biochemistry, Books and Allied Pvt. Ltd.

Reference Books

1. Cooper G.M. (2019). The Cell – A Molecular Approach, 8th Edn. Sinauer Associates p.813.
2. Mason K.A., Losos J.B. and Singer S.R. (2017). Raven Johnson's Biology, 11th Edn. McGraw Hill Education.
3. Urry L.A. Cain M.L., Wasserman S.A., Minorsky P.V., and Orr R.B. (2021). Campbell Biology, 12th Edn.p.1493.
4. Karp G. (2010). Cell and Molecular Biology – Concepts and Experiments, 6th Edn. John Wiley and Sons.
5. Alberts B., Heald R., Johnson B., Morgan D., Raff M., Roberts K. and Walter P. (2022). Molecular Biology of the Cell, 7th Edn., W.W. Norton & Company, p. 1555.

Course Outcome:

Upon successful completion of the course the candidate will

- *be familiar with the bio macromolecules of the cell.*
- *have gained knowledge on the structure and functions of cell wall, plasma membrane, vesicles and cytoskeleton.*
- *understand the structure and functions of the nucleus and different cell organelles.*
- *understand cell division and the significance of cell cycle and its check points.*
- *have gained insight on types of cell signaling, signal amplification and quorum sensing.*

SEMESTER – I

Skill Enhancement Course
SEC-1(A)
MUSHROOM AND SPIRULINA CULTIVATION

Credits: 3

Total hours:45

Course Objectives:

The course imparts entrepreneurial skills with objectives (i) to learn about the types of edible mushrooms and their uses to human kind (ii) to gain knowledge on cultivation methods for mushroom and the diseases that commonly affect them (iii) to appreciate the importance of Spirulina to human kind, understanding their cultivation methods and processing techniques.

Unit – I **5 hours**

Edible and non-edible mushroom – historical account, most commonly cultivated mushrooms in the world, distribution and production in various countries.

Unit – II **10 hours**

Cultivation of button, oyster and paddy straw mushroom – raising a pure culture – spawn preparation and mass cultivation – harvest pests and diseases in mushroom

Unit – III **10 hours**

Economics of mushroom cultivation – precautions in mushroom cultivation – precaution to be taken while selecting the area, spawn preparation, spawn run, during cropping harvesting etc. Mushroom recipes (western and Indian recipes, pickles, powders, jams etc.

Unit – IV **10 hours**

Introduction to SCP production – historical use and rediscovery of *Spirulina* importance – morphology, taxonomy and habitat of *Spirulina*– biochemical composition including proximate composition – amino acids – unsaturated fatty acids – minerals and vitamins. Human health benefits of *Spirulina*.

Unit – V **10 hours**

Natural production – laboratory cultivation – small scale commercial production – commercial and mass cultivation (tank construction, culture medium, strain selection, scaling up of the process) – importance of light and pH in *Spirulina* cultivation – harvesting, drying and packing.

Text Books

1. Changs T. and Hayanes W.A. (Ed.) (1978). Biology and Cultivation of Edible Mushrooms. Academic Press. N.Y.
2. Habib M.A.B., Parvin M., Huntington T.C. and Hasan M.R. (2008). A review on culture, production and use of *Spirulina* as food for humans and feeds for domestic animals and fish. FAO Fishers and Aquaculture Circular No. 1034, FAO, Rome, Italy.

Reference books

1. Biswas S., Datta M. and Ngachan S.V. (2012). Mushrooms: A Manual for Cultivation, PHI.
2. Selvendran D. (2015). Large Scale Algal Biomass (*Spirulina*) Production in India. In: D. Das (Ed.) Algal Biorefinery: An Integrated Approach, Springer.
3. Zadrazil F. and Grabbe K. (1983). Edible Mushroom, Biotechnology Vol. 3, Weinheim: Verlag Chemie, Berlin.

Course Outcome:

Upon successful completion of the course the candidate will

- *gain understanding on the edible mushrooms, its distribution and production in various countries.*
- *gain insight on the cultivation of various mushrooms.*
- *gain knowledge on economics of mushroom cultivation and preparation of various mushroom recipes.*
- *understand the importance of Spirulina and their cultivation methods.*

SEMESTER – I

Skill Enhancement Course
SEC-1(B)
MANAGEMENT OF MICROBIOLOGY LABORATORY

Credits: 3

Total hours:45

Course Objectives:

A skill based learning course with objectives (i) to understand the rules and regulations of microbiological laboratory maintenance (ii) to familiarize with the instruments and quality control measures commonly adopted in microbiology laboratory (iii) to know about the procedures involved in strain maintenance and laboratory waste disposal.

Unit – I **5 hours**

Rules and regulations to be followed in a microbiology laboratory – maintenance of records – familiarizing with common chemicals, instruments and equipments of microbiology laboratory.

Unit - II **10 hours**

Laboratory management: human resources – logistics and supply – test performance – data management – resource tapping – instruments– water and sources of light and electricity – room– table and benches and space in the laboratory.

Unit - III **10 hours**

Laboratory quality control assessment: Internal quality control and external quality control.

Unit – IV **10 hours**

Maintenance of type strains or reference strain of microbes: culture collection centres – preservation and maintenance of cultures.

Unit – V **10 hours**

Laboratory waste disposal system: national and international guidelines for the disposal of waste. Basic concepts of bio-safety and its universal precautions.

Text books

1. Cappuccino J.G. and Welsh C. (2020). Microbiology a laboratory manual. 12th Edn. Pearson.
2. Gile, T.J. and Scungio D. (2014). Complete guide to Laboratory safety, 4th Edn. HCPro a division of BLR.

Reference books

1. Emmert E. (2013). Biosafety guidelines for handling microorganisms in the teaching laboratory: development and rationale. Journal of Microbiology & Biology Education14: 78–83.

Course Outcome:

Upon successful completion of the course the candidate will

- *become familiar with the rules and regulations to be followed in Microbiology laboratory.*
- *become acquainted with management of laboratory.*
- *gain knowledge on laboratory quality control assessment.*
- *have an understanding on maintenance of type strains.*
- *have an idea on laboratory waste disposal system and biosafety*

SEMESTER – I

Skill Enhancement Course
SEC-1(C)
HAEMATOLOGY AND BLOOD BANKING

Credits: 3

Total hours:45

Course Objectives:

A skill based learning course with objectives (i) to appreciate the importance of blood and its examination (ii) to gain knowledge on the methods of counting of blood cells (iii) to know about the coagulation process, stains and staining techniques of examination of blood smear and to gain insight on ABO grouping, Rh typing, donor screening, preservation and storage of blood.

Unit – I **5 hours**

Blood: definition, characters, composition. Collection of blood – capillary blood: from adults and infants, examinations employed. Venous blood: from adults and infants, examinations employed – Anticoagulants: definition – type: Wintrobes, EDTA, heparin, citrate, concentration, examinations, advantages and disadvantages.

Unit – II **10 hours**

Counting of blood cells: Neubauer counting chamber – total RBC count: diluting fluids, normal values – total WBC count: diluting fluids, normal values differential leucocyte count: granulocyte and agranulocytes, morphology and function, staining technique – Platelet count: morphological characters and functions, haemoglobin: composition and normal values, haemoglobin estimation.

Unit – III **10 hours**

Coagulation mechanism: factors, bleeding time, clotting time. Haematological indices: packed cell volume. Erythrocyte sedimentation: principle – determination: introbes, Westergren method – advantages and disadvantages – factors affecting the process.

Unit – IV **10 hours**

Preparation of stains and staining techniques: Wright stain, Leishman's stain, Giemsa's stain, Fields stain, peroxidase stain. Examination of blood smear – peripheral smear report – size, colour and shape. Blood parasites: malarial parasite and microfilaria.

Unit – V **10 hours**

ABO Grouping: History, slide and tube technique, Rh typing: slide and tube technique, Coombs test: direct and indirect method, donor screening – cross matching, collection of blood, preservation and storage.

Text Books

1. Maheswari N. (2008). Clinical Pathology, Haematology and Blood Banking (for DMLT students), 2nd Edn. Jaypee Brothers Medical Publishers.
2. Hoffbrand A.V. and Moss P.A.H. (2015). Hoffbrand's Essential Haematology, 7th Edn. Wiley.

Reference books

1. Greer J.P., Foerster J., Lukens J.N.,Rodgers G.M., Paraskevas F. and Glader B.E. (Ed.) (2013). Wintrobe's Clinical Hematology, 13th Edn. Wolters Kluwer.
2. Hillyer C., Silberstein L., Ness P., Anderson K. and Roback J. (2006). Blood banking and Transfusion medicine, 2nd Edn. Elsevier Press.
3. Godkar P.B. and Godkar D.P. (2013). Textbook Medical Laboratory Technology Vol-I and II, Bhalani Publishing House.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the composition of blood and collection of blood.*
- *gain an insight on the various methods involved in counting of different blood cells.*
- *have a better understanding on the coagulation mechanism and erythrocyte sedimentation.*
- *become acquainted with the preparation of stains and staining techniques of examination of blood smear.*
- *understand ABO grouping, Rh typing, donor screening, preservation and storage of blood.*

SEMESTER – II

Major Disciplinary Course
MJD2
IMMUNOLOGY

Credits: 3+1(P)
Total hours:75

Course Objectives:
The objectives of learning immunology are (i) to understand about the nature of infections and the natural immunity systems functioning in our body (ii) to appreciate the different type of immunoglobulin types and their unique role in immunity (iii) to identify the different assays used to quantify immunoglobulin molecules and to understand about hypersensitive reactions of cells.

Unit – I **9 hours**

History of immunology, host parasitic relationships, microbial infections – types – sources of infection – steps involved in infection – transmission of infection , virulence – toxigenicity and invasiveness, host resistance. Innate immunity and acquired immunity.

Unit – II **9 hours**

Structure, functions and properties of immune cells: stem cell, T cell, B cell, NK cell, macrophage, neutrophil, eosinophil, basophil, mast cell, dendritic cell and immune organs – bone marrow, thymus, lymph node, spleen, GALT, MALT, CALT.

Unit – III **9 hours**

Antigens– types, properties, haptens, adjuvants, vaccines – types – toxoids – antitoxins. Immunoglobulins – structure, types and properties. Hybridoma Technology, complement structure, properties, function of complement components and pathways.

Unit – IV **9 hours**

Antigen and antibody reactions: agglutination, precipitation, Complement Fixation Test, Immunofluorescence, Enzyme Linked Immuno Sorbent Assay (ELISA), Radioimmunoassay.

Unit – V **9 hours**

Hypersensitivity reactions: antibody mediated – type I anaphylaxis – type II antibody dependent cell cytotoxicity – type III – immune complex reactions – type IV – delayed type hypersensitivity reactions. Cell mediated immune responses – lymphokines, cytokines.

Unit – VI **30 hours**

Practical: Separation of serum and plasma, Blood grouping- Forward and Reverse Grouping, Differential Leukocyte Count, Total leukocyte count, Precipitation reactions, Radial immunodiffusion, Counter immuno electrophoresis (CIE), Rocket electrophoresis, Rapid plasma reagin (RPR) test, Agglutination Test – Widal test, Anti - streptolysin O (ASLO) test, ELISA (demonstration).

Text Books

1. Punt J., Stranford S., Jones P., Owen J.A. (2018). Kuby Immunology, 8th Edn. W.H. Freeman.
2. Shetti N. (2005). Immunology: Introductory Text book, 2nd Edn. New Age International Limited.

Reference Books

1. Lydyard P., Whelan A. and Fanger M. (2011). Bios Instant notes in Immunology, 3rd Edn. Garland Science publishers.
2. Delves P.J., Martin S.J., Burton D.R. and Roitt I.M. (2017). Roitt's Essential Immunology, 13th Edn. Wiley publishers.
3. Riedel S., Morse S., Mietzner T. and Miller S. (2022). Jawetz Melnick and Adelberg Medical Microbiology, 28th Edn. McGraw Hill Publications.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the history of immunology and host parasitic relationships.*
- *understand the structure and functions of the cells and organs of immune system.*
- *gain insight on antigens, antibodies and complements.*
- *understand the different antigen-antibody reaction.*
- *gain knowledge on hypersensitivity and cell mediated immune response.*

SEMESTER – II

Minor Disciplinary Course
MID2
CLINICAL BIOCHEMISTRY

Credits: 3+1(P)

Total hours:75

Course Objectives:

Learning clinical biochemistry is (i) to appreciate the applications of biochemistry in clinical background (ii) to understand about the disorders and their impacts which resulted due to malfunctioning of carbohydrate, protein and lipid metabolism (iii) lastly to enlighten about the diagnostic enzymology under clinical conditions.

Unit-I **9 hours**

Basic concepts of clinical biochemistry: A brief review of units and abbreviations used in expressing concentrations and standard solutions. Biological samples – specimen collection – anticoagulant – preservatives for blood and urine – transport of specimens.

Unit - II **9 hours**

Disorders related to carbohydrate metabolism: diabetes mellitus – definition – WHO criteria – classification of diabetes mellitus – signs, symptoms and complications – GTT– galactosemia, galactosuria, fructosuria.

Unit – III **9 hours**

Disorders related to amino acid and lipid metabolism: Inborn errors of metabolism – phenylketonuria, alkaptonuria, albinism and tyrosinosis. Exogenous and endogenous transport of lipids – chylomicron transport, VLDL transport – reverse cholesterol transport – atherosclerosis – fatty liver – risk and anti-risk factors.

Unit – IV **9 hours**

Liver function test: detoxification and excretory functions – protein changes in liver disease – differential diagnosis of jaundice – haemolytic hepatic and obstructive jaundice – Bilirubin metabolism, bile pigment levels in blood and urine – gastric function test – fractional test meal analysis and its interpretation. GI hormones – gastrin, secretin, CCK and gastric inhibitory peptide.

Unit – V **9 hours**

Diagnostic enzymology: plasma enzymes – functional and non-functional enzymes – isoenzymes – enzyme patterns in acute pancreatitis, liver diseases and myocardial infarction.

Unit – VI **30hours**

Practical: Biochemical Specimens – collection – anticoagulants - calorimetric analysis - Blood sugar analysis - Blood urea analysis - Serum – creatinine estimation -Serum uric acid estimation - Serum cholesterol estimation - Serum – bilirubin estimation - estimation of total protein - Determination of A/G ratio - Urine analysis - Estimation of SGOT and SGPT.

Text Books

1. Ahmed N. (2011). Clinical Biochemistry. Oxford University Press.
2. Vasudevan D.M. (2008). Textbook of Biochemistry for Medical Students, 5th Edn, Jaypee publishers.

Reference Books

1. Beckett G., Walker S., Rae P. and Ashby P. (2010). Lecture notes: Clinical Biochemistry, 8th Edn., Wiley-Blackwell.
2. Sathya Narayana U. (1999). Biochemistry, 2nd Edn. Kolkata, Allied Publishers.
3. Mallikarjuna Rao N. (2002). Medical Biochemistry,2nd Edn. New Age Publishers.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the basic concepts in clinical biochemistry.*
- *comprehend disorders related to carbohydrate metabolism.*
- *understand the disorders related to amino acid and lipid metabolism.*
- *understand the importance of liver functions and gastric functions and diagnosis of their disorders.*
- *understand the role of various enzymes in disease diagnosis, prognosis and assessment of response therapy.*

SEMESTER – II

Skill Enhancement Course
SEC2 (A)
QUALITY CONTROL AND ASSURANCE IN MICROBIOLOGY

Credits: 3

Total hours:45

Course Objectives:

The objective of the course includes i) to learn basics about good laboratory practices ii) to understand the role of quality control and quality assurance in microbiology and iii) finally to learn the various microbial standards for food and water.

Unit I **9 hours**

Good laboratory practices (GLPs) – Management of laboratory hazards and knowledge in First aid procedures. Quality assurance – Introduction and overview – Definition, Designing of microbiology laboratory – Quality Control and its Applications.

Unit II **9 hours**

Quality assessment of Equipment, Chemicals, Glass wares and Laboratory environments–Variance – Quality control calculations – Quality management – Maintenance of record sand reports.

Unit III **9 hours**

Quality assurance in Sterilization and Disinfection - Preservation of stock cultures, media and diagnostic kits – Quality control of media and stains.

Unit IV **9 hours**

Quality assessment of Disposal, Decontaminated matters and other biological effluents. Quality management in transportations of cultures. National control of Biological references and standards. Microbial quality control of pharmaceutical products.

Unit V **9 hours**

Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations. Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water.

Text Books

1. Philip Kotler R. (2014). Quality assurance of pharmaceuticals: A compendium of guidelines and related materials. Volume 2. Prentice Hall, Delhi.
2. W. B. Hugo and Russel A. D. (2007). Pharmaceutical Microbiology. 4th Edn. Blackwell Scientific Publications, New Jersey.

Reference Books

1. Baird R.M., Hodges N.A and Denyer S.P. (2019). Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices. CRC Press. USA.
2. Dr Norman Hodges and Professor Geoffrey Hanlon (University of Brighton) (2013). Industrial Pharmaceutical Microbiology, Vol I & Vol II: standards & controls. Wiley - Blackwell Publication, New Jersey.
3. Madigan M.T. (2017). Brock Biology of Microorganisms. 14th Edn. Pearson-Prentice Hall, USA.

Course Outcome:

On completion of the course, the student will be able

- *to understand the good laboratory practices (GLPs)*
- *equip themselves with quality control and quality assurance in Microbiology*
- *gain knowledge on handling, storage, preservation, experimentation, analysis and documentation.*
- *Gain understanding on microbial standards for food and water*

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SEMESTER – II

Skill Enhancement Course
SEC2 (B)
BIOREMEDIATION

Credits: 3

Total hours:45

Course Objectives:

The objective of the course includes i) to learn basics about bioremediation and its types, ii) to understand the role of different microbes in bioremediation, and iii) finally to learn the mechanism behind bioremediation of environmental pollutants.

Unit- I **9 hours**

Introduction to Bioremediation: Types of Bioremediation, Factors affecting Bioremediation, Limitations in Bioremediation, Bioremediation Techniques: *In situ* and *Ex situ* bioremediation techniques.

Unit - II **9 hours**

Microbes for bioremediation – Bacteria, algae and fungi; Role of plasmids in bioremediation; Gene manipulation in creation of new strains; Phytoremediation.

Unit - III **9 hours**

Mechanism of bioremediation - Metabolic pathways for the degradation of xenobiotics; Bioprocess design – Optimization; Problems associated with biotreatment studies; Quantification of biodegradation.

Unit - IV **9 hours**

Bioremediation of pollutants in soil and effluents; Bioreactors - Advantages and disadvantages; Biodegradation of oil spill in marine environment, Biosurfactants; Biosorption of heavy metals.

Unit- V **9 hours**

Anoxic bioremediation; Fermentation; Anaerobic bioremediation of Hydrocarbons, Phenols, Chlorinated phenolic compounds, Polycyclic Aromatic Hydrocarbon (PAH), Dyes and Radioactive wastes.

Text book

1. Rajendran P and Gunasekaran P. (2011). Microbial Bioremediation. MJP Publishers. Chennai, India.

Reference books

1. Ram Chandra (2015). Advances in Biodegradation and Bioremediation of industrial wastes. CRC Press
2. Pandey V. C. and Singh. V. (2020). Bioremediation of Pollutants. Elsevier.
3. Pepper I., Gerba C. and Gentry T. (2015). Environmental Microbiology. 3rdEdn. Academic Press. p.728.

Course Outcome:

- *Upon successful completion of the course, the student will*
- *Understand Bioremediation and its types*
- *List the microbes involved in Bioremediation*
- *Know the mechanisms of Bioremediation*
- *Understand the Bioremediation practices to treat soil and water pollution*
- *Know the anaerobic treatments for different wastes*

SEMESTER – II

Skill Enhancement Course
SEC2(C)
VERMITECHNOLOGY

Credits: 3

Total hours:45

Course Objectives:
The objective of the course includes i) to gain knowledge on the history of vermitechnology and its economic importance, ii) to understand vermiculture and its culture methods, and iii) finally to gain insight on the applications of vermiculture and its future prospects.

Unit- I **9 hours**

Vermitechnology - Definition, history, growth and development in other countries and in India. Economic importance of Earthworms: In sustainable agriculture, organic farming, earthworm activities, soil fertility and texture, soil aeration, water impercolation, decomposition and moisture, bait and food.

Unit- II **9 hours**

Vermiculture – definition, scope and importance; common species for culture; Environmental parameters; culture methods – wormery – breeding techniques; indoor and out door cultures - monoculture and polyculture – merits and demerits.

Unit- III **9 hours**

Vermicomposting of wastes in field pits, ground heaps, tank method, roof shed method, static pile windrows, top fed windrows, wedges & bin method, harvesting the compost, storage, Vermiwash-Preparation and application.

Unit- IV **9 hours**

Applications of vermiculture – Vermiculture bio-technology, vermicomposting, use of vermicastings in organic farming / horticulture, earthworms for management of municipal / selected biomedical solid wastes; as feed / bait for capture / culture fisheries; forest regeneration.

Unit- V **9 hours**

Future perspectives – Predator / pathogen control in wormeries; Potentials and constraints for vermiculture in India. Marketing the products of vermiculture – quality control, market research, marketing techniques – creating the demand by awareness and demonstration, advertisements, packaging and transport, direct marketing.

Text Books

1. Sultan Ahmed Ismail (2005). The Earthworm Book, Second Revised Edition. Other India Press, Goa, India.

2. Bhatnagar and Patla (2007). Earthworm vermiculture and vermi-composting, Kalyani Publishers, New Delhi

Reference Books

1. Mary Violet Christy (2008). Vermitechnology, MJP Publishers, Chennai.

2. Aravind Kumar (2005). Verms and Vermitechnology, A.P.H. Publishing Corporation, New Delhi.

3. Edwards, C.A & J.R Lofty Vermicology – The Biology of earthworm, 1997 Chapman & Hall Publications N.Y.U.S.A.

Course Outcome:

Upon successful completion of the course, the student will

- *Gain insight on the history and economic importance of vermitechnology.*
- *understand vermiculture and its culture methods,*
- *gain insight on the applications of vermiculture*
- *gain insight on vermicomposting*
- *gain knowledge on the future perspective of vermitechnology.*

SEMESTER – III

Major Disciplinary Course
MJD3
MOLECULAR BIOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

The objective of exposing the molecular biology paper in this programme is (i) to understand the historical discoveries that shaped the molecular biology such as DNA discovery (ii) to appreciate the central dogma of molecular biology including transcription and translation (iii) to recognize the role of mutation in shaping the stability of life forms during the course of evolution

Unit-I **9 hours**

History of molecular biology, DNA and RNA as genetic materials, experiments of Griffith, Avery, Macleod and McCarty. Hershey and Chase, Leaderberg and Tatum, Chargaff's principles, primary and secondary structure of DNA and RNA. Alternative forms of DNA double helices – types of RNA.

Unit-II **9 hours**

DNA replication in prokaryotes: Replicons – models of DNA replication– origin and termination of replication – rolling circle replication – proof for semi conservative replication (Meselson and Stahl Experiment) – enzymes and proteins involved in DNA replication (nucleases, polymerases, ligases, helicases, gyrases, single strand binding protein, replisome and primosome) – mechanism of semi discontinuous replication.

Unit-III **9 hours**

Steps involved in transcription of prokaryotes, promoters, transcription factors, RNA polymerases I, II and III – ribosomal RNA transcription and processing – genetic code, deciphering the genetic code, characteristics of genetic code, Wobble hypothesis, central dogma of life and reversal of central dogma.

Unit-IV **9 hours**

Steps involved in translation of prokaryotes– role of proteasomes in protein degradation – mechanism of action of antibiotics on protein synthesis (puromycin, chloramphenicol and streptomycin). Regulation of gene expression in prokaryotes – polycistronic mRNA and operons (*lac* operon and *trp* operon and attenuation mechanism).

Unit-V **9 hours**

Mutation: spontaneous and induced mutations–UV and X - rays –mechanism of action of base analogues, alkylating agents, intercalating agents and teratogens – reversion suppressor mutations and mutation rate – repair of damaged DNA – excision repair, SOS, photoreactivation.

Unit-VI **30 hours**

Practical: Introduction to molecular biology laboratory techniques and development skills - Elaboration of DNA and RNA structure and forms using micrograph or animation - Working on Agarose gel electrophoresis - DNA isolation from bacteria, *E .coli* - DNA estimation – UV irradiation – Transformation (demonstration).

Text Books

1. Verma P.S. and Agarwal V.K. (2016). Cell Biology (Cytology, Biomolecules, Molecular Biology), Paperback, S. Chand and Company Ltd**.**
2. McLennan A., Bates A., Turner P. and White M. (2012). Bios Instant Notes Molecular Biology, 4th Edn. Taylor & Francis.

Reference Books

1. Watson J.D., Baker T.A., Bell S.P., Gann A., Levine M., Losick R. and Harrison S.H. (2014). Molecular Biology of Gene, 7th Edn. Pearson Benjamin-Cummings.
2. Cox M.M., Doudna J.A. and O'Donnell M. (2012). Molecular biology: Principles and Practice, WH Freeman and Company.
3. Lodish H., Berk A., Kaiser C.A., Krieger M., Bretscher A., Ploegh H., Amon A. and Martin K.C. (2016). Molecular Cell Biology, 8th Edn. WH Freeman and Company.

Course Outcome:

Upon successful completion of the course the candidate will

- *comprehend the history behind the development of molecular biology*
- *acquaint oneself with the knowledge on DNA replication in prokaryotes.*
- *understand the steps involved in transcription of prokaryotes.*
- *understand the steps involved in translation of prokaryotes.*
- *understand the basis of spontaneous and induced mutation.*

SEMESTER – III

Major Disciplinary Course
MJD4
FOOD MICROBIOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:
An application oriented paper of microbiology, main objectives are (i) to apprise the biology and epidemiology of food borne organisms (ii) to understand about the various principles behind the preservation of food (iii) to appreciate the role of microbes in fermented foods.

Unit – I **9 hours**

Food as a substrate for microorganisms – microorganisms important in food microbiology: molds, yeasts and bacteria – factors affecting the growth of microorganisms in food.

Unit – II **9 hours**

Principles of food preservation: general principles and application methods – asepsis, removal of microorganisms, anaerobic conditions, high temperature, low temperature, drying and food additives.

Unit – III **9 hours**

Spoilage of food: vegetables, eggs, milk and milk products, meat and meat products, fish and sea foods.

Unit – IV **9 hours**

Fermented foods: pickled cucumber, sauerkraut, cheese, fermented dairy products – acidophilus milk, kefir, koumiss, yogurt, buttermilk.

Unit – V **9 hours**

Food borne infections and intoxications: bacterial infection and bacterial intoxication – microbiology in food sanitation – sewage and waste treatment and disposal – good manufacturing practices – hazard analysis – employee health standards.

Unit – VI **30 hours**

Practical: Bacterial counts of food samples – Quantitative analysis of milk by standard plate count method – Isolation and counting of fecal bacteria in water – Test of quality of milk by methylene blue dye reduction test – Isolation of microorganisms from curd – Isolation of bacteria and fungi from spoiled food – Microbial populations in fruit juices, soft drinks and ice cream.

Text Books

1. Frazier W.C. and Westhoff D.C. (2008). Food Microbiology, 4thEdn. Tata McGraw Hill Publishing Co., New Delhi.
2. Bamforth C.W. and Cook D.J. (2019). Food, Fermentation and Microorganisms, Wiley Blackwell publishers, 2nd Edn. p.262.

Reference Books

1. Doyle M.P. and Buchanan R.L. (Ed.) (2013). Food Microbiology: Fundamentals and Frontiers, 4th Edn. ASM press.
2. Jay J.M., Loessner M.J. and Golden D.A. (2005). Modern Food Microbiology, 7th Edn. Springer Publishers.
3. Robinson R.K. (2002). Dairy Microbiology: Milk and Milk Products, 3rd Edn. Wiley Publishers.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the factors affecting the growth of microorganisms in food.*
- *gain knowledge on the principles of food preservation.*
- *gain understanding on the spoilage of various foods.*
- *have knowledge on fermented foods and fermented dairy products.*
- *understand food borne infections, intoxications, microbiology in food sanitation, sewage and waste treatment, disposal and hazard analysis.*

SEMESTER – III

Minor Disciplinary Course
MID3
ECONOMIC AND MEDICAL ENTOMOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

The objectives are (i) to impart a basic knowledge about the beneficial insects to human kind (ii) to appreciate the importance of pest management strategies (iii) to develop an understanding over the various types of pests attacking the crop plants and human disease vectors.

Unit-I **9 hours**

Classification of insects according to Order –Pests of crops: any three pests for each crop, their life cycle and control measures: food crops – rice, sorghum; pulses – red gram, black gram; cash crops – sugarcane; fibre – cotton; oilseeds – groundnut, coconut.

Unit-II **9 hours**

Pests of stored products, their life cycle and control: beetles – red grain beetle; rice weevil, paddy bore beetle, carpet beetle; moths – paddy grain moth, rice meal worm. Termites and their control – insect vectors of plant diseases and their control.

Unit-III **9 hours**

Beneficial insects: honeybee, silkworm, lac insects – their biology, life cycle and uses to humankind. Insect predators, parasites and parasitoids that destroy crop pests and other harmful insects of human live stocks.

Unit-IV **9 hours**

Principles of insect pest management using physical mechanical, biological, chemical and legal methods. Classification of pesticides and their formulations, both inorganic and organic – mode of their action. Biocides and their efficacy – a brief outline – precautions in handling pesticides and environmental pollution.

Unit-V **9 hours**

Vector borne human diseases– mechanisms of transmission – types of vectors and their identification. (tsetse flies, black flies, sand flies, ticks, mites, lice, bed bugs, fleas, mosquitos) – vector borne disease, mode of infection and control – lyme disease– typhus – Equine infectious anaemia – Chagas disease.

Unit-VI **30 hours**

Practical: Collection, preservation and display of insects (representing any 15 insect orders) – External morphology of an insect (e.g. grasshopper) – Demonstration of Insects metamorphosis – Life cycle of honey bee; beehive and their parts – Collection, observation and importance of crop pests – Collection, observation and importance of storage pests – Collection of medically important pests and understanding their role in human diseases.

Text Books

1. David B.V. and Ramamurthy V.V. (2016). Elements of Economic Entomology, Paperback, 8th Edn. Brillion Publishing.
2. Shukla A. (2009). A Handbook Economic Entomology, Daya Publishing House.

Reference Books

1. Prasad T.V. (2015). Handbook of Entomology, 3rd Edn. New Vishal Publications.
2. Riley W.A. (2017). Handbook of Medical Entomology (Classic Reprint), Forgotten Books.
3. Dhooria M.S. (2008). Ane's Encyclopedic Dictionary of General and Applied Entomology, Ane's Books India, Co published by Springer, Netherlands.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the classification of insects according to Order, pests of crops, their life cycle and control measures.*
- *be able to gain knowledge on pests of stored products, their life cycle and control measures.*
- *be familiar with the beneficial insects, harmful insects of human live stocks.*
- *be able to understand the principles of insect pest management.*
- *have acquired knowledge on vector borne diseases.*

SEMESTER – III

Skill Enhancement Course
SEC3 (A)
BIOINOCULANTS PRODUCTION

Credits: 3

Total hours: 45

Course Objectives:

The objectives of the course include (i) to impart a basic knowledge on the concept and significance of bioinoculants. (ii) to appreciate the mass cultivation of bioinoculants (iii) to develop an understanding on biopesticides, bioherbicides, bioinsecticides. (iv) to gain knowledge on small and large scale strategies of bioinoculants.

Unit-I **9 hours**

Concept and significance of bioinoculants. Types of bioinoculants. General account on asymbiotic, symbiotic nitrogen fixing bacteria, phosphate solubilizing bacteria and mycorrhizae.

Unit-II **9 hours**

Mass cultivation and application of cyanobacteria, *Azospirillum, Azotobacter*, *Rhizobium*, *Azolla* and *Mycorrhizal* bioinoculants.

Unit-III **9 hours**

Concept and significance of biopesticides. Types and their application. Bioherbicides and bioinsecticides. Integrated pest management.

Unit-IV **9 hours**

Mass production and application of herbal, bacterial, fungal and viral biopesticides. Methods of making bio-compost, vermicompost and its application.

Unit-V **9 hours**

National and International scenario of bioinoculants. Quality control, storage and marketing, small and large-scale strategies of bioinoculants.

Text Books

1. Dubey R.C. (2014). A Text book of Biotechnology. 5th Edn. Chand & Company Pvt Ltd. New Delhi, India.
2. Kumaresan V. (2013). Biotechnology, 6th Edition, Saras Publications Pvt Ltd, Nagercoil, Tamil Nadu, India.
3. Subba Rao N.S. (2019). Biofertilizers in Agriculture and Forestry, 3rd Edition. CBS Publishers and Distributors Pvt Ltd, New Delhi, India.

Reference Books

1. Bhattacharya D.P. and Purohit P. (2012). Organic Farming: Biocontrol and Biopesticide Technology, 1st Edition, Agrobios, Jodhpur, Rajesthan, India.
2. Sadasivam K, Kumar K and Govindarajan K. (2004). Biofertilizers Technology, 1st Edition, Scientific Publishers Pvt Ltd, Chennai, India.
3. Dixon, G.R., Tilston and Emma L. (2010). Soil Microbiology and Sustainable Crop Production, Springer publisher.
4. Eldor Paul.(2015). Soil Microbiology, Ecology and Biochemistry, fourth edition, Acadmic Press,Wyman St.,Waltham.

Course Outcome:

Upon successful completion of the course the candidate will be able to

- *understand the concept and significance of bio-fertilizers.*
- *gain an understanding on Mass cultivation and application of bioinoculants.*
- *demonstrate the skills on mass production of different bio-pesticides.*
- *have acquired knowledge on quality maintenance and marketing strategies of bio-fertilizers.*

SEMESTER – III

Skill Enhancement Course
SEC3 (B)
DIAGNOSTIC MICROBIOLOGY

Credits: 3

Total hours: 45

Course Objectives:

The objectives of the course include (i) to acquire knowledge on the importance of diagnosis of various diseases (ii) to understand the collection and transport of clinical specimens. (iii)to understand the direct microscopic methods and culture which helps in diagnosis (iv)to gain knowledge on the serological and molecular methods in diagnosis. (v) to understand the antibiotic sensitivity testing of bacteria in diagnosis.

Unit-I **9 hours**

Importance of diagnosis of diseases –bacterial, viral, fungal and protozoan Diseases of various human body systems – Disease associated clinical samples for diagnosis.

Unit-II **9 hours**

Collection of clinical samples – oral cavity, throat, skin, Blood, CSF, urine and faeces and precautions required. Method of transport of clinical samples to laboratory and storage.

Unit-III **9 hours**

Direct Microscopic Examination And Culture – Examination of samples by staining - Gram stain, Ziehl-Neelson staining for tuberculosis, Giemsa stain, Thin blood film for malaria, Preparation and use of culture media – Blood agar, Chocolate agar, Lowenstein-Jensen medium, Mac Conkey agar, Distinct colony properties of various bacterial pathogens.

Unit-IV **9 hours**

Serological and Molecular Methods in diagnosis – Agglutination, Precipitation, ELISA and PCR. Kits for rapid detection of Typhoid, Dengue, HIV and Swine flu.

Unit-V **9 hours**

Testing for antibiotic sensitivity in bacteria – Importance, Determination of resistance/sensitivity of bacteria using disc diffusion method, Determination of minimal inhibitory concentration (MIC) of an antibiotic by serial dilution method.

Text Books

1. Ananthanarayan R and Paniker C.K.J. (2009). Textbook of Microbiology, 8th edition, Universities Press Private Ltd.
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013). Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Randhawa, VS, Mehta G and Sharma K.B. (2009). Practicals and Viva in Medical Microbiology 2nd edition, Elsevier India Pvt Ltd

Reference Books

1. Patricia M. Tille (2021). Bailey & Scott's Diagnostic Microbiology 15th edition, Elsevier Publication.
2. Gary W. Procop, Deirdre L. Church, et al. (2020). Koneman's Color Atlas and Textbook of Diagnostic Microbiology, 7th edition, Jones and Bartlett Publishers, Inc.
3. Connie R. Mahon MS MT (ASCP) CLS and Donald C. Lehman (2018). Textbook of Diagnostic Microbiology, 6thedition, Elsevier Publication.
4. Maria Dannessa Delost (2014). Introduction To Diagnostic Microbiology for The Laboratory Sciences, Jones and Bartlett Publishers, Inc.

Course Outcome:

Upon successful completion of the course the candidate will be able to

- *understand the details of diagnosis of diseases.*
- *understand the importance of collection of clinical samples.*
- *understand in depth Microscopic examination of microbes.*
- *specify the details of Testing for antibiotic sensitivity in bacteria.*

SEMESTER – III

Skill Enhancement Course
SEC3(C)
MICROBIAL FOOD SAFETY

Credits: 3

Total hours: 45

Course Objectives:

The objectives of the course includes (i) to learn about different microorganisms in food, (ii) to study microbial food spoilage, (iii) to understand various techniques on food preservation and food safety management tools.

Unit-I **9 hours**

Microorganisms in food – Classification, Morphology of microorganisms in food – Importance in food (bacteria, fungi, yeasts and viruses), Significance of spores, Microbial Growth in Food– Bacterial growth curve, Factors affecting the growth of microorganisms in food.

Unit-II **9 hours**

Determining Microbes in Food – Culture and microscopic methods - Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical and immunological methods – Limulus lysate test for endotoxin, Molecular methods - Nucleic acid probes, PCR based detection, biosensors.

Unit-III **9 hours**

Enumeration techniques and control of microorganisms in foods: Qualitative and quantitative methods-conventional as well as rapid, Principles and methods of preservation (thermal and non thermal),Introduction to Hurdle Technology.

Unit-IV **9 hours**

Introduction to Food Safety: Definition, Types of hazards, biological, chemical, physical hazards, Factors affecting Food Safety. Hygiene and Sanitation in Food Service Establishments: Sources of contamination, Control methods using physical and chemical agents, Waste Disposal, Pest and Rodent Control.

Unit-V **9 hours**

Food Safety Management Systems: Basic concept, Prerequisites, HACCP, ISO series, TQM and Risk Analysis. Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water.

Text Books

1. Andres Vasconcellos J. (2005). Quality Assurance for the Food industry - A practical approach. CRC press.
2. Jay, James M. (2000) Modern Food Microbiology, CBS Publication, New Delhi

Reference Books

1. Harrigan W.F. (1998). Laboratory Methods in Food Microbiology, 3rd Edn. Academic Press
2. Garg N., Garg K.L. and Mukerji K.G. (2010). Laboratory Manual of Food Microbiology I. K: International Publishing House Pvt. Ltd., New Delhi.
3. Jay J.M., Loessner M.J. and Golden D.A. (2005). Modern Food Microbiology, 7th edition. Springer.

Course Outcome:

Upon successful completion of the course the candidate will be able to

- *understand microbial growth in food.*
- *determine the microbes in food.*
- *understand various techniques to control microbes in food.*
- *understand food safety and hygiene, types of hazards associated with food.*
- *understand current food regulations and food safety management systems.*

SEMESTER – IV

Major Disciplinary Course
MJD5
BACTERIAL PHYSIOLOGY AND METABOLISM

Credits: 3+1(P)

Total hours: 75

Course Objectives:

The objective of this course is (i) to gain knowledge about the types and role of nutrients in bacterial metabolism (ii) to provide a basic understanding about the transport of nutrients in cells (iii) to appreciate the anabolic and catabolic pathways which lies central to bacterial metabolism.

Unit–I **9 hours**

Nutritional classification of microorganisms – importance of various macro, micro elements and growth factors – Microbial growth – turbidometry and nephlometery. Continuous culture – synchronous culture – sporulation.

Unit-II **9 hours**

Transport of nutrients – uptake of nutrient – passive diffusion – facilitated diffusion – active transport (periplasmic binding protein and ABC transport) simple transport (uniport, symport and antiport) – group translocation and protein export system. Role of osmoregulatory proteins – permiomics.

Unit–III **9 hours**

Biosynthesis of cell structures from glucose (cell wall, capsule, flagella structure and synthesis, cell inclusions) – biochemistry of nitrogen fixation – nitrogenase enzyme – nitrogen assimilation – sulfate assimilation – Anaplerotic reactions in the catabolic pathways.

Unit–IV **9 hours**

Photosynthesis – characteristics and metabolism of autotrophs, anoxygenic photosynthetic bacteria and cyanobacteria – CO_2 fixation and mechanism of photosynthesis – chemotlithotrophs – hydrogen bacteria – nitrifying bacteria, sulphur bacteria and iron bacteria – methanogens – methylotrophs.

Unit–V **9 hours**

Central catabolic pathways – glycolysis, hexose monophosphate pathway, Entner Doudoroff pathway, tricarboxylic acid cycle – electron transport system–components – adenosine tri phosphate structure and their generation types – fermentations – types – anaerobic respirations.

Unit–VI **30hours**

Practical – Determination of growth curve of bacteria – Bacterial population count by turbidity method – Estimation of fungal growth by gravimetric estimation – Effect of temperature on bacterial growth – Effect of pH on bacterial growth – Biochemical characterization of bacterial cultures: catalase, urease, cytochrome oxidase and sugar fermentation, citrate utilization, gelatin liquefaction, sulfide indole motility test, Nitrification and denitrification by bacteria.

Text Books

1. Drummond J.T., White D. and Fuqua C. (2012). The Physiology and Biochemistry of Prokaryotes, 4thEdn. Oxford University Press.
2. Kim B.H. and Gadd G.M. (2008). Bacterial Physiology and Metabolism, Cambridge University Press.

Reference Books

1. Schaechter M. (Ed.) (2009). Physiology In: Encyclopedia of Microbiology, 3rd Edn. Academic Press.
3. Moat A.G., Foster J.W. and Spector M.P. (2002). Microbial Physiology, 4th Edn. Wiley-Liss Publishers.
2. Rosenberg E., Delong E.F., Lory S., Stackebrandt E. and Thompson F. (2013). The Prokaryotes: Prokaryotic Communities and Ecophysiology, 4th Edn. Springer Reference.

Course Outcome:

Upon successful completion of the course the candidate will

- *be familiar with the different nutritional classification of bacteria with an in depth knowledge on bacterial growth, growth curve and measurement of microbial growth.*
- *be able to get acquainted with different transport systems.*
- *have an added knowledge on biosynthesis of cell structures and physiology of nitrogen fixation.*
- *have got acquainted with carbon dioxide fixation and mechanism of photosynthesis.*
- *have acquired knowledge on central catabolic pathways.*

SEMESTER – IV

Major Disciplinary Course
MJD6
VIROLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

This course exposes the students (i) to learn about the classification of various types of viruses (ii) to familiarize about the replication and morphological features of the viruses (iii) to impart knowledge about the mode of transmission, multiplication, infection and control of commonly occurring viruses.

Unit - I **9 hours**

General properties – structural – classification – cultivation – isolation and identification of animal viruses, plant viruses, bacterial, algal and fungal viruses and insect viruses.

Unit - II **9 hours**

Eukaryotic DNA virus replication, eukaryotic RNA virus replication. Viral propagation – chick embryo and cell lines. Purification and assay. Laboratory diagnosis of viral diseases. Viral vaccines, interferons and antiviral drugs.

Unit - III **9 hours**

Morphology, classification, characteristics pathogenicity, laboratory diagnosis, prevention and control of infections produced by the following group of viruses. Adeno virus, Pox virus, Herpes virus, Papilloma virus, viral Hepatitis, Ebola and Zika viruses.

Unit – IV **9 hours**

Morphology, classification, characteristics pathogenicity, laboratory diagnosis, prevention and control of infections produced by the following group of viruses. Polio, HIV, Picorna viruses, Influenza and Rhabdo viruses. T even and T odd phages, viriods and prions.

Unit – V **9 hours**

Arbo viruses: Flavi viruses – Yellow fever viruses – Dengue virus – Chickungunya virus – Japanese encephalitis virus.

Unit - VI **30 hours**

Practical– Isolation of bacteriophage from sewage sample – Preparation of bacteriophage stock – Titration of bacteriophage – One step growth of bacteriophage – Plaque assay – Chick embryo inoculation (demonstration) – Study of plant viral symptoms (demonstration) – Study of disease symptoms caused by viroids (demonstration) – Animal inoculation (demonstration).

Text Books

1. Singh V. (2010). Text book of Virology, 1st Edn. IBDC publishers.
2. Oarsman S.N.J., van Zyl G.U., Nutt L., Anderson M.I. and Preiser W. (2012). Virology Illustrated colour text, 1st Edn. Elsevier Health Sciences.

Reference Books

1. Carter J. and Saunders V. (2013). Virology: Principles and Applications (paperback) 2nd Edn. Wiley-Blackwell Publishers.
2. Dimmock, N.J., Easton A.L. and Leppard, K.N. (2007). Introduction to Modern Virology. 6th Edn. Blackwell Publishing Ltd.
3. Flint, S.J., Enquist, L.W., Krug, R.M., Racaniello V.R. and Skalka A.M. (2004). Principles of Virology, Molecular Biology, Pathogenesis and Control, 2nd Edn. ASM press Washington DC.

Course Outcome:

Upon successful completion of the course the candidate will

- *have learnt about the general properties, classification and cultivation of viruses.*
- *be conversant in eukaryotic DNA and RNA virus replication, viral propagation and laboratory diagnosis of viral diseases.*
- *have gained an insight on the spectrum of diseases caused by viral pathogens and their control*

SEMESTER – IV

Major Disciplinary Course
MJD7
RECOMBINANT DNA TECHNOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

This course serves as an extension of molecular biology paper as its practical application, the specific objectives are (i) to get introduced about the concept of recombinant DNA (rDNA) technology (ii) to appreciate the types and role of vectors in rDNA technology (iii) to know the steps in gene library construction (iv) to translate the rDNA basics as application in various fields.

Unit - I **9 hours**

Introduction to recombinant DNA technology –tools for rDNA technology –DNA manipulative enzymes: restriction enzymes, ligases, polynucleotide kinase, phosphatase, cutting of DNA molecules – joining of DNA molecules – homopolymer tails, linkers, adapters.

Unit - II **9 hours**

Gene cloning vectors: salient features, plasmids – properties, types, pBR322 and pUC18, bacteriophage vectors –λ, λZAP, cosmids, artificial chromosomes – BAC, YAC, MAC. Cloning bovine somatotropin gene in *E. coli*.

Unit - III **9 hours**

Transformation of r-DNA into target host organisms: calcium chloride mediated gene transfer, *Agrobacterium* mediated DNA transfer, electroporation, microinjection, particle gun bombardment. Screening and selection of recombinant host cells: blue/white screening.

Unit - IV **9 hours**

Construction of gene libraries: genomic and cDNA libraries. Blotting techniques, polymerase chain reaction (PCR) and its applications.

Unit – V **9 hours**

Applications of rDNA technology in industry, medicine, agriculture and pharmacy.

Unit – VI **30 hours**

Practical – Agarose gel electrophoresis – Isolation of total bacterial DNA – Isolation of yeast DNA – Isolation of DNA from red blood cells – Isolation of plasmid DNA – Restriction digestion – Ligation – Production of competent *E. coli* cells – Transformation of bacteria and isolation of transformants.

Text Books

1. Primrose S.B. and Twyman R.M. (2006). Principle of Gene Manipulation and Genomics, 7th Edn. Blackwell Publishing.
2. Nicholl D.S.T (2008). An Introduction to Genetic Engineering, 3rdEdn. Cambridge University Press.

Reference Books

1. Brown T.A. (2016). Gene Cloning and DNA Analysis – An Introduction, 7thEdn. Wiley-Blackwell.
2. Glick B.R. and Patten C.L. (2017). Molecular Biotechnology. Principles and Application of Recombinant DNA, 5th Edn. ASM Press, Washington.
3. Watson J.D., Gann A., Baker T.A., Levine M., Bell S.P. and Losick R. (2014). Molecular Biology of Gene, 7thEdn. Pearson publishers.

Course Outcome:

Upon successful completion of the course the candidate will

- *get acquainted with the basic tools used in recombinant DNA technology.*
- *understand the different gene cloning vectors.*
- *have learnt the techniques in transformation of recombinant DNA into target host organisms.*
- *understand the construction of gene libraries, blotting techniques and PCR.*
- *understand the various applications of recombinant DNA technology in various fields.*

SEMESTER – IV

Minor Disciplinary Course
MID4
PLANT PATHOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

An application oriented paper of microbiology focuses with primary objectives for (i) understanding the disease triangle with emphasis on disease cycle and pathogenicity (ii) identifying the role of virulence factors and their impact as physiological response (iii) imparting knowledge on the common plant diseases from the stand point of etiological agents.

Unit- I **9 hours**

Concept of plant disease – Importance, definitions of disease, concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases. Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

Unit-II **9 hours**

Stages in development of a disease – Infection, invasion, colonization, dissemination of pathogens and perennation. Plant disease epidemiology – Concepts of monocyclic, polycyclic and polyetic diseases, disease triangle & disease pyramid, forecasting of plant diseases and its relevance in Indian context.

Unit-III **9 hours**

Virulence factors of pathogens: enzymes, toxins (host specific and nonspecific) growth regulators, virulence factors in viruses (replicase, coat protein, silencing suppressors) in disease development. Effects of pathogens on host physiological processes (photosynthesis, respiration, cell membrane permeability, translocation of water and nutrients, plant growth and reproduction).

Unit-IV **9 hours**

Concept of resistance (*r*) gene and avirulence (*avr*) gene; gene for gene hypothesis, types of plant resistance–Concepts of constitutive defense mechanisms in plants, inducible structural defenses –inducible biochemical defenses hypersensitive response (HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis related (PR) proteins, plantibodies, phenolics, quinones, oxidative bursts.

Unit-V **9 hours**

Control of Plant Diseases – Principles and practices involved in the management of plant diseases by different methods, viz. regulatory - quarantine, crop certification, avoidance of pathogen, use of pathogen free propagative material, cultural - host eradication, crop rotation, sanitation, polyethylene traps and mulches, chemical - protectants and systemic fungicides, antibiotics, resistance of pathogens to chemicals, biological - suppressive soils, antagonistic microbes-bacteria and fungi, trap plants.

Unit-VI **30 hours**

Practical – Preparing a plant pathology herbarium – Examining diseased cereal crops, pulse crops, cash crops for various disease symptoms, identification and microscopic examination – Critical examination of citrus canker symptoms from infected samples– Recognition of Pathological specimens and control measures of any 2 plant diseases.

Text Books

1. Ravichandra N.G. (2013). Fundamentals of Plant Pathology, PHI Learning Pvt. Ltd.
2. Vidyasekharan P. (2010). Principles of Plant Pathology. CBS Publishers & Distributor's.

Reference Books

1. Vidhyasekaran P. (2004). Concise Encyclopedia of Plant Pathology. CRC Press.
2. Sharma J.N., Karthikeyan G. and Sh. Mohinder Singh (2007). Fundamentals of Plant pathology. ICAR E-course.
3. Agrios G.N. (2005). Plant Pathology, 5thEdn. Elsevier Academic Press.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the concept of plant diseases.*
- *have gained understanding on disease triangle and disease pyramid.*
- *have become acquainted with the virulence factors of pathogens and effects of pathogens on host physiological processes.*
- *understand the concept of resistance and avirulence gene.*
- *gain an in-depth knowledge on basic principles of disease management.*

SEMESTER – V

Major Disciplinary Course
MJD8
PHARMACEUTICAL MICROBIOLOGY

Credits: 3+1(P)
Total hours: 75

Course Objectives:

This paper focuses on the objectives (i) to understand the basics of pharmaceutical microbiology and microbial roles in pharmaceuticals (ii) to appraise the different products of microbial origin and their role in pharmacology. (iii) to appreciate the role of secondary metabolites in pharmaceutical industry.

Unit – I **9 hours**

Introduction – Overview of products, classification of pharmacologic agents based on chemistry and source. Phytopharmaceuticals: screening tests for phytoconstituents – alkaloids and terpenoids. Three examples of commercial natural products from marine and terrestrial organisms.

Unit – II **9 hours**

Drug development: Biology guided fractionation methods: *in vitro* assay systems based on enzymes, tissue, and organ or growth inhibition. Animal models: transgenic animals, cell lines. Antimicrobial activity studies (antibacterial, antiviral, antifungal and antiparasitic activities).

Unit – III **9 hours**

Gene therapy: general introduction, *ex vivo* and *in vivo* gene therapy, potential targets for gene therapy, inherited disorders. Vaccine design and production, classification, genetically recombinant vaccines, advantages and disadvantages – examples – hepatitis B vaccines, cholera vaccines, edible vaccines, DNA vaccines – principles and mechanism.

Unit – IV **9 hours**

Immunological products: Antisera – hyper immune gamma globulin – monoclonal antibodies – uses. Recombinant proteins: strategies and genetic manipulations for overproduction of biomolecules – insulin production, production of interferons.

Unit – V **9 hours**

Other biomolecules: probiotics and neutraceuticals – economic and legal considerations in pharmaceutical biotechnology: FDA guidelines – preclinical trials, acute, sub-acute, chronic and teratogenic studies. Clinical trials – Phases I, II, III and IV. ICMR guidelines for design and conduct of clinical trials, licensing and drug control.

Unit – VI **30 hours**

Practical – Preparation of medicinal plant extracts –Sterility testing of vaccines and injections – Antibacterial activity of antibiotic preparations – Antifungal tests – Estimation of thiamine, riboflavin, ascorbic acid content of multivitamin formulations – MIC- by broth and agar dilution method – Phenol co-efficient test – Proteolytic digestion of antibodies – Analysis of digested fragments.

Text Books

1. Denyer S.P., Hodges N.A. and Gorman S.P. (2004). Hugo and Russell's Pharmaceutical Microbiology, 7th Edn. Blackwell Publishers.
2. Mehra P.S. (2011). A text book of Pharmaceutical Microbiology, IK International Publishing House.

Reference Books

1. Baird R.M., Hodges N.A. and Denyer S.P. (2005). Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, Taylor and Francis Inc.
2. Saghee M.R., Sandle T. and Tidswell E.C. (2011). Microbiology and Sterility Assurance in Pharmaceuticals and Medical devices, Business Horizons publishers.
3. Hanlon G. and Sandle T. (2015). Industrial Pharmaceutical Microbiology: Standards and Controls, Euromed Communications.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the classification of pharmacological agents.*
- *gain an insight on drug development.*
- *understand the importance of gene therapy and different types of vaccines.*
- *become familiar with immunological products, probiotics and neutraceuticals.*

SEMESTER – V

Major Disciplinary Course
MJD9
MICROBIAL DIVERSITY AND BACTERIAL PHYLOGENY

Credits: 3+1(P)
Total hours: 75
Course Objectives:
This paper exposes the students to appreciate the world of bacteria, the students will be able (i) to understand about the Big Tree of Life (ii) to provide an overview on bacterial taxonomy and Bergey's Manual (iii) to study the role played by candidate phyla.

Unit -I **9 hours**

Microbial Big Tree of Life – The domain Archaea – Bacteria –Eukaryotes – Eukaryotic tree of life – Endosymbiosis theory and the role of horizontal gene transfer in shaping of domains – Different types of microbial diversity – Importance of microbial diversity – Methods of examining microbial diversity.

Unit-II **9 hours**

Eukaryotic diversity and Bacterial phylogeny – Fungal diversity – Protist (algae and protozoa) diversity – Viral diversity – their importance and role in shaping human community. History of bacterial classification – Concept of bacterial phylogeny – Phylogenetic markers – Polyphasic taxonomy – Overall view of bacterial phyla – Bergey's Manual of Systematic Bacteriology (2^{nd}Edn.).

Unit-III **9 hours**

Archaea and Gram negatives: An overview of their ecological occurrence, morphological diversity, structural, metabolic and genetic diversity, their importance and classification of Archaeal phyla – Gram negative bacteria including cyanobacteria – Deeply branching phyla – Proteobacteria – their classes.

Unit-IV **9 hours**

Gram Positives and heterogeneous members**:** Overall view of– ecological occurrence, morphological diversity, structural, metabolic and genetic diversity, their importance and classification of phyla Firmicutes – Actinobacteria – Bacteroidetes – Spirochetes – Tenericutes (Mollicutes) – Acidobacteria – Planctomycetes – Verrucomicrobia – Chlamydia.

Unit-V **9 hours**

Uncultivated majorities: The Great Plate count anomaly – novel bacterial cultivation strategies – cultivation independent methods of assessing bacterial diversity – Candidatus status of the bacteria – Candidate phyla radiation – their importance.

Unit-VI **30 hours**

Practical: Microscopic observation of bacteria, fungi, algae, protozoa. – Isolation and observation on a Gram positive bacteria –Isolation and observation of a Gram negative bacteria – Observation of morphologically distinct cyanobacteria – Observation of morphologically distinct algal populations. Observation of fungi and their types – Comparative observation of fungi and actinobacteria – Isolation and observation of an Archaea – Demonstrating the great plate count anomaly.

Text Books

1. Brown J.W. (2015). Principles of Microbial Diversity, ASM Press.
2. Madigan M.T., Bender K.S., Buckley D.H., Sattley W.M. and Stahl D.A. (2017). Brock Biology of Microorganisms, 15th Edn. (Global Edn.) Pearson Education.

Reference Books

1. Epstein S.S. (2009). Uncultivated microorganisms, Springer-Verlag Publishers.
2. Rosenberg E., DeLong E., Lory S., Stackebrandt E. and Thompson F.(Ed.) (2013). The Prokaryotes (Total of eleven reference book series), Springer-Verlag publishers.
3. Bertrand J.C., Caumette P., Lebaron P., Matheron R., Normand P. and Sime-Ngando T. (Eds.) (2015). Environmental Microbiology: Fundamentals and Applications, Springer Publishers.
4. List of Prokaryotic Names with Standing in Nomenclature (LPSN)- Prokaryotic Nomenclature Up-to-date (PNU) merged site-https://lpsn.dsmz.de/

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the Microbial Big Tree of Life*
- *have an in-depth knowledge on different types of microbial diversity and its importance.*
- *understand bacterial taxonomy - Bergey's manual.*
- *have an understanding on uncultivated majorities and their importance.*

SEMESTER – V

Major Disciplinary Course
MJD10
MEDICAL MYCOLOGY AND PARASITOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

It is an applied microbiology related paper included with the objectives (i) to provide an overview of fungal classification. (ii) to develop an understanding over the collection, transport and detection of fungal pathogens (iii) to understand the role of medical parasitology to human kind.

Unit - I **9 hours**

General properties of fungi – morphology, taxonomy, nomenclature and classification of medically important fungi – virulence factors of fungi causing infection.

Unit -II **9 hours**

Collection, transport and processing of clinical specimens for detection of superficial, subcutaneous and systemic mycoses. Dermatophytes – *Trichophyton –Microsporum* – epidermophyton – dermatophytosis, superficial mycoses – Tinea versicolor, Tinea nigra, Black piedra , White piedra**.**

Unit -III **9 hours**

Subcutaneous mycoses – mycetoma, dimorphic fungi causing systemic mycoses – *Histoplasma capsulatum – Blastomyces dermatitidis – Coccidioides immitis – Paracoccidioides brasiliensis*. Opportunistic mycoses – Candidiasis, Cryptococcosis.

Unit –IV **9 hours**

Introduction to medical parasitology– morphology, classification, characteristics, pathogenesis, laboratory diagnosis, prevention and control of the following agents. *Entamoeba histolytica, Giardia lamblia, Trichomonas vaginalis, Trypanosoma brucei.*

Unit –V **9 hours**

Morphology, classification, characteristics, pathogenesis, laboratory diagnosis, prevention and control of the following agents. *Leishmania donovani, Plasmodium falciparum, Balantidium coli, Taenia saginata, Ascaris lumbricoides.*

Unit –VI

Practical: KOH preparation for skin scrapings for fungi –Lactophenol preparation for fungi – Germ tube test for *Candida albicans* – Wet mount preparation for *Candida* and *Cryptococcus*– Sugar fermentation and sugar assimilation test for yeasts – Cultivation of fungi and yeast on SDA or corn meal agar – Slide culture technique – Saline wet mount examinations of stool for parasites – Iodine mount examinations of stool for parasites – LPCB mount examinations of stool for parasites– Floatation sedimentation techniques for stool examination.

Text Books

1. Chander J. (2009). Text Book of Medical Mycology, 3rd Edn. Mehta Publishers.
2. Ananthanarayan R. and Kapil A. (2013). Ananthanarayan & Panicker's Text book of Microbiology, 9th Edn. Paperback, Orient Black Swan.
3. Parija S. C. (2013). Text Book of Medical Parasitology – Protozoology and Helminthology, 4th Edn. All India Publishers and Distributors, New Delhi.

Reference Books

1. Reiss E. Shadomy H.J. and Lyon G.M. (2011). Fundamental Medical Mycology, Wiley-Blackwell.
2. Brooks G., Carrol K.C., Butel J. and Morse S. (2012). Jawetz Melnick and Adelberg Medical Microbiology, 26th Edn. Lange Medical Publications.
3. Chatterjee K.D. (2009). Parasitology: Protozoology and Helminthology, 13th Edn. CBS Publishers & Distributors Pvt. Limited.

Course Outcome:

Upon successful completion of the course the candidate will

- *gain understanding on the general properties of fungi and classification of medically important fungi.*
- *gain insight on collection, transport and processing of clinical specimens for detection of fungal pathogens.*
- *have an understanding on superficial, subcutaneous, systemic and opportunistic mycosis.*
- *have a knowledge on different parasites affecting man and their control.*

SEMESTER – V

Minor Disciplinary Course
MID5
MICROBES IN HUMAN WELFARE

Credits: 3+1(P)

Total hours: 75

Course Objectives:

It is an applied microbiology related paper included with the objectives (i) to provide students with a thorough understanding of the diverse types of microbes and their roles in various ecosystems.(ii)to investigate the beneficial and detrimental impacts of microbes on human health (iii) to study the applications of microbes in industrial processes, including the production of enzymes, and biofertilizers.(iv) to examine the role of microbes in food fermentation (v) to understand the role of microbes in environmental processes like biodegradation, bioremediation, and renewable energy production(vi) to isolate, identify, and utilize microbes, and analyze experimental data to solve practical problems in microbiology.

Unit - I **9 hours**

Introduction to Microbes in Human Welfare: Overview of microbes (bacteria, fungi, viruses, protozoa, and algae) – Role of microbes in the environment – Beneficial and harmful effects of microbes on humans – Microbial ecology and symbiosis – Industrial microbiology: production of antibiotics, enzymes, and bioactive molecules.

Unit -II **9 hours**

Microbes in Agriculture: Bio-fertilizers and bio-pesticides - types and applications, beneficial microorganisms in agriculture, AM fungi, Mushroom cultivation, Biogas production. Soil microbiology: Rhizosphere, mycorrhizae, and nitrogen-fixing bacteria - Role of microbes in composting and organic matter decomposition – Role of microbes in bioremediation of polluted soils – Plant-microbe interactions and their impact on crop productivity

Unit -III **9 hours**

Food and Fermentations: Fermented Foods – Types, nutritional values and health benefits. Probiotics, prebiotics, synbiotics and nutraceuticals. Fermented Products – Alcoholic and non-alcoholic beverages.

Unit –IV **9 hours**

Microbes in Medicine: Antibiotics: discovery, types, functions and antibiotic therapy - Vaccines: history, development, and types – Microbial diagnostics: traditional and molecular methods – Microbiome and human health – Role of microbes in novel therapeutic approaches – phage therapy, fecal microbiota transplantation.

Unit –V **9 hours**

Environmental Microbiology and Biotechnology: Microbial biodegradation and bioremediation of pollutants – Waste treatment and management: role of microbes in wastewater treatment – Bioindicators and microbial monitoring of environmental health–Microbes in renewable energy production: biofuels and biogas – Extremophiles and their applications in biotechnology

Unit –VI **30 hours**

Practical: Analysis of microbial communities in soil and water samples – Microbial Fermentation – production of ethanol and organic acids – Antibiotic Sensitivity Testing – Water Quality Analysis – Isolation and identification of probiotics from food products – Production of microbial enzymes like amylase or cellulase.

Text Books

1. Ananthanarayan R. and Kapil A. (2013). Ananthanarayan & Panicker's Text book of Microbiology, 9th Edn. Paperback, Orient Black Swan.
2. Paul E.A. (Ed.) (2015). Soil microbiology, ecology and biochemistry, 4th Edn. Academic Press.
3. Frazier, W.C. and Westhoff, D.C. (1988). Food microbiology. 4th Edition. McGraw Hill NY.
4. Casida L.E. (2020). Industrial Microbiology. 1stEdition.New Age International Publishers, New Delhi, India.

Reference Books

1. Subba Rao, N.S. (1995). Soil Microorganisms and plant growth, Oxford and IBH publishing Co. Pvt. Ltd.
2. Denyer S.P., Hodges N.A. and Gorman S.P. (2004). Hugo and Russell's Pharmaceutical Microbiology 7 th edition. Blackwell scientific publications / Oxford.
3. Subba Rao, N.S. (1995). Biofertilizers in agriculture and forestry. 3rd Edition. Oxford and IBH publication Co. Pvt. Ltd., New Delhi.

Course Outcome:

Upon successful completion of the course the candidate will

- *be able to explain the diversity of microbial life and their ecological roles in various environments*
- *demonstrate an understanding of how microbes are utilized in industrial processes to produce antibiotics, enzymes and other bioactive compounds.*
- *evaluate the role of microbes in enhancing soil fertility, promoting plant growth, and managing agricultural pests through biopesticides and biofertilizers.*
- *understand the microbial processes involved in food fermentation and the use of probiotics for health benefits .*
- *discuss the significance of microbes in the development of antibiotics, vaccines, microbial diagnostics, and novel therapeutic approaches.*
- *describe the role of microbes in environmental sustainability, including biodegradation, bioremediation, wastewater treatment, and bioenergy production.*
- *apply laboratory techniques to isolate, identify, and utilize microbes, and analyze experimental data to solve practical problems in microbiology.*

SEMESTER – VI

Major Disciplinary Course
MJD11
MICROBIAL PROCESS AND PRODUCTS TECHNOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

A paper with focus on exposing industrial importance of the microbiology to students with objectives (i) to understand the role of microbes in microbial process such as pigment production (ii) to appreciate the role of microbes in aroma and flavour compound synthesis (iii) to provide students with in-depth practical experience and technical skills required to master various microbial processes involved in the production of valuable microbial products.

Unit –I **9 hours**

Scope of the subject – Importance of microbial products over chemically synthesized products – ill effects of chemicals – overall view of microbes involved in pigment, flavour and aroma production.

Unit – II **9 hours**

Biochemical and physiological basis of pigment, flavour and aroma compounds production – compound synthesis and biocatalysis – Culture dependent and culture independent methods to identify the organisms – Techniques used to identify novel potential organisms.

Unit – III **9 hours**

Bacterial pigments – prodigiosin – violacein and deoxyviolacein – fungal monascin – bacterial and algal carotenoids – astaxanthin – occurrence, isolation, chemistry and biological properties – catalysis – its applications and importance.

Unit – IV **9 hours**

Terpenes – pyrazines – lactones – esters – jasmonic acid – high bulk flavour – vanillin– Occurrence – chemical – biological significance – synthesis – biotransformation – biotechnological applications of natural and nature identical flavour and aroma compounds.

Unit – V **9 hours**

Genetic engineering in pigment, flavour and aroma production – Mass multiplication – up scaling – product recovery – purification of pigments, flavour and aroma compounds – future strategies and innovative areas of research – ethical, biosafety and legal aspects of production.

Unit – VI **30 hours**

Practical :Observation of *Dunaliella* sp.– a beta carotene producing algae – Isolation of *Monascus* sp. from soil – Pigment production by *Monascus* spp. – Mass production of pigment using *Monascus* fungal culture – Isolation of pigment producing bacteria/actinobacteria. Production of carotenoid Pigments by *Micrococcus luteus*– Biosynthesis of prodigiosin by *Serratia marcescens*– Production of pyocyanin by *Pseudomonas aeruginosa* Isolation of Beta-carotene from *Blakesleatrispora* – Vanillin production by Fermentation using Fungi – Biosynthesis of earthly smelling, Geosmin by *Streptomyces* spp. – Production of 2-phenylethanol by Yeast (*Saccharomyces cerevisiae*)

Text books

1. Margalith P.Z. (1992). Pigment Microbiology, Chapman and Hall.
2. Berger R.G. (Ed.) (2007). Flavours and Fragrances: Chemistry, Bioprocessing and Sustainability, Springer-Verlag.

Reference books

1. Berger R.G. (1995). Aroma Biotechnology, Springer-Verlag.
2. Gabelman A. (Ed.) (1994). Bioprocess production of flavour, fragrance and colour ingredients, John Wiley and Sons.
3. Lauro G.J. and Francis F.J. (2000). Natural food colourants – Science and Technology, Marcel and Dekker.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the importance of microbial products over chemically synthesized products.*
- *understand the biochemical and physiological basis of pigment, flavor and aroma compound.*
- *understand the genetic engineering in pigment, flavor and aroma production.*
- *gain understanding on ethical, biosafety and legal aspects of production.*
- *will demonstrate the capability to apply microbial processes and principles in real-world industrial settings.*

SEMESTER – VI

Major Disciplinary Course
MJD12
AGRICULTURAL MICROBIOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

A microbiological application oriented paper added with objectives (i) to appreciate the wealth of soil microbiota (ii) to appreciate the role of biochemical cycling of nutrients (iii) to know about the importance of biofertilizers and biopesticides.

Unit-I **9 hours**

Introduction to Agriculturally important microorganims – bacteria (cyanobacteria and actinobacteria), algae, fungi, protozoans, nematodes and viruses – Role of microbes in soil fertility.

Unit-II **9 hours**

Microbial associations in phytosphere: rhizosphere – phyllosphere – spermosphere. Mycorrhiza – types and importance to agriculture – organic matter decomposition – humus formation.

Unit-III **9 hours**

Biofertilizers – definition, importance – types and their application methods – Steps in mass production of bacterial biofertilizers – quality guidelines for biofertilizers.

Unit-IV **9 hours**

Mass production of blue green algae, *Azolla* and mycorrhiza – importance of liquid inoculants in crop production - Plant response to biofertilizers application.

Unit -V **9 hours**

Plant growth promoting rhizobacteria – Biological control of phytopathogens – Mechanism of control – *Trichoderma* sp. and *Pseudomonas fluorescens* as biocontrol agents – Disease suppressive soils –Biopesticide and their importance: Bacterial, fungal and viral.

Unit -VI **30 hours**

Practical: Isolation of bacteria, fungi and actinobacteria from soils – Isolation of nitrogen fixing bacteria from root nodules of legumes –Enumeration of rhizosphere to non rhizosphere population of bacteria – Isolation of antagonistic *Pseudomonas* from soil – Microscopic observations of root colonization by VAM fungi – Isolation of *Azospirillum* sp. from the roots of grasses – Isolation of phyllosphere microflora – Isolation of P solubilizing microorganisms – Observation of *Anabaena* from *Azolla* plants – Demonstration on different biofertilizers types, formulation and application methods.

Text Books

1. Sylvia D.M., Fuhrmann, J.J., Hartel P.J. and Zuberer D.A. (2005). Principles and Applications of Soil Microbiology, 2nd Edn. Pearson, Prentice Hall.
2. Subba Rao N.S. (2001). Soil Microorganisms and plant growth, Oxford and IBH Publishing Co.Pvt. Ltd.

Reference Books

1. Glick B.R. (2015). Beneficial Plant Bacterial Interactions, Springer.
2. Paul E.A. (Ed.) (2015). Soil Microbiology, Ecology and Biochemistry, 4thEdn, Academic Press.
3. Madigan M.T., Bender K.S., Buckley D.H., Sattley W.M. and Stahl D.A. (2017). Brock Biology of Microorganisms, 15thEdn. (Global Edn.) Pearson Education.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the diverse groups of microorganisms in soil and its role in soil fertility.*
- *gain knowledge on the microbial association and biogeochemical cycles.*
- *understand the role of biofertilizers and biopesticides and their importance.*

SEMESTER – VI

Major Disciplinary Course
MJD13
ENVIRONMENTAL MICROBIOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

This paper was added with the objectives (i) to enlighten students about the microbes in several ecosystems (ii) to understand varied interactions that occur within microbial communities (iii) to expose students to environmental awareness related to treatment of wastewater and importance of water quality and indicator organisms.

Unit – I **9 hours**

Environment ecosystems, food chain – niche, soil, water and air environment. Microbial interactions – symbiosis, neutralism, commensalism, synergism, mutualism, ammensalism, competition, parasitism and predation.

Unit – II **9 hours**

Aerobiology – microbes in aerosol. Allergens – assessment of quality of air – air borne diseases caused by bacteria, fungi and viruses – symptoms and preventive measures.

Unit – III **9 hours**

Microbiology of water – determination of water quality – bacteriological examination of water – indicator organisms – water borne pathogens. Microbiology of sewage – chemical and biochemical characteristics of sewage – sewage treatment and disposal of wastes.

Unit – IV **9 hours**

Biodegradation of oil, biodeterioration of materials – paint, paper, wood, leather and metal – mode of deterioration– organism involved – disadvantage and mode of prevention.

Unit – V **9 hours**

Water pollution – BOD – COD. Bioremediation, composting, bioamelioration – biofilm formation – impact on the environment. Environmental protection laws.

Unit – VI **30 hours**

Practical: Bacteriological examination of water by multiple tube fermentation tests - Water analysis for total bacterial population by standard plate count method – Isolation of cellulolytic organism for various soil – Determination of salinity of water – Estimation of oxygen by Winkler's method – Estimation of BOD of water – Estimation of COD of water – Isolation of bacteriophage from the sewage – Isolation of microorganism from air by open plate method.

Text Books

1. Atlas R.N. and Bartha R. (1992). Microbial Ecology: Fundamentals and Applications, 3rdEdn. Redwood City, CA Benjamin/Cummings.
2. Pepper I.L. and Gerba C.P. (2004). Environmental Microbiology: A Laboratory manual, 2nd Edn. Academic Press.

Reference Books

1. Pepper I., Gerba C. and Gentry T. (Ed.) (2014). Environmental Microbiology, Academic Press.
2. Madsen E.L. (2008). Environmental Microbiology: From Genomes to Biogeochemistry, Blackwell publishers.
3. Barton L.E. and Northup D.E. (2011). Microbial Ecology, Wiley-Blackwell.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the environmental ecosystem and microbial interactions.*
- *understand the microbiology of air and assessment of quality of air.*
- *have an in-depth knowledge on microbiology of water and sewage.*
- *be familiar with biodeterioration of different materials, bioremediation and environmental protection laws.*

SEMESTER – VI

Major Disciplinary Course
MJD14
MEDICAL BACTERIOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

It is one of the applied papers of microbiology and the course learning objectives are (i) to understand about the role of microbes in causing diseases (ii) to acquaint with the morphology, cultural, pathogenicity and laboratory diagnosis characteristics of common human pathogens.

Unit - I **9 hours**

Infection: definition, sources of infection, types of infections, methods of transmission of infections. General attributes and virulence factors of bacteria causing infections**.**

Unit - II **9 hours**

Collection and transport of specimens for microbiological examination. Clinical diagnosis of sexually transmitted diseases, urinary tract infections and hospital acquired infections. Methods of disposal of hospital waste.

Unit – III **9 hours**

Morphology, classification, cultural characteristics, pathogenicity, laboratory diagnosis and prevention of infections caused by the following organisms: *Staphylococcus aureus, Streptococcus pyogenes, Neisseria meningitidis, Corynebacterium diphtheriae, Clostridium tetani.*

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Unit – IV **9 hours**

Morphology, cultural characteristics, pathogenicity, laboratory diagnosis and prevention of infections caused by the following organisms: *Escherichia coli, Salmonella, Vibrio cholerae, Pseudomonas, Mycobacterium tuberculosis.*

Unit – V **9 hours**

Morphology, cultural characteristics, pathogenicity, laboratory diagnosis and prevention of infections caused by the following organisms: Zoonotic bacterial diseases such as plague, anthrax, leptospirosis, brucellosis.

Unit – VI **30 hours**

Practical: General requirements of collection, transport of clinical specimens, direct examination, staining of specimens, methods of enriched, selective, and enrichment culture techniques used to isolate organisms from clinical specimens – Simple, differential and special staining of clinical material – Isolation of microflora from human throat – Differential test of *Staphylococcus* by examining growth on agar plates – Antimicrobial sensitivity Testing – Quantitative urine culture – Isolation and identification of bacterial pathogens from clinical specimens – Biochemical tests for identification of selected pathogens.

Text Books

1. Collee, J.C., Fraser A.C., Marmion B.P. and Simmons A. (2007). Mackie & McCartney Practical Medical Microbiology, 14th Edn. Elsevier Health Sciences.
2. Ananthanarayan R. and Kapil A. (2013). Ananthanarayan & Panicker's Text book of Microbiology, 9th Edn. Paperback, Orient Black Swan.

Reference Books

1. Forbes B.A., Sham D.E. and Weissfeld A.S. (2007). Bailey and Scotts Diagnostic Microbiology 12th Edn, Mosby Publications.
2. Brooks G., Carrol K.C., Butel J. and Morse S. (2012). Jawetz Melnick and Adelberg Medical Microbiology, 26th Edn. Lange Medical Publications.
3. Greenwood D., Slack R.C.B., Barer M.R. and Irving W.L. (2012). Medical Microbiology, 18th Edn. Elsevier Churchill Livingstone.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the basis of infection and the virulence of bacteria causing infections.*
- *become acquainted with the basic concepts of collection and transport of clinical specimens.*
- *have gained knowledge on variety of bacteria causing infections and their prevention.*
- *understand zoonotic bacterial diseases and their prevention.*

SEMESTER – VI

Minor Disciplinary Course
MID5
MICROBIAL CULTURE AND CONTROL

Credits: 3+1(P)

Total hours: 75

Course Objectives

The objectives of the course include (i) to learn the basics of culture media and its types (ii) to understand various methods of culture preservation and maintenance and (iii) to know physical and chemical agents in controlling microbes.

Unit-I **9 hours**

Culture media: Classification- ingredients of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media, anaerobic media (with examples)- Microbial nutrient requirements (micro and macro) – factors affecting microbial growth– Bacterial growth curve.

Unit – II **9 hours**

Preservation and maintenance methods of microbial cultures: slant culture, stab culture, soil culture, mineral oil overlaying, refrigeration, glycerol preservation, cryopreservation, lyophilization – National and international Culture Collection Centres.

Unit-III **9 hours**

Collection and processing of samples: serial dilution – Isolation methods – spread plate method, streak plate method, pour plate method, swab culture. Enumeration methods of microorganisms: CFU, optical density, Mac Farlands scale, Total viable count, Direct microscopic count – Safety measures undertaken during culturing of microorganisms.

Unit-IV **9 hours**

Physical methods of microbial control: Heat: moist heat, dry heat, pasteurization – Filtration: membrane filters, HEPA filters – Radiation: ultraviolet, ionizing radiation – Low temperature: refrigeration, freezing – Desiccation and lyophilization.

Unit – V **9 hours**

Chemical methods of microbial control: Disinfectants and antiseptics: types and mode of action – Evaluation of antimicrobial chemicals: phenol coefficient, use-dilution test – Antibiotics: classification, mechanisms of action, resistance – Chemotherapeutic agents: sulfa drugs, antivirals, antifungals – Biofilm control and removal.

Unit-VI **30 hours**

Practical: Introduction to disinfection and discarding techniques in laboratory – Control of microorganisms using moist heat & dry heat sterilization –Preparation of media, Isolation of bacteria in pure culture by streak plate method – Study of colony and growth characteristics of some common bacteria – Enumeration of bacteria: standard plate count – Antimicrobial sensitivity test and demonstration of drug resistance – Maintenance of stock cultures: slants, stabs and glycerol stock cultures – Determination of Minimum Inhibitory Concentration (MIC) – Biofilm Formation and Control Assay.

Text Books:

1. Willey J.M., Sherwood L.M. and Woolverton C.J. (2013). Prescott's Microbiology, 9th Edn. McGraw-Hill Higher Education.
2. Madigan M.T., Bender K.S., Buckley D.H., Sattley W.M. and Stahl D.A. (2017). Brock Biology of Microorganisms, 15th Edn. (Global Edn.) Pearson Education.

Reference Books

1. Talaro K.P. and Chess B. (2012). Foundations in Microbiology, 8th Edn. The McGraw Hill Companies.
2. Tortora G.J., Funke B.R. and Chase C.L. (2013). Microbiology: An Introduction, 11th Edn. Pearson-Benjamin Cummings.
3. Brown A. and Smith H. (2015). Benson's Microbiological Applications: Laboratory Manual in General Microbiology, 13th Edn. McGraw-Hill Companies.

Course Outcome:

Upon successful completion of the course the candidate will

- *be well equipped with the microbiological techniques including culturing, enumeration of microorganisms and microbial culture preservation techniques.*
- *understand the different types of media used for the cultivation of microbes.*
- *Understand the physical and chemical methods of microbial control.*
- *be equipped with the different methods of controlling microorganisms.*

SEMESTER – VII

Major Disciplinary Course
MJD15
MICROBIOME BIOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives

*The objectives of the course include (i) to provide a comprehensive understanding on Microbiome biology (ii) to explore the methodologies used in microbiome research (iii) to analyse the interactions between microbiome and the host (iv)to understand the process of biofilm formation and analyse the role in health, disease and industry***.**

Unit-I **9 hours**

Microbiome – definition – uncultured majority – Candidatus phyla radiation – definition, History of microbiome perspective, Microbiome evolution. Earth Microbiome project.

Unit – II **9 hours**

Approaches in Microbiome analysis, Metagenomics (open and closed formats), Meta-transcriptomics, Pan-genomics, Epigenomics, Microfluidics technology to study the human microbiome, single cell genomics.Metagenomics: – definition – principles – methods - whole genome shotgun cloning – metagenomic library preparation.

Unit - III **9 hours**

Human microbiome: biodiversity and major genera of human-microbiome, human-microbiome system as a "holobiont" or "superorganism", microbiome distributions in healthy individuals; composition of specific body sites' microbiome - nose, skin, Oral, urogenital.

Unit-IV **9 hours**

Microbiome and disease biology: Dysbiosis and its role in diseases – inflammatory bowel disease (IBD), obesity, diabetes – Microbiome related therapeutic strategies – Drug delivery using microbes engineered to secrete peptides – Microbes as neuromodulators – Microbes as cancer therapeutics – impacts of antibiotics on the development of resistomes – Fecal Microbiota Transplantation (FMT).

Unit – V **9 hours**

Biofilm biology: biofilm – definition, cell-cell communication, extracellular polymeric substances (EPS), Formation of biofilms – Biofilms in health, disease and industry – Strategies for biofilm control and removal.

Unit -VI **9 hours**

Practical: Isolation and identification of gut microflora from stool samples – DNA extraction from environmental samples like soil and water – Gel electrophoresis for DNA fragment analysis – Antibiotic resistance profiling of microbiome samples – FMT in a model system – Assessment of microbial biofilm formation on surfaces.

Text Books

1. Angela E. Douglas (2018). Fundamentals of Microbiome Science – how microbes shape animal biology, Princeton University Press, New Jersey, United States.
2. Rob de Salle and Susan L. Perkins (2015). Welcome to the microbiome. getting to know the trillions of bacteria and other microbes in, on, and around you. Yale University Press.
3. Rodney Dietert (2016). The Human Superorganism: how the microbiome is revolutionizing the pursuit of a healthy life. Dutton Books.
4. Julia Segre (2020). The Human Microbiome: A New Frontier in Health and Disease. Oxford University Press. 1st edition. Oxford.

Reference Books

1. Justin Sonnenburg and Erica Sonnenburg (2014). The good gut: taking control of your weight, your mood, and your long-term health. Penguin Press.
2. Emeran Mayer (2016). The Mind-Gut Connection: How the Astonishing Dialogue Taking Place in Our Bodies Impacts Health, Weight, and Mood. eBook, Harper Wave Books.
3. Martin J. Blaser (2014). Missing Microbes: How the Overuse of Antibiotics Is Fuelling Our Modern Plagues. Harper Collins Publishers. Toronto.
4. Diana Marco (2014). Metagenomics of the Microbial Nitrogen Cycle: Theory, Methods and Applications Book: 978-1-908230-48-5. ebook: 978-1-908230-60-7, Caister Academic Press.
5. Pilar Francino, M (2012). Horizontal Gene Transfer in Book: 978-1-908230-10-2. ebook: 978-1-908230-72-0, Caister Academic Press.

Course Outcome

Upon successful completion of the course the candidate will

- *understand the concept and significance of microbiome*
- *explore the methodologies used in microbiome research*
- *to understand the concept of dysbiosis and its association with diseases*
- *to understand the process of biofilm formation and its regulation..*

SEMESTER – VII

Major Disciplinary Course
MJD16
DAIRY MICROBIOLOGY

Credits: 3+1(P)
Total hours: 75

Course Objectives

The objectives of the course include (i) to understand the microbiological aspects of milk and dairy products (ii) to learn about the methods of detecting and controlling microbial contamination in dairy processing (iii) to study the microbial processes involved in the production of fermented dairy products (iv) to develop practical skills in analyzing and ensuring the microbiological quality of dairy products.

Unit-I **9 hours**

Introduction to Dairy Microbiology: Composition and properties of milk **–** Nutritive value of milk **–** Microflora of raw milk: sources and types of microorganisms **–** Factors affecting microbial growth in milk.

Unit – II **9 hours**

Dairy Microbiology: Contamination and spoilage of milk and milk products – preservation of Milk and Milk Products – Refrigeration, Thermisation, Pasteurization – Types - LTLT, HTST, Ultra pasteurization, Sterilisation

Unit - III **9 hours**

Fermented Dairy Products - Curd - Butter milk - cheese –types – different varieties of cheese - Yogurt - Acidophilus milk - Kefir - Koumiss - sour cream, Villi.

Unit-IV **9 hours**

Milk borne diseases: bacterial – Diphtheria, Q fever, Tuberculosis, Mastitis, Viral - Foot and mouth disease, enterovirus. Fungal - *Microsporum, Aspergillus.*

Unit – V **9 hours**

Bacteriological tests for milk : MBRT test – Resazurin Reduction Test (RT) – Phosphatase milk - Standard plate count - Direct microscopic count (DMC) – Clot on Boiling (COB) test – Burri smear - Alizarin alcohol test – Lactometer test – Detection of *Staphylococcus aureus* in milk – CAMP test

Unit –VI

Practical : Preparation and Sterilization of Milk Samples - Standard Plate Count for Milk Samples Detection of Coliforms in Milk by MPN Method – Methylene Blue Reduction Test for Milk Quality– Resazurin Test for Assessing Milk Quality – Isolation and Identification of Lactic Acid Bacteria from Yogurt – Production of Yogurt using Commercial Starter Cultures– Isolation of Spoilage Microorganisms from Milk– Microbial Examination of Cheese– Examination of Milk for Phosphatase Activity– Isolation and Enumeration of Yeasts and Molds in Dairy Products– Study of Probiotic Cultures in Fermented Dairy Products.

Textbooks

1. James M. Jay, Martin J. Loessner, David A. Golden (2005). Modern Food Microbiology. Springer, 7th Edition.
2. Richard K. Robinson (2005). Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products. Wiley-Interscience, 3rd Edition.

Reference Books

1. Elmer H. Marth, James L. Steele (2001). Applied Dairy Microbiology. Marcel Dekker, 2nd Edition.
2. P. F. Fox, Paul L. H. McSweeney (2013). Advanced Dairy Chemistry Volume 1: Proteins, Parts A&B. Springer, 4th Edition.
3. Richard K. Robinson (2002). Encyclopedia of Dairy Sciences. Academic Press, 1st Edition.

Course Outcome

Upon completion of the course the candidate will be able to

- *describe the microbiological characteristics of milk and dairy products.*
- *apply techniques to detect and control microbial contamination in dairy processing.*
- *explain the microbial processes involved in the production of fermented dairy products.*
- *conduct experiments to analyze the microbiological quality of milk and dairy products and interpret the results.*

SEMESTER – VII

Major Disciplinary Course
MJD17
RESEARCH METHODOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

The objectives of this course include (i) to understand the concept behind designing the research, data collection and data analysis using statistical methods (ii)an understanding of research methodologies and their applications in microbiology (iii) to develop skills in designing and conducting scientific research (iv)to understand the basic and applied statistical methods for data analysis (v) to equip students with the ability to critically analyze and interpret scientific data.

Unit - I **9 hours**

Research: Meaning of research – Definition –Characteristics of research – Objectives – Approaches – Types – Significance.

Unit - II **9 hours**

Research Guidelines: Problem Selection and project designing – Review of literature – source of collection – processing of data– error– editing the final draft – presentation of research project.

Unit – III **9 hours**

Biological research: Institutional Ethical committee – Animal ethical committee – Use of laboratory animals in research - Laboratory animal management.

Unit - IV **9 hours**

Basic Biostatistics: Collection of data, Classification and tabulation of data – Diagrammatic representation and graphic representation of data – Scale diagram – Histogram – Frequency curve.

Unit - V **9 hours**

Applied Biostatistics: Measures of central tendency – Arithmetic mean, Median, Mode. Calculation of mean, median, mode in series of individual observation, discrete series, continuous, open end classes, measure of dispersion, standard deviation and standard error.

Unit - VI **30 hours**

Practical: Literature Review on a Microbiology Research Topic – Formulation of Research Questions and Hypotheses– Designing a Survey Questionnaire for Microbiological Research – Data Collection from Secondary Sources – Collection and Tabulation of Data – Diagrammatic Representation of Data – Creating a Histogram and Frequency Curve – Calculation of Arithmetic Mean, Median, and Mode – Calculation of Measures of Dispersion: range, variance, standard deviation, and standard error for a dataset.

Textbooks

1. C. R. Kothari, Gaurav Garg (2019). Research Methodology: Methods and Techniques. New Age International Publishers, 4th Edition.
2. Wayne W. Daniel, Chad L. Cross (2018). Biostatistics: A Foundation for Analysis in the Health Sciences. Wiley, 11th Edition.

Reference Books

1. Zina O'Leary (2017). The Essential Guide to Doing Your Research Project. SAGE Publications Ltd, 3rd Edition.
2. Ranjit Kumar (2014). Research Methodology: A Step-by-Step Guide for Beginners. SAGE Publications Ltd, 4th Edition
3. Andy Field (2017). Discovering Statistics Using IBM SPSS Statistics. SAGE Publications Ltd, 5th Edition..

Course Outcome

Upon successful completion of the course, students will be able to

- *design and conduct scientific experiments using appropriate research methodologies.*
- *apply basic and advanced statistical techniques to analyze microbiological data.*
- *interpret and critically evaluate scientific results.*
- *effectively communicate research findings through scientific writing and presentations.*
- *understand ethical considerations in scientific research.*

SEMESTER – VII

Minor Disciplinary Course
MID7
PUBLIC HEALTH MICROBIOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

This paper helps in skill enhancement with the objectives (i) to comprehend the role of microbiology in public health (ii) to discern the airborne and food borne pathogens in public health (iii) to develop an understanding over nosocomial infections.

Unit - I **9hours**

Introduction to public health: definition, scope, concept and importance of public health microbiology – roles of microbiologist in public health – microbial association of water, air and soil.

Unit - II **9 hours**

Air borne infections: air and its composition – indoor air – outdoor air – air borne diseases (bacterial, fungal and viral) – methods of enumeration of microorganisms in air

Unit - III **9 hours**

Water borne infections: kinds of water – water borne diseases (viral, bacterial, protozoan) – methods of enumeration of microorganisms in water – indicator organism – water treatment, control of water borne diseases.

Unit - IV **9 hours**

Food borne diseases: definition and importance of food hygiene – types (spoilage of meat and its products, fish and fish products and eggs) – role of microorganisms in food spoilage and poisoning – food borne diseases – types of food borne diseases

Unit - V **9 hours**

Hospital acquired infection: Prophylactic immunization – disposal of infective hospital and laboratory materials – monitoring of sanitation in community – techniques used for the diagnosis of hospital acquired infection.

Unit - VI **30 hours**

Practical: Isolation and Identification of Pathogenic Bacteria from Water Samples – Antibiotic Susceptibility Testing Using the Kirby-Bauer Disk Diffusion Method – Detection of Fecal Coliforms in Food Samples – Hand Hygiene Efficacy Test – Air Quality Testing for Microbial Contaminants – Testing for Bacterial Contamination on Common Surfaces – Detection of *Salmonella* in Food Samples – Isolation of Microorganisms from Clinical Samples like Throat Swabs etc., – Testing the Efficacy of Water Purification Methods.

Text books

1. Ghimire P. and Parajuli K. (2005). A Text Book of Microbiology, Vidhyarthi Pustak Bhandar Publication, Kathmandu.
2. Brownson, R.C., Baker, E.A., Leet T.L. and Follespie K.N. (2003). Evidence Based Public Health, Oxford University Press.

Reference books

1. Engelkirk P.G. and Duben-Engelkirk J. (2015). Burton's Microbiology for the Health Sciences, 10thEdn. Wolters Kluwer Health.
2. Park K. (2017). Parks Text Book of Preventive and Social Medicine, Banarsidas Bhanot Publishers.
3. Jay J.M., Loessner M.J. and Golden D.A. (2005). Modern Food Microbiology, 7th Edn. Springer.

Course Outcome:

Upon successful completion of the course the students will

- *understand the importance of Public Health Microbiology.*
- *have gained understanding on the air borne diseases and methods used in the enumeration of microorganisms in air.*
- *have an understanding on water borne diseases and enumeration of microorganisms in water.*
- *have a basic knowledge on food borne diseases and its types.*
- *have an understanding on hospital acquired infections.*

SEMESTER – VII

Minor Disciplinary Course
MID8
BIOINFORMATICS

Credits: 3+1(P)
Total hours: 75

Course Objectives:

Introduces the basic concepts and methods in bioinformatics. The objectives include (i) to provide knowledge about basics of computers. (ii) to provide knowledge on techniques to analyse biological data. (iii) to provide an overview on sequence analysis, structural bioinformatics and genomics.

Unit-I **9 hours**

Principles of Computing-computer hardware-system software-application of software-algorithm design and analysis-flow charts- structured and object oriented programming.

Unit-II **9 hours**

Database management systems-data processing-introduction to database management systems-database designs. Telecommunication- Introduction to telecommunications-computer networks-communication systems-distributed systems. Computer networking-uses-LAN, WAN, MODEM, Fiber Optics newtwork. Introduction to internet- WWW, NCNET, ERNET, VSNL, ISDN.

Unit-III **9 hours**

Introduction to Bioinformatics - Role of internet and www in Bioinformatics. Biological Databases- Analysis of DNA and protein sequences – codon distributions, frequency statistics, pattern and motif searches – randomization.

Unit-IV **9 hours**

Sequence alignments: Scoring matrices – PAM and BLOSUM – local and global alignment concepts – dynamic programming methodology – Needleman and Wunsch algorithm, Smith – Waterman algorithm – statistics of alignment score – multiple sequence alignment – progressive alignment – database searches for homologous sequences – FASTA and BLAST versions.

Unit-V **9 hours**

Evolutionary analysis: distances – clustering methods – rooted and unrooted tree representations – bootstrapping strategies.

Unit- VI **30 hours**

Practical: Various browsers-search engines, email- Text document with images with multiple formating options using specified office package – Spreadsheet using a specified office package-Presentation on a specified topic using the specified office package- Files and directories in windows and Linux in the specified locations- Retrieval of Nucleotide sequence from GenBank - Retrieval of Protein sequence from GenBank-

Sequence Similarity Search using BLASTN - Sequence Similarity Search using BLASTP - Predicting secondary structure of protein.

Text Books

1. Stair, R. M., & Reynolds, G. W. (2018). Fundamentals of information systems. Cengage Learning.
2. Claverie J.M. and Notredame C. (2007). Bioinformatics for Dummies, 2nd Edn. Wiley Publishers.

Reference Books

1. Brown. S M. (2000). Bioinformatics: A Biologist's Guide to Biocomputing and the Internet.Ealton Publishing, Natick.
2. Hodgman T.C., French A. and Westhead D.R. (2010). Bios Instant Notes Bioinformatics, Taylor & Francis.
3. Mount D.W. (2005). Bioinformatics: Sequence and Genome analysis, 2nd Edn. Paperback, CBS Publishers.

Course Outcome:

Upon successful completion of the course the students will be able to

- *Understand the fundamental concepts and methods in bioinformatics.*
- *acquire knowledge about basics of computers.*
- *gain understanding on techniques to analyse biological data.*
- *provide an overview on sequence analysis, structural bioinformatics and genomics.*

SEMESTER – VIII

Major Disciplinary Course
MJD18
MICROBES AND THEIR APPLICATIONS (Credit Seminar)

Credits: 2+2(P)

Total hours: 75

Course Objectives:

This course is a credit seminar paper included with the objectives (i) to understand about the importance of seminar preparation (ii) to develop the art of presenting the microbiology topics with a logic insight and discussion with their peers.

Unit – I **10 hours**

Identifying suitable topic in fundamentals of microbiology or applications of microbiology to human kind and society.

Unit – II **15 hours**

Literature survey and collection.

Unit – III **20 hours**

Preparation of a report – abstract preparation for seminar presentation.

Unit – IV **15 hours**

Presentation of the seminar in Powerpoint format.

Unit – V **15 hours**

Discussion on the topic and evaluation of the seminar report.

Reference

Microbiology Undergraduate credit seminar (MBI 490), a component of *Capstone Experience in Microbiology taken up as a part of Undergraduate Microbiology programme of University of Miami* https://miamioh.edu/cas/academics/departments/microbiology/academics/capstones/index.html#seminar

For the Major Disciplinary Course MJD 18: Microbes and Their Applications (Credit Seminar), the course will be classified as a Category B course. The End Semester Examination, worth 50 marks, will be conducted and evaluated internally by the Department of Microbiology.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the advanced study topics related to microbiology.*
- *able to document scientific content critically and present the same with better understanding.*
- *individually render oral presentation with discussion among peers.*

SEMESTER – VIII

Major Disciplinary Course
MJD19
INDUSTRIAL MICROBIOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

An application oriented paper of microbiology with objectives (i) to impart theoretical knowledge on microbial roles in industrial biomolecules production. (ii) to obtain a fundamental knowledge on the fermentation equipments and types of fermentation (iii) to learn about the industrial level production of food products and proteins.

Unit – I **9 hours**

General concepts of industrial microbiology, principles of exploitation of microorganisms of their products, screening, strain development, immobilization methods, fermentation media, raw materials used in media production, antifoaming agents, industrial sterilization.

Unit – II **9 hours**

Fermentation equipment and its uses, types of fermentation – single, batch, continuous, multiple, surface, submerged, and solid state fermentation.

Unit – III **9 hours**

Food fermentations and food produced by microbes: bread, cheese, malt beverages, vinegar, fermented dairy products and oriental fermented foods. Microbial cells as food – single cell proteins.

Unit – IV **9 hours**

Industrial products derived from microbes: industrial enzymes – amylase, protease, cellulase. Aminoacids production: glutamic acid and lysine. Production of antibiotics: penicillin, streptomycin.

Unit – V **9 hours**

Industrial products derived from microbes: Vitamins – riboflavin, cyanocobalamin. Vaccines: genetic recombinant vaccines. Organic acids: citric acid, acetic acid. Steroid conversion. Production of alcoholic beverages: beer and wine, Biofuels: ethanol, methane, biogas. Disposal of industrial waste.

Unit – VI **30 hours**

Practical: Wine production – Isolation of lactic acid bacteria from curd – Isolation of lipolytic organisms from butter or cheese – Immobilized bacterial cells for production of hydrolytic enzymes – Enzyme production and assay – cellulase, protease and amylase – Alcohol production – Immobilization of yeast.

Text Books

1. Waites M.J. Morgan N.L., Rockey J.S. and Higton G. (2011). Industrial Microbiology. An Introduction, Paperback, WB Publishers.
2. Patel A.H. (2016). Industrial Microbiology, 2nd Edn. Laxmi Publications.

Reference Books

1. Baltz R.H., Demain A.L. and Davies J.E. (2010). Manual of Industrial Microbiology and Biotechnology, ASM Press.
2. Flickinger M.C. and Drew S.W. (1999). Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis and Bioseparation, (Vol 1-5), Wiley publishers.
3. Stanbury P.T., Whitaker A. and Hall S. (2016). Principles of Fermentation Technology, Butterworth-Heinemann.

Course Outcome:

Upon successful completion of the course the candidate will

- *have got an overview of the versatile role of microbes in industrial microbiology.*
- *have an in-depth knowledge on fermentation equipment and types of fermentation.*
- *have a knowledge on food fermentations and single cell proteins.*
- *have an understanding on the industrial products derived from microbes.*

SEMESTER – VIII

Major Disciplinary Course
MJD20
RESEARCH PROJECT

Credits: 12(P)

Course Objectives:

To enhance the practical understanding of theoretical concepts, students will have the opportunity to engage in project work under the guidance of an expert teacher. A detailed work plan will be developed, outlining the experiments and activities that students will undertake to achieve the project's objectives.

Course Outcome

Upon completing the course, the student will be able to

- *Comprehend the research environment.*
- *Grasp the challenges of basic sciences within the life sciences.*
- *Conduct a literature review of a research paper.*
- *Recognize the importance of research in global community development.*

Project work based on Microbiology may be taken at the University level that may be supervised by teachers and must be completed before the end-of-semester examination.

SEMESTER – VI

Major Disciplinary Course
MJD21
SOIL MICROBIOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

A microbiological application-oriented paper added with objectives (i) to appreciate the wealth of soil microbiota (ii) to appreciate the role of biochemical cycling of nutrients (iii) to know about the importance of microbial interaction with organic pollutant and metals.

Unit-I **9 hours**

The Great plate count anomaly – bacteria (cultured and uncultured), algae, fungi, protozoans, nematodes and viruses

Unit-II **9 hours**

Biogeochemical cycles – carbon, nitrogen cycle and its components; nitrogen fixers – nitrifiers – denitrifiers – annamox and comammox.

Unit-III **9 hours**

Biogeochemical cycles – Biochemistry of nitrogen fixation - Phosphorus and S cycling – Fe cycle including micronutrient cycling

Unit-IV **9 hours**

Metals and metal sources in soil – Metal toxicity effects on microbial cells – Mechanisms of microbial metal resistance.

Unit -V **9 hours**

Organic contaminant in soils – overall process of biodegradation – contaminants structure, toxicity and biodegradability – factors affecting biodegradation.

Unit -VI **30 hours**

Practical: Isolation and enumeration of soil microorganisms using serial dilution and plating techniques – Analysis of microbial diversity in different soil samples using culture-dependent methods – Isolation and characterization of nitrogen-fixing bacteria from root nodules – Isolation and characterization of nitrifying bacteria – Nitrate Reduction test – Study of antimicrobial activity of soil microorganisms – Quantitative estimation of microbial biomass in soil using the chloroform fumigation method.

Text Books

1. Sylvia D.M., Fuhrmann, J.J., Hartel P.J. and Zuberer D.A. (2005). Principles and Applications of Soil Microbiology, 2nd Edn. Pearson, Prentice Hall.
2. Madigan M.T., Bender K.S., Buckley D.H., Sattley W.M. and Stahl D.A. (2017). Brock Biology of Microorganisms, 15thEdn. (Global Edn.) Pearson Education.
3. Pepper I., Gerba C. and Gentry T. (2015). Environmental Microbiology. 3rd Edn. Academic Press. p.728.

Reference Books

1. Madsen E.L. (2015). Environmental Microbiology: From genomes to Biogeochemistry, 2nd Edn. Wiley-Blackwell publishers, p.592.
2. Paul E.A. (Ed.) (2015). Soil Microbiology, Ecology and Biochemistry, 4thEdn, Academic Press.
3. Yates M.V., Nakatsu C.H., Miller R.V. and Pillai S.D. (2016). Manual of Environmental Microbiology, 4th Edn. ASM press, p.1088.

Course Outcome:

Upon successful completion of the course the candidate will

- *understand the diverse groups of cultured and uncultured organism in soil.*
- *gain knowledge on the microbial association and biogeochemical cycles.*
- *understand the role of microbes interaction with organic pollutants and metals.*

SEMESTER – VIII

Major Disciplinary Course
MJD22
TECHNIQUES IN MICROBIOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

The objectives of the course include (i) to provide an understanding of basic and advanced microbiological techniques (ii) to develop practical skills in handling, culturing, and analysing microorganisms (iii) to familiarize with various microbial identification and characterization methods (iv) to introduce modern molecular techniques used in microbiology.

Unit - I **9 hours**

Culturing Techniques **:**Types of culture media: selective, differential, enriched – Isolation of pure cultures: streak plate, pour plate, spread plate methods – Growth conditions: temperature, pH, oxygen requirements – Measurement of microbial growth: viable count, turbidity – Preservation and maintenance of microbial cultures

Unit - II **9 hours**

Microscopy and Staining Techniques: Principles and applications of light microscopy, phase contrast , fluorescence microscopy, Electron microscopy: transmission and scanning electron microscopy – Staining techniques: simple staining, differential staining (Gram staining, acid-fast staining), structural staining (spore, capsule).

Unit - III **9 hours**

Microbial Identification and Characterization**:** Biochemical tests for microbial identification: catalase, oxidase, IMViC, urease, nitrate reduction – Antibiotic susceptibility testing: disk diffusion, MIC determination – Molecular methods for microbial identification: PCR, DNA sequencing, RFLP, RAPD –Genomic and proteomic techniques in microbiology

Unit – IV **9 hours**

Chromatography, Centrifugation, and Spectrophotometry: Principles of chromatography: paper chromatography, thin-layer chromatography, gas chromatography, HPLC – Centrifugation techniques: differential, density gradient, ultracentrifugation –Spectrophotometry: principles and applications, UV-Vis spectrophotometry, measurement of microbial growth and enzyme activities.

Unit – V **9 hours**

Modern Molecular Techniques in Microbiology**:** Gel electrophoresis: agarose and polyacrylamide gels – Pulse Field Gel Electrophoresis – Gel documentation – Blotting : Western, Southern and Northern Blots – PCR –CRISPR-Cas technology and its applications in microbiology

Unit – VI **9 hours**

Practical: Isolation of pure cultures using streak plate method –Performing pour plate and spread plate techniques for isolating microbes – Determination of microbial growth curve by measuring optical density –Viable count of bacteria using serial dilution and plating – Observation of microbial cells using light microscopy – Gram staining, acid-fast staining, endospore staining – Biochemical identification using IMViC tests – Antibiotic susceptibility testing by disk diffusion method – PCR amplification of bacterial DNA – Separation of amino acids by paper chromatography – Agarose gel electrophoresis of DNA samples.

Textbooks

1. Patrick R. Murray, Ken S. Rosenthal, Michael A. Pfaller (2015). Medical Microbiology. Elsevier, 8th Edition.
2. Michael J. Leboffe, Burton E. Pierce (2015). A Photographic Atlas for the Microbiology Laboratory. Morton Publishing Company, 5th Edition.

Reference Books

1. James G. Cappuccino, Natalie Sherman (2014). Microbiology: A Laboratory Manual. Pearson, 10th Edn.
2. David B. Fankhauser (2013). Laboratory Manual for General Microbiology. Cengage Learning, 1st Edn.
3. Jeffrey C. Pommerville (2017). Fundamentals of Microbiology. Jones & Bartlett Learning, 11th Edn.
4. Wilson and Walker (2000). A Biologists guide to Principles and Techniques of Practical Biochemistry (5th Edn.)Cambridge University Press.
5. David Freifelder (1982). Physical Biochemistry. (2nd Edn.) W. H. Freeman and Company, New York.

Course Outcome

Upon completion of the course, the candidate will be able to

- *perform basic and advanced microbiological techniques proficiently.*
- *identify and characterize microorganisms using classical and modern methods.*
- *apply molecular techniques to study microbial genetics and physiology.*
- *maintain and manage a microbiology laboratory with proper safety protocols.*

SEMESTER – VIII

Major Disciplinary Course
MJD17
ENTREPRENEURIAL MICROBIOLOGY

Credits: 3+1(P)

Total hours: 75

Course Objectives:

The Entrepreneurial Microbiology course aims to (i) provide students with a comprehensive understanding of the intersection between microbiology and entrepreneurship(ii) gain in-depth knowledge of various microbial products such as fermentation products, biofertilizers, biofuels, and single-cell proteins (iii) Identify and evaluate entrepreneurial opportunities in industrial microbiology, including risk assessment, market potential, and business development (iv) Emphasize the importance of sustainable practices in microbiological industries, particularly in biofertilizer and biofuel production

Unit – I **9 hours**

Entrepreneurial society – Entrepreneur development, activity, Institutes involved, Government contributions to entrepreneurs, risk assessment.

Unit – II **9 hours**

Microbial cells as fermentation products –Baker's yeast, food and feed yeasts, bacterial insecticides, legume inoculants, mushrooms, algae. Enzymes as fermentation products – Bacterial and Fungal Amylases, Proteolytic Enzymes, Pectinases, Invertases, and other enzymes**.**

Unit – III **9 hours**

Mushroom cultivation – Cultivation of *Agaricus campestris, Agaricus bisporus*, and *Volvariella volvaciae***–** Preparation of compost, filling tray beds, spawning, maintaining optimal temperature, casing, watering, harvesting, storage. Biofertilizers – Historical background, Chemical fertilizers versus biofertilizers, organic farming. *Rhizobium sp., Azospirillum sp., Azotobacter sp.,* as biofertilizers.

Unit – IV **9 hours**

Biofuels: Production of methane, biohydrogen, ethanol and biobutanol. Single cell oils – commercially produced microbial oils – Gamma linolenic acid – polyunsaturated fatty acids – oils used as biofuels**.**

Unit -V **9 hours**

Introduction to SCP production: history, raw materials, SCP production methodology, microbes used – Advantages and disadvantages, Applications – *Spirulina* mass multiplication technology.

Unit -VI **30 hours**

Practical: Cultivation of mushroom – Bed spawn preparation – Composting using microbes – Isolation of *Azospirillum* for bio fertilizers production – Ethanol production – *Spirulina* cultivation – *Azolla* mass multiplication – Mass multiplication of *Methylobacterium* as biofertilizers – Biofertilizers production – demonstration – Biogas generation from kitchen garbage – VAM mass multiplication – Microbial pigment mass production (*Monascus* pigment).

Text Books

1. K.R. Aneja (2003). Experiments in Microbiology, Plant pathology, Tissue culture and Mushroom production technology, 4th Edition New age International publication.
2. Patel A.H. (2007). Industrial Microbiology, Pan Macmillan.

Reference Books

1. Waites M. J. Morgan N.L. Rockey J.S. and Higton G. (2007). Industrial Microbiology An Introduction, Scientific Book Company.
2. Lee B.H. (2015). Fundamentals of Food Biotechnology, 2nd Edn. Wiley-Blackwell.
3. Anonymous (2006) Biofertilizers Manual, Japan Atomic Industrial Forum.

Course Outcomes

Upon successful completion of this course, students will be able to:

- *demonstrate proficiency in cultivating key microbial products such as Baker's yeast, food and feed yeasts, bacterial insecticides, legume inoculants, mushrooms, and algae.*
- *develop and manage production processes for bacterial and fungal enzymes, and biofertilizers using various microbial species.*
- *Implement Mushroom Cultivation Techniques.*
- *Understand the processes involved in the production of biofuels such as methane, biohydrogen, ethanol, and biobutanol, and their applications.*
- *Mass Multiply Microbial Products.*
- *Promote Sustainable Agricultural Practices.*