PONDICHERRY UNIVERSITY
PUDUCHERRY

NEP

SYLLABUS AND REGULATIONS IN

B.Sc. (Honors) BIOTECHNOLOGY

Academic Year 2023-2024 onwards

[AFFILIATED COLLEGES]

PREAMBLE

PONDICHERRY UNIVERSITY

B.Sc. (Honors) in Biotechnology DEGREE COURSE

REVISED REGULATION & SYLLABUS

UG PROGRAMME IN B.Sc. (Honors) in BIOTECHNOLOGY DEGREE COURSE

The revised syllabus shall be effective from the academic year 2024 -2025 onwards.

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 3 and 4 years leading to the award of UG Degree.

All UG courses shall focus on conceptual understanding and development of critical thinking in a given field of Study, incidentally, skills such as communication, teamwork, and leadership shall 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 the first year of the **B.Sc. / B.S Honors in Biotechnology** degree shall require to have **passed Higher Secondary course with Biology/Botany/Zoology** as one of the subject 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.S honors in Biotechnology:
   Student should complete **UG certificate course with major subject as Biotechnology and minor subject as Biochemistry** from any University.

2. Lateral Entry for III Year B.Sc. / B.S honors in Biotechnology:

   Student should complete **UG Diploma course in Biotechnology with minor subject as plant science and animal science** from any University.
3. Lateral Entry for IV Year B.S honors in Biotechnology:
   Student should complete B.Sc. Biotechnology from any University.

COURSE STRUCTURE

All Academic Programmes offered under NEP shall be offered in terms ofcredits. 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 Biotechnology** 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 Biotechnology** 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 they will be awarded **UG degree in B.Sc. Biotechnology** after successful completion of three years, provided they have earned a minimum of 124 credits.

MEDIUM OF INSTRUCTION

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

Breakup 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 3 year UG student is expected to complete in 3 duration.

TABLE I
BREAKUP OF CREDITS AND COURSES

Sl. No.	Component	3 Year Degree	4 Year Hons Degree
1	Major Disciplinary Courses	60 Credits (15 Courses of 4 credits each)	80 Credits (20 Courses of 4 credits each)
2	Minor Discipline 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 3credits each)	9 Credits (3 courses of 3 credits each)
4	Ability Enhancement Courses	8 Credits (4 courses of 2 credits each)	8 Credits (4 courses of 2 credits each)
5	Skill Enhancement Course	9 Credits (3 courses of 3 credits each)	9 Credits (3courses of 3 credits each)
6	Common Value added courses	8 Credits (4 course of 2 credits each)	8 Credits (4 course of 2 credits each)
7	Community Science	2 Credits (1 field based course)	2 Credits (1 field based course)
8	Research Dissertation Project	-	12 Credits (Project report & background subjects)
9	Total (3 year) credits required	120 Credits	160 Credits1

Minimum requirement of credits for the students to complete the respective course. 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. A student of 4-year BS honors in Biotechnology programme is mandated to complete a minimum of 160 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): (60/80 credits)

Major disciplinary courses are subject specific compulsorysubjects 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. (Biotechnology) or with multiple major disciplines like B.Sc. (Biotechnology, Bioinformatics &Genetics).

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

Minor disciplinary courses refer to those subjects which are Allied/Specialization/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) Mathematics & Statistics
d) Computer Science/Applications
e) Data Analysis
f) Social Sciences
g) Humanities
h) Commerce & Management
i) Library Science
j) Media Sciences, etc.

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 atleast 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. Eg. 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, e t c . 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 and Technological solutions
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 to4 to 6 week Summer Internship in an industrial organisations/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 neighborhood 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 SemesterUniversity exam is for 75 marks. In case of Practical, Project work, etc., it is 50:50 marks for Internal and End-Semester Exams.

Break up of Internal Assessment Marks:

Total Internal Assessment mark for a theory subject is 25 marks.The breakup is:

a)	Mid Semester Exam (one) - 15 Marks
b)	Percentage of Attendance - 10 Marks
Total - 25 Marks	

Marks for Attendance is as follows:

Below 75%	00
75% - 80%	02
80% - 85%	04
85% - 90%	06
90% - 95%	08
95% - 100%	10

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 ofresults by the University

Internal Assessment marks for Practicals / Project work / Internships subjects:

Faculty member in-charge of Lab practicals shall evaluate the practical subjects for 50 marks. The break up is as follows:

1. Attendance	10 marks
2. Observation Notebook	15 marks
3. Practical Record	25 marks

Internal Assessment marks for Project work / Internships subjects:

Faculty member in-charge of Lab practicals shall evaluate the practical subjects for 50 marks. The break up is as follows

a). Attendance	10
b) Demo note/Work dairy / etc	20
c) I nternship Report / Field visit report etc.	20
Total	**50**

End-Semester University Exam:

Controller of Examinations (COE) of Pondicherry University schedules the End-Semester exams for all theory and practicalsubjects based on university calendar.

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:

a) Theory subjects: (Sec A, Sec B and Sec C) Question from all units of syllabus	75 marks
b) Practical/Internship Project Worksubjects (Based on Practical Exams/Presentation/Viva)	50 marks

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 said 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 Calculationof 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 grades would be worked as follows:

Highest marks in the given subject = X
Cut of marks for grading purpose = 50 marks
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 scheme will be followed.

(i) If K ≥ 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
Below 40	F	0
Absent (Lack of Attendance)	Ab	0

(ii) If K<5, then the grades shall be awarded as given in Table 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
Below 40	F	0
Absent (lack of attendance)	Ab	0

Calculation of Semester Grade Point average 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 beingthe number of credits that each subject carries.

Cumulative Grade Point Average (CGPA) CGPA shall be calculated as the weighted average of credits that course carries and the value of Gradepoints 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 withthe 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) = Σ(Ci x Gi) / ΣCi

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 inany course.

Semester	**Course**	**Credit**	**Letter Grade**	**Grade point**	**Credit Point** (Credit xGrade)
I	Course 1	3	A	8	3 X 8 = 24
I	Course 2	4	B+	7	4 X 7 = 28
I	Course 3	3	B	6	3 X 6 = 18
I	Course 4	3	O	10	3 X 10 = 30
I	Course 5	3	C	5	3 X 5 = 15
I	Course 6	4	B	6	4 X 6 = 24
		20			139
			SGPA		139/20=6.95

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

Semester	**Course**	**Credit**	**Letter Grade**	**Grade point**	**Credit Point** (Credit xGrade)
I	Course 1	3	A	8	3 X 8 = 24
I	Course 2	4	B+	7	4 X 7 = 28
I	Course 3	3	B	6	3 X 6 = 18
I	Course 4	3	O	10	3 X 10 = 30
I	Course 5	3	C	5	3 X 5 = 15
I	Course 6	4	F	0	4 X 0 = 00
		20			115
			SGPA		115/20=5.75

(iii) Example for Computation of SGPA where candidate has failed in twocourses.

Semester	**Course**	**Credit**	**Letter Grade**	**Grade point**	**Credit Point** (Credit xGrade)
I	Course 1	3	A	8	3 X 8 = 24
I	Course 2	4	B+	7	4 X 7 = 28
I	Course 3	3	F	0	3 X 0 = 00
I	Course 4	3	B	6	3 X 6 = 18
I	Course 5	3	C	5	3 X 5 = 15
I	Course 6	4	F	0	4 X 0 = 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 courseswill 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 Below 5.99	Second Class
4.0 4.99	Pass Class

SCHEME OF EXAMINATION FOR THEORY PAPER

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

INTERNAL EXAMINATION: Maximum Marks: 25.

- Mid-Semester Examination for 1.30 Hours duration shall be taken: 15 Marks
- Attendance: 10 Marks

EXTERNAL EXAMINATION: Maximum Marks: 75.

- Examinations shall be in three sections.
- Section-A (Definition based) for 20 Marks,
- Section –B (Short note based) for 25 Marks
- Section-C (Essay based) for 30 Marks.
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Question Paper Pattern
SECTION – A: (10 x 2 = 20 Marks) • It is of short answer type. Each question carries 2 marks. • 10 questions to be given by setting 2 questions from each unit. • Candidate should Answer all the questions.
SECTION – B: (5 x 5 = 25 Marks) • It is of short answer type. Each question carries 5 marks. • 10 questions to be given by setting 2 questions from each unit. A or B • Candidate should Answer 5 questions out of 10 questions.
SECTION – C: (3 x 10 = 30 Marks) • It is of essay answer type. Each question carries 10 Marks. • 5 questions to be given by setting One question from each unit. • Candidate should answer 3 questions out of 5 questions.

BLUEPRINT FOR QUESTION SETTING

Sl.No	UNIT	Section A	Section B	Section C
1.	Unit I:	2	2	1
2.	Unit II	2	2	1
3.	Unit III	2	2	1
4.	Unit IV	2	2	1
5.	Unit V	2	2	1

SCHEME OF EXAMINATION FOR PRACTICAL PAPER

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

INTERNAL EXAMINATION: Maximum Marks: 50

Components of Internal Evaluation (50 Marks)

1. Attendance (10)
2. Observation Notebook (15)
3. Practical Record (25)

END-SEMESTER PRACTICAL EXAMINATION: Maximum marks: 50

1. Major Question (20)
    a. Aim – 2,
    b. Principle - 3,
    c. Materials required – 3,
    d. Procedure - 10,
    e. Result-2
2. Practical Performance (15)
    a. Performance 10 Marks
    b. Interpretation of result cum viva- 5 marks
3. Spotters (5 x 3 =15 marks)
    a. Identification – 1 mark
    b. Description – 2 marks

SCHEME OF EXAMINATION FOR PROJECT / INTERNSHIP / FIELD WORK

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

INTERNAL EXAMINATION: Maximum Marks: 50 marks

a). Attendance	10 marks
b) Demo note/Work dairy / etc	20 marks
c) Internship Report / Field visit report etc.	20 marks

EXTERNAL EXAMINATION: Maximum Marks: 50 marks .

a). Project Report	20 Marks
b) Oral Presentation cum viva	30 Marks

Course Structure Credits and Work Hours on a Semester Basis In Accordance With the National Education Policy (NEP) For Academic Year 2024-2025 onwards

SEMESTER I				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Teaching hrs**
MJD 01	Major Disciplinary courses	Cell Biology	4 (T)	4
MID 01	Minor Disciplinary courses	Biological Macromolecules	4 (T)	4
MLD 01	Multi-Disciplinary courses	Natural Science	3 (T)	4
SEC 01	Skill Enhancement Course	Biotechnological Laboratory Technique -I	3 (P)	6
AEC 01	Ability Enhancement courses	English or Tamil / Hindi / French	2+1 (T)	4
VAC 01	NEP Value added common courses I	Environmental Studies	2 (T)	4
	NEP Value added common courses II	Understanding India	2 (T)	4
Total Credits/ Total Hours of Work			**21 Credit**	**30 Hours**
SEMESTER II				
Code No	Nature of Course	**Title of the Course**	**Credits**	**Teaching hrs**
MJD 02	Major Disciplinary courses	Microbiology	4 (T)	4
MID 02	Minor Disciplinary courses	Intermediary Metabolism	4 (T)	4
MLD 02	Multi- Disciplinary courses	Physical Science	3 (T)	4
SEC 02	Skill Enhancement Course	Biotechnological Laboratory Technique -II	3 (P)	6
AEC 02	Ability Enhancement courses	English or Tamil / Hindi / French	2+1 (T)	4
VAC 02	NEP Value added common courses I	Health, Wellness, Yoga Education, Sports & Fitness	2 (T)	4
	NEP Value added common courses II	Digital Technological Solutions	2 (T)	4
Total Credits/ Total Hours of Work			**21 Credit**	**30 Hours**

The Practical Paper is structured to be conducted in batches, with class divisions occurring if the student enrollment surpasses 25. Students choosing to conclude their studies after the first year will receive a **Certificate in Biotechnology**, contingent upon achieving a **minimum of 42 credits**. Additionally, they must fulfill a work-based vocational course or internship, earning 4 credits, during the summer break of the first year.

SEMESTER III				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Teaching hrs**
MJD 03	Major Disciplinary courses	Molecular Biology	4(T)	5
MJD 04	Major Disciplinary courses	Analytical Techniques in Biology	4(T)	5
MID 03	Minor Disciplinary courses	Plant Science	3(T) +1(P)	6
MLD 03	Multi- Disciplinary courses	Humanities/Social Science	3 (T)	4
SEC 03	Skill Enhancement Course	Biotechnological Laboratory Technique -III	3 (P)	6
AEC 03	Ability Enhancement courses	English or Tamil / Hindi / French	2+1 (T)	4
Total Credits/ Total Hours of Work			**21 Credit**	**30 Hours**

SEMESTER IV				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Teaching hrs**
MJD 05	Major Disciplinary courses	Immunology	3(T) +1(P)	6
MJD 06	Major Disciplinary courses	Genetic Engineering	3(T) +1(P)	6
MJD 07	Major Disciplinary courses	Parasitology and Entomology	4 (T)	4
MID 04	Minor Disciplinary courses	Animal Science	3(T) +1(P)	6
AEC 04	Ability Enhancement courses	English or Tamil / Hindi / French	2+1 (T)	4
SEC	Winter Training	Community Engagement	2 (T)	4
Total Credits/ Total Hours of Work			**21 Credit**	**30 Hours**

The Practical Paper is structured to be conducted in batches, with class divisions occurring if the student enrollment surpasses 25.

Students choosing to conclude their studies after the second year will receive a **Diploma in Biotechnology** upon achieving a minimum of 84 credits. Additionally, they must undertake a work-based vocational course or internship worth 4 credits during the summer break of the second year

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SEMESTER V				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Teaching hrs.**
MJD 08	Major Disciplinary courses	Bioprocess Technology	3(T) +1(P)	6
MJD 09	Major Disciplinary courses	Animal Biotechnology	3(T) +1(P)	6
MJD 10	Major Disciplinary courses	Environmental Biotechnology	3(T) +1(P)	6
MID 05	Minor Disciplinary courses	**Scientific Writing & Presentation Skills**	4(T)	6
MJD 11	Skill Enhancement Course	Summer Internship	4(T)	6
Total Credits/ Total Hours of Work			**20 Credit**	**30 Hours**

SEMESTER VI				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Teaching hrs**
MJD 12	Major Disciplinary courses	Plant Biotechnology	3(T) +1(P)	6
MJD 13	Major Disciplinary courses	Bioinformatics	3(T) +1(P)	6
MJD 14	Major Disciplinary courses	Pharmaceutical Biotechnology	3(T) +1(P)	6
MJD 15	Major Disciplinary courses	Marine Biotechnology	3(T) +1(P)	6
MID 06	Minor Disciplinary courses	Genomics & Proteomics	4(T)	6
Total Credits/ Total Hours of Work			**20 Credit**	**30 Hours**

The Practical Paper is structured to be conducted in batches, with class divisions occurring if the student enrollment surpasses 25.

Students who choose to withdraw will receive a Bachelor of Science (B.Sc.) degree in Biotechnology upon successfully completing three years, provided they have accumulated a minimum of 124 credits.

SEMESTER VII				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Teaching hrs.**
MJD 16	Major Disciplinary courses	Medical Biotechnology	3(T) +1(P)	6
MJD 17	Major Disciplinary courses	Industrial Biotechnology	3(T) +1(P)	6
MJD 18	Major Disciplinary courses	Agricultural Biotechnology	3(T) +1(P)	6
MID 08	Minor Disciplinary courses	Molecular Diagnostics & Forensic Science	4(T)	5
MID 09	Minor Disciplinary courses	**Developmental Biology**	4(T)	5
Total Credits/ Total Hours of Work			**20 Credit**	**28 Hours**

SEMESTER VIII				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Teaching hrs**
MJD 19	Major Disciplinary courses	Nanotechnology	3(T) + 1(P)	6
MJD 20	Minor Disciplinary courses	Enzyme Technology	3(T) + 1(P)	6
RP 01	**Research Project (OR)** 3 Major Disciplinary Course	**Project**	12 (OR)	16 (OR)
MJD 21		Biological Data Analysis	3(T) + 1(P)	6
MJD 22		Stem cell & Cancer Biology	4 (T)	5
MJD 23		Entrepreneurial Development, & IPRs, Biosafety and Bioethics	4(T)	5
Total Credits/ Total Hours of Work			**20 Credit**	**28 Hours**

The Practical Paper is structured to be conducted in batches, with class divisions occurring if the student enrollment surpasses 25.

SEMESTER I

CELL BIOLOGY Theory Paper

Course code: **MJD 01** Total Marks : 100 (IA 25+EA75) Credits: 4

UNIT -I (10 hours)

History of cell Biology, cell as basic unit of life, Cell theory, Protoplasm theory, Organismal theory, Classification & characterization of cell types, Organization, Ultrastructure of plant cell, animal cell, bacterial cell and viruses

UNIT -II (10 hours)

Structure and function of cell wall - Bacterial and Plant. Ultra structure of plasma membrane – fluid mosaic model, membrane fluidity, Transport across membranes - Symport, antiport, uniport, active and passive transport, Differentiation of cell surface: Basement membrane, tight junction, gap junctions, Desmosomes, hemidesmosomes. Cytoskeletal structures – microtubules, microfilaments (actin, myosin), Intermediate filament.

UNIT -III (10 hours)

Structure & Functions of cell organelles: Endoplasmic Reticulum (SER & RER), Golgi apparatus, lysosomes, microbodies (peroxisomes and glyoxysomes), ribosomes and its types, centrioles, basal bodies. Structure and functions of mitochondria, chloroplast, organization of respiratory chain in mitochondria, photophosphorylation in chloroplast.

UNIT -IV (15 hours)

Structure and organization of nucleus, nuclear membrane, organization of chromosomes-structural organization of chromatids, centromere, chromatin, telomere, nucleosomes, euchromatin and heterochromatin, specialized structures- polytene and lampbrush chromosome

UNIT -V (15 hours)

Cell division - Cell cycle, mitosis and meiosis, regulations of cell cycle and check points and proteins involved in cell cycle check points. Basics in cell signaling- ligand molecules and receptors, G protein coupled receptors, Tyrosine kinase receptor, apoptosis and necrosis.

Course Learning Outcomes (CLO): Students will be able to

1. Understand cell structures and functions, including organelles in plant, animal, bacterial cells, and viruses.
2. Study cell interactions with their environment, focusing on membrane dynamics, transport mechanisms, and surface differentiation.
3. Learn the organization of the nucleus and chromosomes, understanding cellular inheritance and specialized structures.
4. Understand the cell cycle, mitosis, meiosis, and regulation mechanisms with

checkpoints and proteins.

5. Explore cell signaling pathways, receptor mechanisms, apoptosis, and necrosis, understanding cellular communication and death.

Reference Books :

1. E.D. P. De Robertis and E.M.F. De Robertis, Jr. (2012). Cell and Molecular Biology (8th edition). B.I. Waverly Pvt. Ltd., New Delhi.
2. Harvey Lodish, Arnold Berk, S. Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Dernell (2009). Molecular Cell Biology (4th edition). W.H. Freeman and Company.
3. P.S. Verma and V.K. Agarwal (2012). Concepts of Cell Biology. S. Chand & Company Ltd., New Delhi.
4. Bruce Alberts (2009). Essential Cell Biology (3rd edition). Garland Science.
5. Gerald Karp (2013). Cell and Molecular Biology: Concepts and Experiments (7th edition). John Wiley & Sons.
6. James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, and Richard Losick (2014). Molecular Biology of the Gene (7th edition). Cold Spring Harbor Laboratory Press.
7. David Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter (2015). Molecular Biology of the Cell (6th edition). Garland Science.
8. Thomas D. Pollard and William C. Earnshaw (2017). Cell Biology (3rd edition). Elsevier.
9. Geoffrey M. Cooper and Robert E. Hausman (2013). The Cell: A Molecular Approach (6th edition). Sinauer Associates.
10. Lehninger, Albert L., Michael M. Cox, and David L. Nelson (2017). Lehninger Principles of Biochemistry (7th edition). W.H. Freeman and Company.

BIOLOGICAL MACROMOLECULES Theory Paper

Course code: MID 01 Total Marks : 100 (IA 25+EA75) Credits: 4

UNIT -I (10 hours)

Carbohydrates: Classification of carbohydrates, Occurrence and structure of mono, di and polysaccharides (homo and heteropolysaccharides), asymmetry, stereo-isomerism and optical isomerism of sugars, anomeric form and mutarotation. Biological importance of carbohydrates (starch, cellulose, chitin)

UNIT -II (10 hours)

Amino acids & Proteins: Classification, structure and Properties of amino acids, Essential and non-essential amino acids, peptide bond and chemical bonds involved in protein structure - Protein classification based on solubility, shape, composition and function, Structure of proteins (Primary, secondary tertiary and quaternary), Biologically important peptides (insulin, glutathione, vasopressin).

UNIT -III (10 hours)

Enzymes: Definition, Classification & nomenclature of enzymes - Specificity of enzyme action - Fischer's Lock and Key Hypothesis & Koshland's Induced Fit Hypothesis - Active site – coenzyme - Enzyme kinetics, Michaelis-Menten equation and Lineweaver-burk plot) - significance of Km and Vmax – enzyme inhibitors (reversible, irreversible and feedback inhibitions), Modes of enzyme inhibition, Regulatory enzymes (Allosteric & covalently modulated enzymes). Biological importance of enzymes (ribonuclease and chymotrypsin)

UNIT -IV (15 hours)

Lipids: Classification, nomenclatures, structure and functions of Simple, Compound and Derived lipids, Structure and functions of fatty acids (Essential Fatty Acids), Tri-acyl glycerol, phospholipids, sphingolipids, Glycolipids and Gangliosides. Biological importance of lipids (PUFA)

UNIT -V (15 hours)

Nucleic acid: Structure, Properties and types of nucleic acid, Composition of DNA and RNA -Watson and Crick model of DNA, Structure of purines and pyrimidines, Structure of Nucleosides and Nucleotides. Structural forms of DNA, Biological importance of Nucleic acids

Course Learning Outcomes (CLO): Students will be able to

1. Classify and describe the structures of carbohydrates, amino acids, proteins, lipids, and nucleic acids.
2. Comprehend enzyme kinetics, inhibition mechanisms, and regulation, and their roles in biochemical processes.
3. Identify and explain the structural levels of proteins and their biological

functions.

4. Classify different lipids and understand their structures and biological functions.
5. Describe the structure, types, and properties of nucleic acids, understanding their significance in genetics.

Reference Books :

1. Nelson, D.L., Cox, M.M. (2013). Lehninger: Principles of Biochemistry (6th Edition). W.H. Freeman and Company.
2. Devlin, T.M. (2011). Textbook of Biochemistry with Clinical Correlations (7th Edition). John Wiley & Sons, Inc.
3. Berg, J.M., Tymoczko, J.L., Stryer, L. (2012). Biochemistry (7th Edition). W.H. Freeman and Company.
4. Voet, D., Voet, J.G. (2011). Biochemistry (4th Edition). John Wiley & Sons.
5. Garrett, R.H., Grisham, C.M. (2013). Biochemistry (5th Edition). Cengage Learning.
6. Murray, R.K., Granner, D.K., Mayes, P.A., Rodwell, V.W. (2012). Harper's Illustrated Biochemistry (29th Edition). McGraw-Hill Medical.
7. Mathews, C.K., van Holde, K.E., Appling, D.R., Anthony-Cahill, S.J. (2012). Biochemistry (4th Edition). Pearson.
8. Horton, H.R., Moran, L.A., Ochs, R.S., Rawn, J.D., Scrimgeour, K.G. (2011). Principles of Biochemistry (5th Edition). Pearson.
9. Freeman, W.H., Donald, J.V., Judith, G.V., Charlotte, W.P. (2013). Biochemistry (4th Edition). W.H. Freeman and Company.
10. Zubay, G. (1998). Biochemistry (4th Edition). Wm. C. Brown Publishers.

BIOTECHNOLOGICAL LABORATORY TECHNIQUE -I Practical

Course code: **SEC 01** Total Marks : 100 (IA 25+EA75) Credits: 3

List of Practicals

1. Microscopic techniques- light microscopy.
2. Observation of permanent slides
3. Measurement of cell usi g ocular micrometer and stage micrometer
4. Cell types- Microbial, animal and plant cells
5. Cell counting method- animal cell: Haemocytometer
6. Cell counting method- p ant cells-stomatal density
7. Mitosis in onion root tip.
8. Meiosis in Pollen mothe r cells of plants (demo)
9. Subcellular fractionation
10. Plasmolysis in onion
11. Extraction and Characterization of Starch
12. Qualitative test for Carbohydrates
13. Isoelectric precipitation of proteins
14. Precipitation of Immunc globin from serum
15. Intracellular total protei precipitation by TCA/ Acetone method
16. Qualitative analysis of p roteins
17. Separation of Amino acids by chromatography
18. Karyotyping (demo)
19. Crude DNA extraction

I.

SEMESTER II

MICROBIOLOGY Theory Paper

Course code: MJD 02 Total Marks : 100 (IA 25+EA75) Credits: 4

UNIT -I (10 hours)

Microbial Diversity: Basics of microbiology, History and Scope of microbiology, General features and Classification of Archaea, Bacteria, Fungi, Algae, Protozoa, Viruses and Prions. Differences between prokaryotic and eukaryotic organisms.

UNIT -II (10 hours)

Ultrastructure of Bacteria: Sub-cellular structures - Cell wall of bacteria and its biosynthesis, Cell envelope - capsule and slime layer, Cellular appendages - pili, flagella and fimbriae, Cell membrane, inclusion bodies, Plasmid DNA and chromosomal DNA. **Bacterial genetics** - conjugation, transduction (generalized and specialized), and transformation.

UNIT -III (10 hours)

Microscopy: Staining - Principles and types of staining (simple and differential) **Microscopy -**Instrumentation, principles and applications of light microscopes (bright field, dark field, phase contrast, fluorescent microscopes) and electron microscopes (transmission and scanning electron microscopes)

UNIT -IV (15 hours)

Microbial Nutrition: Classification of microorganisms based on their nutritional types, Preparation of media, types of media, culturing of microbes, Microbial growth curve, viral replication: lytic and lysogenic cycles, Isolation, preservation and maintenance of microorganisms, Aerobic and Anaerobic culturing of bacteria, Effect of biotic and abiotic factors on the growth of organisms.

UNIT -V (15 hours)

Microbial Control: Sterilization, disinfection, antisepsis, fumigation. Physical control: Temperature (moist heat, autoclave, dry heat, hot air oven and incinerators), desiccation, osmotic pressure, radiation, UV-light, electricity, ultrasonic sound waves, filtration. Chemical control: Antiseptics and disinfectants (halogens, alcohol, gaseous sterilization)

Course Learning Outcomes (CLO): Students will be able to

1. Define microbiology, its development, and its significance in fields like healthcare and biotechnology.
2. Describe microbial diversity, including classification and features of Archaea, Bacteria, Fungi, Algae, Protozoa, Viruses, and Prions.
3. Explain the ultrastructure of bacteria, including cell wall biosynthesis, cellular appendages, and genetic mechanisms.
4. Demonstrate microscopy techniques, including principles and applications of various types of microscopes.

5. Understand microbial nutrition, growth, and control methods, including sterilization, disinfection, and physical and chemical control methods.

Reference Books :

1. M.J. Pelczar Jr., E.C.S. Chan, and N.R. Krieg, Microbiology, 5th edition (2001), Tata McGraw-Hill, New Delhi.
2. R. Ananthanarayanan and C.K. Jayaram Paniker, Textbook of Microbiology, 12th edition (2022), Universities Press, Hyderabad.
3. Lansing M. Prescott, John P. Harley, and Donald A. Klein, Microbiology, 10th edition (2017), McGraw-Hill Education, New York.
4. R.C. Dubey and D.K. Maheswari, A Textbook of Microbiology, 4th edition (2014), S. Chand & Company Ltd., New Delhi.
5 Gerard J. Tortora, Berdell R. Funke, and Christine L. Case, Microbiology: An Introduction, 13th edition (2018), Pearson, New York.
6. Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley, and David A. Stahl, Brock Biology of Microorganisms, 15th edition (2017), Pearson, Boston.
7. Joanne M. Willey, Linda M. Sherwood, and Christopher J. Woolverton, Prescott's Microbiology, 10th edition (2017), McGraw-Hill Education, New York.
8. James G. Cappuccino and Natalie Sherman, Microbiology: A Laboratory Manual, 11th edition (2019), Pearson, Boston.
9. Robert W. Bauman, Microbiology with Diseases by Taxonomy, 5th edition (2017), Pearson, Boston.
10. David Greenwood, Richard Slack, John Peutherer, and Mike Barer, Medical Microbiology: A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis and Control, 18th edition (2012), Churchill Livingstone, London.

INTERMEDIARY METABOLISM Theory Paper

Course code: **MID 02** Total Marks : 100 (IA 25+EA75) Credits: 4

UNIT -I (10 hours)

Carbohydrate Metabolism: Glycolysis, Fermentation, Citric acid cycle, Oxidative Phosphorylation & Electron transport chain, Gluconeogenesis, Pentose phosphate pathway, Glyoxylate shunt, Glycogen metabolism (glycogenesis and glycogenolysis)

UNIT -II (10 hours)

Amino Acids Metabolism: General aspects of amino acid metabolism, Transamination, Transamidation, Deamination, Uric acid biosynthesis, Nitrogen excretion - Urea cycle, Amino acid catabolism, Amino acid biosynthesis - Fixation of ammonia into amino acid, biosynthesis of amino acids (Tryptophan and Methionine).

UNIT -III (10 hours)

Lipid Metabolism: Biosynthesis of fatty acids - long chain, unsaturated, Triacylglycerols, phospholipids, comparison of fatty acid synthesis and degradation; Oxidation of fatty acids – even chain saturated fatty acids, Unsaturated fatty acids, odd chain fatty acids (α, β, ω), ketone bodies, cholesterol metabolism, dietary absorption of lipids.

UNIT -IV (15 hours)

Nucleic Acid Metabolism: Biosynthesis of purines and pyrimidines, NMP conversion to NTP, Nucleotide degradation, salvage pathways, degradation of purine and pyrimidines to uric acid & urea, nucleotides as regulatory molecules, non-enzymatic transformation of nucleotides & nucleic acids.

UNIT -V (15 hours)

Inborn errors of metabolism – Introduction, Symptoms and genetics of metabolic diseases: disorders of carbohydrate metabolism – Diabetes mellitus type I and Pompe's disease; disorders of amino acid metabolism – Homocystinuria and Carbamoyl phosphate synthetase I deficiency; disorders of fatty acid metabolism - Gauchers's disease and Tay-Sach's disease; disorders of nucleic acid metabolism – Lesch-Nyhan syndrome and Miller syndrome.

Course Learning Outcomes (CLO): Students will be able to

1. Understand carbohydrate metabolism: glycolysis, fermentation, citric acid cycle, oxidative phosphorylation, gluconeogenesis, glycogen metabolism.
2. Analyze amino acid metabolism: transamination, deamination, urea cycle, catabolism, biosynthesis.
3. Evaluate lipid metabolism: fatty acid biosynthesis, oxidation, ketone bodies, cholesterol metabolism.
4. Demonstrate comprehension of nucleic acid metabolism: biosynthesis, conversion, degradation, salvage pathways, regulatory roles.
5. Identify and understand inborn errors of metabolism and their genetic and

symptomatic characteristics.

Reference Books :

1. Voet, D., Voet, J. G., & Pratt, C. W. (2018). Fundamentals of Biochemistry: Life at the Molecular Level (5th Edition). Wiley.
2. Nelson, D. L., Cox, M. M., & Lehninger, A. L. (2017). Lehninger Principles of Biochemistry (7th Edition). W. H. Freeman.
3. Berg, J. M., Tymoczko, J. L., & Gatto Jr, G. J. (2021). Stryer's Biochemistry (9th Edition). W. H. Freeman.
4. Wilson, K., & Walker, J. (2019). Principles and Techniques of Biochemistry and Molecular Biology (8th Edition). Cambridge University Press.
5. Murray, R. K., Bender, D. A., Botham, K. M., Kennelly, P. J., Rodwell, V. W., & Weil, P. A. (2018). Harper's Illustrated Biochemistry (31st Edition). McGraw-Hill Education.
6. Garrett, R. H., & Grisham, C. M. (2016). Biochemistry (6th Edition). Cengage Learning.
7. Metzler, D. E., Metzler, C. M. (2001). Biochemistry: The Chemical Reactions of Living Cells (2nd Edition). Academic Press.
8. Mathews, C. K., van Holde, K. E., Appling, D. R., & Anthony-Cahill, S. J. (2012). Biochemistry (4th Edition). Pearson.
9. Devlin, T. M. (2010). Textbook of Biochemistry with Clinical Correlations (7th Edition). Wiley.
10. Berg, J. M., Tymoczko, J. L., Gatto Jr, G. J., & Stryer, L. (2015). Biochemistry (8th Edition). W. H. Freeman.

BIOTECHNOLOGICAL LABORATORY TECHNIQUE -II Practical

Course code: SEC 02 Total Marks : 100 (IA 25+EA75) Credits: 3

List of Practicals

1. Microscopic Examination of Bacteria, Yeasts, and Fungi
2. Bacterial Motility Assay
3. Simple Staining of Bacteria
4. Gram Staining Procedure
5. Preparation of Solid, Liquid, and Semi-Solid Media
6. Techniques for Inoculation
7. Isolation and Maintenance of Pure Bacterial Cultures
8. Enrichment Culture Techniques
9. Microbial Growth Curve Analysis
10. Carbohydrate Estimation using Anthrone Method
11. Qualitative Analysis of Carbohydrates via Osazone Method
12. Total Protein Estimation with Lowry's Method
13. Amino Acid Estimation using Ninhydrin Method
14. Total Cholesterol Estimation with Zak Method
15. Determination of Bile Salts in Urine
16. Measurement of Albumin Levels in Urine
17. Analysis of Unsaturated Fatty Acids
18. Assay for Salivary Amylase Activity

The syllabus for value-added courses at Pondicherry University, including Environmental Studies, Understanding India, Health, Wellness, Yoga Education, Sports & Fitness, and Digital Technological Solutions, is standardized as per the National Education Policy (NEP).

Value-added common courses I cover Environmental Studies, while Value-added common courses II focus on Understanding India.

For Value-added common courses III, the emphasis is on Health, Wellness, Yoga Education, Sports & Fitness. Lastly, Value-added common courses IV concentrate on Digital Technological Solutions.

VAC 01	NEP Value added common courses I	Environmental studies
	NEP Value added common courses II	Understanding India
VAC 02	NEP Value added common courses III	Health, Wellness, Yoga Education, Sports & Fitness
	NEP Value added common courses IV	Digital technological solutions

SEMESTER III

Theory Paper

MOLECULAR BIOLOGY

Course code: MJD 03 Total Marks : 100 (IA 25+EA75) Credits: 4

UNIT -I (10 hours)

Introduction to Molecular Biology, Types of genetic materials- Experiments of Griffith, Avery, MacLeod and McCarty, Hershey and chase, John Cairns experiment, Meselson- Stahl experiment, Central dogma of life.

UNIT -II (10 hours)

Replication of DNA, Models of DNA replication, Mechanism of DNA replication in prokaryotes (initiation, elongation, replication fork, replication machinery, termination), Enzymes and proteins involved in DNA replication (nucleases, DNA polymerases, DNA helicases, gyrases, SSBP, topoisomerase, primase).

UNIT -III (10 hours)

Mechanism of transcription in prokaryotes and eukaryotes. Enzymes and proteins involved in transcription, post transcriptional modifications. Inhibitors of transcription.

UNIT -IV (15 hours)

Genetic code - characteristics and properties, Wobble hypothesis. Protein biosynthesis in prokaryotes and eukaryotes, post translational modifications, protein degradation, Inhibitors of protein synthesis. Regulation of gene expression (lac, trp and gal operons).

UNIT -V (15 hours)

Mutation and its types- spontaneous, induced, reverse, suppressor mutations; chemical mutagens- alkylating agent, nitrous acid, hydroxylamine; physical mutagen- radiation. DNA repair- mismatch repair, base excision repair, nucleotide excision, direct repair and SOS repair.

Course Learning Outcomes (CLO): Students will be able to

1. Understand molecular biology fundamentals, including key experiments and genetic material types.
2. Explain DNA replication mechanisms in prokaryotes, involving enzymes and replication machinery.
3. Describe transcription processes, post-transcriptional modifications, and transcriptional inhibitors.
4. Analyze genetic code characteristics, protein biosynthesis, mutations, mutagens, and DNA repair mechanisms.
5. Comprehend the regulation of gene expression and the significance of operons in genetic control.

Reference Books :

1. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D., & Darnell, J. (2012). Molecular Cell Biology (7th ed.). W. H. Freeman.
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014).

Molecular Biology of the Cell (6th ed.). Garland Science.
3. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R. (2013). Molecular Biology of the Gene (7th ed.). Cold Spring Harbor Laboratory Press.
4. Voet, D., & Voet, J.G. (2010). Biochemistry (4th ed.). John Wiley & Sons.
5. Lehninger, A.L., Nelson, D.L., & Cox, M.M. (2021). Lehninger Principles of Biochemistry (8 th ed.). W. H. Freeman.
6. Krebs, J.E., Goldstein, E.S., & Kilpatrick, S.T. (2017). Lewin's GENES XII (12th ed.). Jones & Bartlett Learning.
7. Strachan, T., & Read, A.P. (2010). Human Molecular Genetics (4th ed.). Garland Science.
8. Brown, T.A. (2010). Gene Cloning and DNA Analysis: An Introduction (6th ed.). Wiley-Blackwell.
9. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., & Doebley, J. (2015). Introduction to Genetic Analysis (11th ed.). W. H. Freeman.
10. Berg, J.M., Tymoczko, J.L., Gatto Jr, G.J., & Stryer, L. (2015). Biochemistry (8th ed.). W. H. Freeman.

ANALYTICAL TECHNIQUES IN BIOLOGY Theory Paper

Course code: **MJD 04** Total Marks : 100 (IA 25+EA75) Credits: 4

UNIT -I (10 hours)

Solutions: Water- Structure and interaction, water as solvent, pH, Bronsted-Lowry concept of acid and bases, ionization, Buffer: Henderson-Hasselbalch equation, Biological buffer system (bicarbonate, phosphate buffers and Tris buffers), Determination of molecular weight- molarity, molality, normality, equivalent weight

UNIT -II (10 hours)

Spectroscopy: Colorimetry, Basic principles, Beer-Lamberts law, instrumentation and application of UV-Vis and IR spectroscopy, Centrifugation – Principle & types, sedimentation co-efficient, sedimentation velocity, ultra centrifugation, separation of macromolecules, subcellular fractionation.

UNIT -III (10 hours)

Chromatography – Basic principle & types – paper chromatography, thin layer chromatography, column chromatography: gel exclusion, adsorption, ion exchange, affinity. Application of chromatographic technique – separation of biomolecules

UNIT -IV (15 hours)

Electrophoresis and Tracer techniques: – Principle, DNA and RNA gel electrophoresis, Protein gel electrophoresis – SDS PAGE, native-PAGE, documentation, 2D-electrophoresis, Isoelectric focusing. Nature of radioactivity, isotopes, radioactive decay, α, β and γ radiation, Scintillation counter, application of radioisotopes in biological sample.

UNIT -V (15 hours)

Bio-Physical Techniques: Crystallography: basic concepts & laws, symmetry of elements in crystal X–ray crystallography, determination of crystal structure. Fluorescence: concepts, emission, chemi-luminescence, luminometry. NMR-2D & 3D structure prediction.

Course Learning Outcomes (CLO): Students will be able to

1. Grasp intricate water properties, pH, and acid-base theories thoroughly.
2. - Master spectroscopy techniques for precise biomolecule analysis.
3. - Proficiently employ chromatography methods for effective biomolecule separation.
4. - Skillfully apply advanced bio-physical techniques for accurate structure prediction
5. Grasp intricate water properties, pH, and acid-base theories thoroughly.

Reference Books :

1. Skofronick, J.G., Turn, S.Q., & Szuminsky, N.J. (2014). Fundamentals of Analytical Chemistry (9th ed.). Cengage Learning.
2. Christian, G.D., & O'Reilly, J.E. (2018). Instrumental Analysis (7th ed.). Waveland Press.
3. Skoog, D.A., Holler, F.J., & Crouch, S.R. (2007). Principles of Instrumental Analysis (6th ed.). Brooks/Cole.
4. Miller, J.N., & Miller, J.C. (2018). Statistics and Chemometrics for Analytical Chemistry (6th ed.). Pearson.
5. Harris, D.C. (2015). Quantitative Chemical Analysis (9th ed.). W. H. Freeman.
6. Belcher, R. (2019). A Practical Approach to Quantitative Metal Analysis of Organic Matrices (2nd ed.). Springer.
7. Townshend, A. (2015). Chromatographic and Electrophoretic Techniques (5th ed.). Butterworth-Heinemann.
8. Jennings, K.R. (2015). Analytical Atomic Absorption Spectroscopy (2nd ed.). Academic Press.
9. Jenkins, R., & Snyder, L.R. (2013). Introduction to X-ray Powder Diffractometry (2nd ed.). Wiley.
10. Freeman, A., & Hall, A.J. (2019). Basic Analytical Chemistry (2nd ed.). Royal Society of Chemistry.

PLANT SCIENCE Theory Paper with Practical

Course code: **MID 03** Total Marks : 100 (IA 25+EA75) Credits: 3(T) + 1(P)

UNIT -I (10 hours)

Cryptogams: Algae, Fungi, Bryophytes, Pteridophytes - structure and reproduction from evolutionary viewpoint. Distribution of Cryptogams in India and their economic potential. Phanerogams: Gymnosperms: Concept of Progymnosperms. Classification and distribution of Gymnosperms. Angiosperms: Systematics, anatomy, embryology, and phylogeny.

UNIT -II (10 hours)

Plant Physiology: Water relations, Mineral nutrition, and ion transport, mineral deficiencies. Photoperiodism and flowering, vernalization, senescence. Growth substances - chemical nature, role in agri-horticulture, growth movements. Stress physiology (heat, water, salinity, metal). Fruit and seed physiology.

UNIT -III (10 hours)

Genetics & Evolution: Development of genetics, gene versus allele concepts (Pseudo alleles). Quantitative genetics. Linkage and crossing over - gene mapping methods including molecular maps. Sex chromosomes and sex-linked inheritance, sex determination. Origin of life, natural selection, mutation in evolution, mimicry, variation, isolation, speciation. Hardy-Weinberg Law.

UNIT -IV (15 hours)

Plant Utility and Exploitation: Origin of cultivated plants, Vavilov's centres. Plants as sources for food, fodder, fibres, spices, beverages, drugs, timber, cellulose, starch and other special products. Importance of Ethnobotany in India. Energy plantation. Botanical Gardens and Herbaria.

UNIT -V (15 hours)

Plant geography: Forest types of India - afforestation, deforestation and social forestry. Endangered plants, endemism and Red Data Books. Bio-diversity. Convention of Biological Diversity, Sovereign Rights.

Course Learning Outcomes (CLO): Students will be able to

1. Understand the diversity, structure, and economic significance of Cryptogams and Phanerogams.
2. Explain fundamental plant physiology concepts such as water relations, mineral nutrition, and photoperiodism.
3. Comprehend key genetics and evolution principles, including gene mapping and speciation.
4. Analyze the utility of plants, plant geography, and biodiversity conservation.
5. Demonstrate knowledge of plant physiology, genetics, and the importance of conservation in practical applications.

Reference Books :

1. Taiz, L., & Zeiger, E. (2010). Plant Physiology (5th ed.). Sinauer Associates, Inc. Sunderland.
2. Taylor, D. J., Green, N.P.O., & Stout, G.W. (2008). Biological Science (3rd ed.). Cambridge University Press.
3. Raven, P.H., Johnson, G.B., Mason, K.A., Losos, J.B., & Singer, S.R. (2011). Biology (9th ed.). Tata McGraw Hill Education, New Delhi.
4. Gardner, E.J., Simmons, M.J., & Snustad, D.P. (2008). Principles of Genetics (8th ed.). Wiley India.
5. Hopkins, W.G., & Hüner, N.P.A. (2008). Introduction to Plant Physiology (4th ed.). Wiley.
6. Buchanan, B.B., Gruissem, W., & Jones, R.L. (2015). Biochemistry and Molecular Biology of Plants (2nd ed.). Wiley Blackwell.
7. Singh, G. (2016). Plant Systematics: Theory and Practice (3rd ed.). Oxford & IBH Publishing.
8. Mauseth, J.D. (2014). Botany: An Introduction to Plant Biology (6th ed.). Jones & Bartlett Learning.
9. Smith, A.M., Coupland, G., Dolan, L., Harberd, N., Jones, J., Martin, C., Sablowski, R., & Amey, A. (2010). Plant Biology (2nd ed.). Garland Science.
10. Pandey, B.P. (2016). Economic Botany. S. Chand Publishing.

PLANT SCIENCE PRACTICALS

Code: MJD 01 (P) Practical marks: 100 (IA 50+EA 50)

List of Practicals

1. Dissection of stem of dicot plants and monocot plants
2. Dissection of root of dicot plants and monocot plants.
3. Dissection of leaf of dicot plants and monocot plants.
4. Demonstration of Barr body from buccal cheek cells.
11. Isolation of polytene chromosomes from Chironomus larva.
12. Estimate the rate of transpiration using Ganong's potometer.
13. Dissection of Pinus leaf.
14. Determination of stomatal frequency and stomatal index of leaf.
15. Determination of osmotic potential of cell sap by plasmolytic method.
16. Herbarium.

BIOTECHNOLOGICAL LABORATORY TECHNIQUES -III

Practical Paper

Course code: **SEC 03** Practical Marks : 100 (IA 50+EA50) Credits: 3

List of Practicals

1. Operating shakers, incubators, pH meters, and centrifuges.
2. Preparing buffers such as Phosphate, Acetate, and Citrate.
3. Performing density gradient centrifugation.
4. Conducting agarose gel electrophoresis for DNA.
5. Executing Poly Acrylamide Gel Electrophoresis for proteins.
6. Staining SDS-PAGE gels using Coomassie Brilliant Blue and silver staining methods.
7. Utilizing column chromatography for separation.
8. Implementing thin-layer chromatography.
9. Estimating nucleic acid content via colorimetric methods.
10. Isolating DNA from prokaryotes like E. coli.
11. Extracting DNA from eukaryotes such as Saccharomyces cerevisiae.
12. Extracting proteins from E. coli.
13. Determining the molecular weight of DNA.
14. Inducing physical mutations using UV irradiation.
15. Quantifying DNA content.
16. Isolating total RNA from bacterial samples.
17. Analyzing DNA melting curves.

SEMESTER IV

IMMUNOLOGY Theory with practical Paper

Course code: **MJD 05** Total Marks : 100 (IA 25+EA75) Credits: **3(T) +1(P)**

UNIT -I (10 hours)

Immunology - History & Milestones, Microbial infections and host resistance. Immune response: Innate & Adaptive responses, Humoral and cell mediated Immune Responses. Structures, composition and functions of cells and organs of immune system.

UNIT -II (10 hours)

Antigens & Immunogenicity. Antigens - Types, properties, Haptens, Adjuvants, Toxoids, Immunoglobulins- structure, types and properties, Theories of antibody formation, Structural and genetic basis of antibody formation.

UNIT -III (10 hours)

Antigen and antibody reactions, Immunodiagnostic methods - Agglutination, precipitations, complement fixation, RIA, ELISA and its types, Immunofluorescence, Production of Monoclonal Antibodies and Hybridoma technique.

UNIT -IV (15 hours)

Cytokines & Chemokines - Classification, types and its functions, Complement system: structure, properties, functions of complement components and its pathways.

UNIT -V (15 hours)

Immune disorders and tumors: Types of tumors, tumor antigens, immune response to tumors. Immunodeficiency and Auto immune diseases, MHC - Structure and function of class I and class II MHC molecules, Hypersensitivity reactions: Type I, II, III and IV Transplantation immunology - types and mechanisms involved.

Course Learning Outcomes (CLO): Students will be able to

1. Describe and explain the fundamental principles of modern immunology.
2. Understand and apply related immunological techniques in medical laboratories.
3. Relate and apply medical laboratory science knowledge to immunological changes in healthy and disease contexts.
4. Analyze the roles of cytokines, chemokines, and the complement system in immune responses.
5. Evaluate immune disorders, tumor immunology, and transplantation immunology.

Reference Books :

1. Roit, I.M., & Delves, P.J. (2001). Essential Immunology (10th ed.). Blackwell Science, Oxford.

2. Kuby, J. (2013). Immunology (8th ed.). W.H. Freeman and Company, New York.
3. Kumar, M.S., & Sai, L.K. (2014). Microbiology and Immunology (2nd ed.). Jaypee Brothers Medical Publishers.
4. Male, D., & Roth, D. (2013). Immunology (8th ed.). Reed Elsevier India Pvt Limited.
5. Abbas, A.K., Lichtman, A.H., & Pillai, S. (2016). Cellular and Molecular Immunology (8th ed.). Elsevier.
6. Janeway, C.A., Travers, P., Walport, M., & Shlomchik, M.J. (2012). Immunobiology: The Immune System in Health and Disease (8th ed.). Garland Science.
7. Goldsby, R.A., Kindt, T.J., Osborne, B.A., & Kuby, J. (2012). Immunology (7th ed.). W.H. Freeman and Company.
8. Punt, J., Stranford, S., Jones, P., & Owen, J. (2019). Kuby Immunology (8th ed.). W.H. Freeman and Company.
9. Parham, P. (2009). The Immune System (3rd ed.). Garland Science.
10. Murphy, K., Weaver, C., & Berg, L. (2016). Janeway's Immunobiology (9th ed.). Garland Science.

IMMUNOLOGY PRACTICALS

Code: **MJD 05 (P)** Practical Marks : 100 (IA 50+EA50)

List of Practicals

1. Single Immunodiffusion analysis
2. Double Immunodiffusion analysis.
3. Rocket Immuno-electrophoresis.
4. Separation of PBMC from the blood sample.
5. Slide & Tube Agglutination Reaction
6. Extraction of antigens from microbes
7. Purification of Antibodies.
8. Preparation of murine splenolymphocytes
9. Enzyme-Linked Immunosorbent Assay

GENETIC ENGINEERING Theory with practical Paper

Course code: **MJD 06** Total Marks : 100 (IA 25+EA75) Credits: **3(T) +1(P)**

UNIT -I (10 hours)

History and basic steps involved in genetic engineering, Enzymes involved in genetic engineering (Nucleases, Restriction enzymes and their types, DNA ligases and ligation, Kinases, Phosphatases, Reverse transcriptase, Deoxynucleotidyl transferases, DNA polymerase), Restriction mapping.

UNIT -II (10 hours)

Basic design of cloning vectors - plasmid (pBR322 and pUC 18/19), cosmids, phage vectors (lambda and M13), phagemid, yeast vectors (YEp, YRp, YIp), shuttle vectors, BAC and YAC

Expression of cloned genes - general features of an expression vector, expression of eukaryotic gene in prokaryotes - advantages and limitations.

UNIT -III (10 hours)

Gene transfer techniques - physical (Electroporation, microinjection and biolistic transformation), chemical ($CaCl_2$ mediated transformation and Lipofection), transduction.

Selection of recombinants - blue and white screening and plus and minus screening.

UNIT -IV (15 hours)

Construction of genomic and cDNA library, PCR- steps involved, Guidelines for PCR primer designing, variants of PCR (multiplex, nested, quantitative real time, RT- PCR), applications and limitations.

Blotting - southern, northern and western blotting; Nucleic acid and immuno probes.

UNIT -V (15 hours)

Manipulation of gene sequences by random mutations and site directed mutagenesis, Applications of Genetic engineering in industry, medicine and agriculture. Bioethics and Biosafety.

Course Learning Outcomes (CLO): Students will be able to

1. Apply landmark discoveries to develop molecular techniques in rDNA technology.
2. Select suitable hosts for specific vectors in diverse applications.
3. Utilize restriction enzymes and other tools for genetic manipulations.
4. Conduct PCR applications and gene expression experiments for research purposes.
5. Understand the ethical and safety considerations in genetic engineering applications.

Reference Books :

1. Primrose, S.B., & Twyman, R. (2006). Principles of Gene Manipulation and Genomics (7th ed.). Wiley-Blackwell.
2. Brown, T.A. (2010). Gene Cloning and DNA Analysis: An Introduction (6th ed.). Wiley-

Blackwell.
3. Winnacker, E.L. (2003). From Genes to Clones: Introduction to Gene Technology (4th ed.). Panima Publishing Corporation.
4. Green, M.R., & Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual (4th ed.). Cold Spring Harbor Laboratory Press.
5. Glick, B.R., & Pasternak, J.J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA (4th ed.). ASM Press.
6. Dale, J.W., & von Schantz, M. (2007). From Genes to Genomes: Concepts and Applications of DNA Technology (2nd ed.). Wiley-Blackwell.
7. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the Cell (6th ed.). Garland Science.
8. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R. (2013). Molecular Biology of the Gene (7th ed.). Cold Spring Harbor Laboratory Press.
9. Clark, D.P., & Pazdernik, N.J. (2012). Biotechnology: Applying the Genetic Revolution (2nd ed.). Elsevier Academic Press.
10. Campbell, A.M., & Heyer, L.J. (2006). Discovering Genomics, Proteomics, and Bioinformatics (2nd ed.). Benjamin Cummings.

GENETIC ENGINEERING PRACTICALS

Code: **MJD 06 (P)** Practical Marks : 100 (IA 50+EA50)

List of Practicals

1. Plasmid DNA isolation.
2. Restriction digestion of pBR322
3. Ligation using pET vector
4. Southern hybridization.
5. Preparation of Competent Cell.
6. Transformation & blue white screening.
7. Isolation of total RNA from Bacteria.
8. Polymerase chain reaction.
9. SDS-PAGE of Bacterial Proteins.
10. Plasmid curing.

PARASITOLOGY AND ENTOMOLOGY Theory Paper

Course code: **MJD 07** Total Marks : 100 (IA 25+EA75) Credits: 4 **(T)**

UNIT -I (10 hours)

General Consideration: Taxonomy, Transmission of parasites, Pathogenesis and pathology, Host immunity in parasitic infections, Clinical manifestations of parasitic infections, Laboratory diagnosis of parasitic infections, Prevention and control of parasitic infections

UNIT -II (10 hours)

Protozoa: *Plasmodium falciparum*- Habitat, Morphology, Pathogenesis and pathology, Host immunity in parasitic infections, Clinical manifestation and laboratory diagnosis of *P. falciparum*, its prevention and control.

UNIT -III (10 hours)

Platyhelminthes: *Fasciola hepatica*- Habitat, Morphology, Pathogenesis and pathology, Host immunity in parasitic infections, Clinical manifestation and laboratory diagnosis of *F. hepatica*, its prevention and control.

UNIT -IV (15 hours)

Nematodes: *Wuchereria bancrofti*- Habitat, Morphology, Pathogenesis and pathology, Host immunity in parasitic infections, Clinical manifestation and laboratory diagnosis of *W. bancrofti*, its prevention and control.

UNIT -V (15 hours)

Entomology and disease transmission: Life cycles of arthropod vectors - ticks, mites, fleas, mosquitoes and flies. Vector transmitted diseases in India and control measures

Course Learning Outcomes (CLO): Students will be able to

1. Understand the taxonomy, transmission, pathogenesis, and pathology of parasitic infections.
2. Analyze host immunity, clinical manifestations, and laboratory diagnosis of specific parasitic infections including Plasmodium falciparum, Fasciola hepatica, and Wuchereria bancrofti.
3. Evaluate prevention and control measures for parasitic infections, considering clinical, laboratory, and public health perspectives.
4. Examine the life cycles of arthropod vectors and their role in transmitting diseases, with a focus on vector-borne diseases in India and corresponding control strategies.
5. Integrate knowledge of parasitology and entomology to develop comprehensive strategies for managing parasitic diseases and vector-borne illnesses.

Reference Books :

1. Parija SC, Text Book of Medical Parasitology, Protozoology & Helminthology (3rd edition), All India Publishers & Distributors (2008).
2. Arora. D.R. and Arora, B, Medical Parasitology (1st edition), CBS Publishers & Distributors, New Delhi (2002).
3. Easwari Nayar, Hand Book on Medical Entomology, Kalpana Printing House, Delhi (1994).
4. Garcia LS, Bruckner DA, Diagnostic Medical Parasitology. American Society for Parasitology, Washington DC, (2004).
5. Chatterjee KD, Parasitology: Protozoology and Helminthology (13th edition), CBS Publishers & Distributors, New Delhi (2009).
6. Roberts LS, Janovy J, Nadler S. Foundations of Parasitology (9th edition), McGraw-Hill Education (2012).
7. Smyth JD, Animal Parasitology (3rd edition), Cambridge University Press (1996).
8. Service MW, Medical Entomology for Students (5th edition), Cambridge University Press (2012).
9. Mullen GR, Durden LA, Medical and Veterinary Entomology (2nd edition), Academic Press (2009).
10. Chandler AC, Read CP, Introduction to Parasitology (10th edition), Wiley (1961).

ANIMAL SCIENCE Theory with practical Paper

Course Code: **MID 04** Total Marks : 100 (IA 25+EA75) Credits: **3(T) +1(P)**

UNIT -I (10 hours)

Nemathelminthes: General features, life history, and parasitic adaptation. Annelida: Coelom, metamerism; life history of nereis and earthworm. Arthropoda: Larval forms and parasitism in Crustacea; vision and respiration in arthropods ; mouthpart modifications in insects ; insect metamorphosis and hormonal regulation; social organization in insects .

UNIT -II (10 hours)

Mollusca: Feeding, respiration, locomotion, shell diversity; life history of Pila and Sepia, torsion, and detorsion in gastropods. Echinodermata: Feeding, respiration, locomotion, larval forms; life history of Asterias. Protochordata: Origin of chordates; life history of Branchiostoma and Herdamania. Pisces: Scales, respiration, locomotion, migration. Amphibia: Origin of tetrapods; parental care, paedomorphosis. Reptilia: Origin of reptiles; skull types; status of Sphenodon and crocodiles. Aves: Origin of birds; flight adaptation, migration.

UNIT -III (10 hours)

Non-chordata and Chordata: Classification and relationships of phyla up to subclasses; Acoelomata and Coelomata; Protostomes and Deuterostomes; Bilateralia and Radiata; Status of Protista, Parazoa, Onychophora, Hemichordata; Symmetry. Porifera: Skeleton, canal system, reproduction; life history of Obelia and Aurelia.

UNIT -IV (15 hours)

Mammalia: Origin of mammals; dentition; features of egg-laying mammals, pouched mammals, aquatic mammals, and primates; endocrine glands and hormone-producing structures. Comparative functional anatomy of vertebrate systems.

UNIT -V (15 hours)

Economic Zoology & Ethology: Apiculture, sericulture, lac culture. Major infectious and communicable diseases, their vectors, pathogens, prevention. Pests of sugar cane (Pyrilla perpusiella), oilseed (Achaea janata, and rice (Sitophilus oryzae). Sensory filtering, responsiveness, sign stimuli, learning, instinct, habituation, conditioning, imprinting. Role of hormones in drive; pheromones in alarm spreading; crypsis, predator detection, social behavior in insects and primates; courtship

Course Learning Outcomes (CLO): Students will be able to

1. Understand the diversity and adaptations of major invertebrate and vertebrate groups.
2. Analyze the classification and characteristics of Non-chordata and Chordata phyla.
3. Evaluate economic aspects of zoology such as apiculture, sericulture, and disease prevention.
4. Examine principles of ethology including learning, instinct, and social behavior in animals.

5. Comprehend the physiological and anatomical adaptations in various animal taxa and their evolutionary significance.

Reference Books :

1. Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford University Press.
2. Pough, H. (2008). Vertebrate Life. VIII Edition. Pearson International.
3. Taylor, D. J., Green, N.P.O., & Stout, G.W. (2008). Biological Science (3rd Edition). Cambridge University Press.
4. Hall, B.K., & Hallgrimsson, B. (2008). Strickberger's Evolution (4th Edition). Jones and Bartlett Publishers Inc.
5. Hickman, C.P., Roberts, L.S., & Larson, A. (2009). Integrated Principles of Zoology (15th Edition). McGraw-Hill.
6. Pechenik, J. A. (2014). Biology of the Invertebrates (7th Edition). McGraw-Hill.
7. Brusca, R.C., & Brusca, G.J. (2003). Invertebrates (2nd Edition). Sinauer Associates.
8. Romer, A.S., & Parsons, T.S. (1986). The Vertebrate Body (6th Edition). Saunders College Publishing.
9. George, J.C., & Bhaskaran, M. (2010). Animal Physiology (2nd Edition). S. Chand & Company Ltd.
10. Hickman, C.P., & Kats, L.B. (2017). Laboratory Studies in Integrated Principles of Zoology (16th Edition). McGraw-Hill.

ANIMAL SCIENCE PRACTICALS

Code: MJD 07 **(P)** Practical Marks : 100 (IA 50+EA50)

List of Practicals

1. Dissection of mouth parts of cockroach.
2. Isolation of body setae from earth worm.
3. Isolation of placoid scales from cartilaginous fishes.
4. Isolation of polytene chromosomes from Chironomus larva.
5. Studying the age of the fish from the scales.
6. Dissection of appendages of prawn.
7. Identification of male and female in Drosophila.
8. Mounting of penial setae of earthworm.
9. Mounting of radula in Pila.
10. Mounting of mouth parts of mosquito and honey bee.
11. Isolation of ctenoid scales in bony fishes.

SEMESTER V

BIOPROCESS TECHNOLOGY Theory with practical Paper

Course code: **MJD 08** Total Marks : 100 (IA 25+EA75) Credits: **3(T) + 1 (P)**

UNIT -I (10 hours)

Principles of Bioprocess technology – Introduction and history of traditional and modern bioprocess technology. General concepts of fermentation technology – Outline of an integrated bioprocess and various unit operations. Industrially important microbes: Isolation, Screening & Preservation techniques – Slant culture, spore culture, overlaying culture with mineral oil, Lyophilization, Cryopreservation – Strain improvement – mutation, protoplast fusion & rDNA techniques for strain development– Maintenance of Industrially important microbes.

UNIT -II (10 hours)

Introduction to fermentation - Types of fermentation processes (Submerged & solid static) - Media formulation - Synthetic and complete media, Sterilization (batch & continuous) – Air, Filter and Media sterilization – Operation: Inoculum preparation and sampling. Fermenters: Design of a fermenter – Types: Stirred tank, Fluidized bed, Immobilized bed bioreactors, Photo bioreactors, Air lift bioreactors and its other types.

UNIT -III (10 hours)

. Microbial growth and death kinetics - Bioprocess control & monitoring of various factors, temperature, agitation, pressure, pH, dissolved oxygen and foam sensing – online measurements, Control systems – Manual control, Automatic control - on/off control & PID control, Computer applications in fermentation technology - Scale up & Scale down of microbial reactions.

UNIT -IV (15 hours)

Down- stream processing: Removal of microbial cells and solid matter – Precipitation, Filtration, Centrifugation, Liquid – Liquid extraction, Chromatography and membrane processes, BOD and COD measurements, Disposal of industrial wastes.

UNIT -V (15 hours)

Industrial waste water treatment and disposal: Physical treatment, chemical treatment and biological treatments. Aerobic processes - trickling filter, towers, biologically aerated filters, rotating drums, fluidized bed systems, activated sludge process. Anaerobic treatment - anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blankets. Disposal - seas and rivers, lagoons, spray irrigation, well-disposal, landfilling, incineration, disposal of effluents to sewers.

Course Learning Outcomes (CLO): Students will be able to

1. Understand principles, history, and types of bioprocess technology and fermentation.

2. Learn microbial growth kinetics, bioprocess control, and fermenter design.
3. Apply downstream processing techniques and waste measurement methods.
4. . Evaluate industrial wastewater treatment and disposal methods.
5. Integrate knowledge of bioprocess technology to optimize and innovate industrial microbial processes for various applications.

Reference Books :

1. Stanbury P.F., Whitaker. A & Hall. S. J., Principles of Fermentation Technology (2nd edition), Aditya Books Private Ltd., 2000.
2. Crueger, W. and Crueger, A., Biotechnology: A Textbook of Industrial Microbiology (2nd edition), Panima Publishing Corporation, New Delhi, 2000.
3. Waites M.J., Morgan N.L., Rockey J.S., Industrial Microbiology (2nd edition), Blackwell Science, 2002.
4. Demain L. & Davies E., Manual of Industrial Microbiology and Biotechnology (2nd edition), ASM Press, Washington, 2004.
5. Shuler M.L. and Kargi F., Bioprocess Engineering: Basic Concepts (2nd edition), Prentice Hall, 2002.
6. Doran P.M., Bioprocess Engineering Principles (2nd edition), Academic Press, 2012.
7. Patel A.H., Industrial Microbiology (1st edition), Macmillan India Ltd, 1996.
8. El-Mansi E.M.T., Bryce C.F.A., Fermentation Microbiology and Biotechnology (3rd edition), CRC Press, 2011.
9. Moo-Young M., Comprehensive Biotechnology (2nd edition), Pergamon Press, 2011.
10. Casida L.E., Industrial Microbiology (1st edition), New Age International Publishers, 1999.

BIOPROCESS TECHNOLOGY PRACTICALS

Code: **MJD 08 (P)** Practical Marks : 100 (IA 50+EA 50)

List of Practicals

1. Fermenter design and structure.
2. Inoculum preparation and sterilization
3. Preparation of Wine
4. Isolation of lactic acid bacteria from curd
5. Isolation of amylase producing microorganisms
6. Isolation of antibiotic producing microorganisms from soil
7. Estimation of COD.
8. Estimation of BOD.
9. Immobilization of bacterial cells.

ANIMAL BIOTECHNOLOGY Theory with practical Paper

Course code: **MJD 09** Total Marks : 100 (IA 25+EA75) Credits: **3(T) + 1 (P)**

UNIT -I (10 hours)

Introduction, history, basic concepts of animal cell culture, primary cell culture and established cell lines, maintenance of cultures, requirements of animal cell culture, media - natural (clots, biological fluids and tissue extracts) and synthetic (serum containing media, serum free media, chemically defined media, protein free media).

UNIT -II (10 hours)

Basic techniques of mammalian cell culture, disaggregation of animal tissues - mechanical, enzymatic and EDTA, evolution of cell line, monolayer culture, suspension culture, immobilized culture, organ culture - plasma clot, raft method, agar gel, grid method, embryo culture, maintenance of cell culture.

UNIT -III (10 hours)

. Artificial insemination, Super ovulation, In vitro fertilization and embryo transfer, applications and limitation, Transgenic animals (avian, rodent & ruminants), Transgenic methods, Embryonic Stem cell transfer, Targeted Gene Transfer, Detection of transgenic animals, Production of useful proteins in transgenic animals, Sericulture basics and production of useful proteins through sericulture.

UNIT -IV (15 hours)

Role of Animal models in Experimentation. Molecular markers - RFLP, RAPD, VNTR, AFLP. Somatic and Reproductive cloning - Definition, history and types. Somatic cell nuclear transfer, story of dolly, Therapeutic cloning and its significance.

UNIT -V (15 hours)

Animal diseases (cattle) -Mad cow, Anthrax, Foot and Mouth, Lumpy skin, Bluetongue; (Poultry)- Newcastle; Bird flu, Avian Influenza, Marek's disease – Vaccines; Bioethics and biosafety in animal handling.

Course Learning Outcomes (CLO): Students will be able to

1. Explain the fundamental scientific principles of animal cell culture and techniques for cell isolation, maintenance, and growth.
2. Gain insight into mammalian cell culture techniques, disaggregation methods, and various culture types.
3. Understand artificial insemination, IVF, transgenic animals, and production of proteins through biotechnological methods.
4. Recognize the significance of animal models, molecular markers, cloning techniques, and bioethics in animal research.
5. Analyze and interpret the impact of various animal diseases on livestock and poultry, and understand the role of vaccines and bioethics in disease

management.

Reference Books :

1. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten, Molecular Biotechnology: Principles and Applications of Recombinant DNA (4th edition), ASM Publisher, 2009.
2. Michael Wink, An Introduction to Molecular Biotechnology: Fundamentals, Methods and Applications (2nd edition), John Wiley and Sons, 2013.
3. Ganga. G & Slochanachetty, An Introduction to Sericulture (2nd edition), Oxford and IBH Publishers Pvt. Ltd., Delhi, 2012.
4. Old R.W, Primrose S.B, Twyman R. M, Principles of Gene Manipulation (6th edition), Blackwell Sciences, 2001.
5. R.I. Freshney, Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (6th edition), Wiley-Blackwell, 2010.
6. Ian Freshney, Animal Cell Culture: A Practical Approach (3rd edition), Oxford University Press, 2000.
7. John M. Walker and Ralph Rapley, Molecular Biology and Biotechnology (5th edition), Royal Society of Chemistry, 2014.
8. John R. Masters, Animal Cell Culture: Practical Approach (3rd edition), Oxford University Press, 2000.
9. Bruce Alberts, Molecular Biology of the Cell (5th edition), Garland Science, 2007.
10. Julian Davies, Recombinant DNA Techniques: An Introduction (1st edition), Jones and Bartlett Publishers, 1993.

ANIMAL BIOTECHNOLOGY PRACTICALS

Code: **MJD 09(P)** Practical Marks : 100 (IA 50+EA50)

List of Practicals

1. Isolation of chick emryos
2. Isolation of CAM from chick embryo for culture
3. Isolation of organ rudiments for primary culture from chick embryos. Effect of drugs on PBMCs:
4. Dye exclusion assay- Trypan blue assay and cell counting using Hemocytometer.
5. Effect of various drugs on hPBMCs- lymphocyte proliferation assay. Protein profiling from hPBMCs:
6. Protein isolation from drug treated hPBMCs
7. SDS-PAGE of proteins isolated from drug treated hPBMCs
8. Western blotting

ENVIRONMENTAL BIOTECHNOLOGY Theory with practical Paper

Course code: **MJD 10** Total Marks : 100 (IA 25+EA75) Credits: **3(T) + 1 (P)**

UNIT -I (10 hours)

Introduction to environmental biotechnology, Non Renewable resources - coal, petroleum, and natural gas. Renewable resources - solar, wind, tidal, biomass, nuclear, geothermal and hydroelectric resources. Current status and environmental impact of renewable and non-renewable resources

UNIT -II (10 hours)

Methanogenic bacteria and biogas, microbial hydrogen production, conversion of sugars to alcohols, plant-based petroleum industry, cellulose as the source of energy, Environmental impact of modern fuels.

UNIT -III (10 hours)

. Principles of waste management, types, sources and effects of solid waste, Physical and biological treatment methods, Concept of composting and vermicomposting, Waste to energy conversion, Disposal of wastes.

UNIT -IV (15 hours)

Basics and types of bioremediation, Bioremediation of oil, heavy metals, pesticides contaminated soil and water, Phytoremediation and its types, Biochemical and genetic basis of biodegradation, Xenobiotic compounds and recalcitrance, Biodegradation of pesticides and petroleum products, Biotransformation of heavy metals, Biopolymers and Biodegradable plastics.

UNIT -V (15 hours)

Biomonitoring - Bioassays, Biosensors, Biochips, Biological indicators and Biomarkers, Biorestoration of waste land, Bioleaching – microbes involved, Role of Biotechnology in pollution abatement.

Course Learning Outcomes (CLO): Students will be able to

1. Comprehend environmental issues and the role of biotechnology in the cleanup of contaminated environments.
2. Comprehend the fundamentals of biodegradation, biotransformation, and bioremediation of organic contaminants and toxic metals.
3. Apply biotechnological processes in wastewater and solid waste management.
4. Comprehend biofuels/bioenergy systems; attributes for biofuel/bioenergy production and demonstrate innovative solutions for environmental challenges.
5. Understand and evaluate the applications of biosensors, biochips, and biorestoration in environmental biotechnology.

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Reference Books :

1. Scragg A. H, Environmental Biotechnology (2nd revised edition), Oxford University Press, 2005.
2. Jogdand S. N, Environmental Biotechnology (3rd edition), Himalaya

Publishing House Pvt. Ltd., 2012.
3. Thakur I. S, Environmental Biotechnology: Basic Concepts and Applications (2nd revised edition), I K International Publishing House Pvt. Ltd., 2011.
4. Varnam A. H, Environmental Microbiology (1st Edition), ASM Press, 2001.
5. Rittmann B.E. and McCarty P.L, Environmental Biotechnology: Principles and Applications (1st edition), McGraw-Hill, 2001.
6. Jordening H.J. and Winter J., Environmental Biotechnology: Concepts and Applications (1st edition), Wiley-VCH, 2005.
7. Evans G.M. and Furlong J.C., Environmental Biotechnology: Theory and Application (1st edition), John Wiley & Sons, 2003.
8. Maier R.M., Pepper I.L., and Gerba C.P., Environmental Microbiology (2nd edition), Academic Press, 2009.
9. Singh A. and Ward O.P., Biodegradation and Bioremediation (2nd edition), Springer, 2004.
10. Atlas R.M. and Bartha R., Microbial Ecology: Fundamentals and Applications (4th edition), Benjamin Cummings, 1997.

ENVIRONMENTAL BIOTECHNOLOGY PRACTICALS

Code: MJD 10 **(P)** Practical Marks : 100 (IA 50+EA50)

List of Practicals

1. Biodiesel production from vegetable oil (Lipase-Catalysis method)
2. Bioethanol production from organic waste.
3. Enumeration of microorganisms from sewage samples.
4. Isolation of cellulolytic organisms from soil.
5. Isolation of phage from sewage.
6. Preparation of phage stock.
7. Estimation of total hardness in water.
8. Estimation of nitrite in water sample.
9. Estimation of salinity in water samples.
10. A Visit to Waste water treatment (Sewage and Industrial effluents treatment)

SCIENTIFIC WRITING & PRESENTATION SKILLS Theory Paper

Course code: **MID 05** Total Marks: 100 (IA 25+EA75) Credits: 4 **(T)**

UNIT -I (10 hours)

Purpose, audience, and style of scientific writing; primary vs. secondary sources; peer review process., Structuring documents: abstracts, introductions, methods, results, discussions, conclusions., Effective communication principles: clarity, conciseness, coherence., Ethical considerations: plagiarism, authorship, conflicts of interest.

UNIT -II (10 hours)

Developing research questions and hypotheses., Literature review: searching databases, evaluating sources, synthesizing information., Crafting titles and abstracts; writing methods sections., Presenting results: tables, figures, statistical analysis.

UNIT -III (10 hours)

. Planning presentations: objectives, content structure, visuals., Oral communication: delivery techniques, voice modulation, body language., Designing visual aids: slides, posters, multimedia tools., Handling questions, engaging audience, practice sessions, feedback

UNIT -IV (15 hours)

Publication process: journal selection, manuscript submission, peer review., Manuscript writing: structure, titles, abstracts, formatting., Responding to reviewer comments, revising manuscripts., Ethical publishing: authorship, conflicts of interest, data integrity.

UNIT -V (15 hours)

Grant writing: identifying opportunities, developing proposals., Writing for diverse audiences: policymakers, general public, interdisciplinary., Scientific posters and presentations for conferences., Professional online presence: academic profiles, social media, networking., Career development in science communication: writing, editing, journalism.

Course Learning Outcomes (CLO): Students will be able to

1. Master the principles and ethics of scientific writing, including structuring and clarity.
2. Develop and refine research questions, literature reviews, and effective abstracts.
3. Enhance presentation skills, utilizing visual aids and effective communication techniques.
4. Navigate the publication process, from manuscript writing to responding to reviewer feedback.
5. Write effective grant proposals and communicate scientific information to diverse audiences.

Reference Books :

1. Day, R. A., & Gastel, B. How to Write and Publish a Scientific Paper (8th Edition). Cambridge University Press, 2016.
2. Alley, M. The Craft of Scientific Writing (4th Edition). Springer, 2013.
3. Gopen, G. D., & Swan, J. A. The Science of Scientific Writing. American Scientist, 1990.
4. Silyn-Roberts, H. Writing for Science and Engineering: Papers, Presentations and Reports (2nd Edition). Butterworth-Heinemann, 2012.
5. Katz, M. J. From Research to Manuscript: A Guide to Scientific Writing (2nd Edition). Springer, 2009.
6. Matthews, J. R., & Matthews, R. W. Successful Scientific Writing: A Step-by-Step Guide for the Biological and Medical Sciences (4th Edition). Cambridge University Press, 2014.
7. Peat, J., Elliott, E., Baur, L., & Keena, V. Scientific Writing: Easy When You Know How (1st Edition). BMJ Books, 2002.
8. Schimel, J. Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded (1st Edition). Oxford University Press, 2012.
9. Glasman-Deal, H. Science Research Writing for Non-Native Speakers of English (1st Edition). Imperial College Press, 2010.
10. Hofmann, A. H. Scientific Writing and Communication: Papers, Proposals, and Presentations (2nd Edition). Oxford University Press, 2014.

SEMESTER VI

PLANT BIOTECHNOLOGY Theory with practical Paper

Course code: **MJD 12** Total Marks : 100 (IA 25+EA75) Credits: **3(T) +1(P)**

UNIT -I (10 hours)

Conventional breeding for crop improvement- Introduction, Domestication, Methods of Plant Breeding- Hybridization, Clonally Propagated Species, Breeding Enhancements- Marker-Assisted Selection, Mutation Breeding. Plant genome organization, organization of chloroplast genome, cytoplasmic male sterility, genetic male sterility.

UNIT -II (10 hours)

Basics of Plant tissue culture, Sterilization – Surface and Dry, Components (inorganic, organic and plant hormones) and types of nutrient media, Callus and Suspension cultures, Micropropagation, Somatic embryogenesis and Germplasm conservation. Embryo culture, Rapid clonal propagation, somaclonal variations and synthetic or artificial seeds, embryo rescue, production of haploid plants (microspores and ovules). Applications and limitations of haploid plants. Secondary metabolites from plants.

UNIT -III (10 hours)

. Introduction and Principles of Somatic Hybridization – Protoplast Isolation, Protoplast fusion, Selection of hybrid cell, Regeneration of hybrid plants, Somatic hybrids and cybrids – cytoplasm transfer, Genetic transformation, Advantages and Limitations, Molecular makers – RFLP, RAPD, DNA fingerprinting.

UNIT -IV (15 hours)

Genetic engineering of plants - Gene constructs, Vectors- Plasmid vectors and plant viral vectors (CaMV, Gemini virus, Tobacco Mosaic virus), cloning vectors for higher plants - Genetic manipulation using Agrobacterium tumefaciens. Gene transfer in plants

- Electroporation, Particle Gun Method, Microinjection, Polyethylene glycol mediated transformation, Chloroplast transformation, terminator seed technology.

UNIT -V (15 hours)

Applications of transgenic plants- Pest resistance, Herbicide resistance, virus resistance, Fungal and bacterial resistance, Delay of fruit ripening, Salt & drought tolerance, improvement of crop yield and Quality, Improved nutrition. Biocontrol and biofertilizers.

Course Learning Outcomes (CLO): Students will be able to

1. Gain a good understanding of r-DNA technology, methods of gene transfer, molecular markers, and marker-assisted selection.
2. Understand traditional and modern plant breeding methods for crop improvement.

3. Develop transgenics resistant to biotic and abiotic stresses, and quality characteristics and understand their role in crop improvement.
4. Evaluate transgenic plants for traits like pest resistance, improved yield, and abiotic stress tolerance.
5. Apply plant biotechnology techniques in crop improvement and bioproduction for enhanced agricultural sustainability and productivity.

Reference Books :

1. Trivedi P.C. Plant Biotechnology: Perspectives and Prospects. Pointer Publishers, 2007.
2. Slater A., Scott N., Fowler M. Plant Biotechnology: The Genetic Manipulation of Plants. Oxford University Press, 2008.
3. Hans-Walter Heldt. Plant Biochemistry (4th ed.). Academic Press, 2010.
4. Old R.W., Primrose S.B., Twyman R.M. Principles of Gene Manipulation (6th ed.). Wiley-Blackwell, 2002.
5. Bhojwani S.S. & Razdan M.K. Plant Tissue Culture: Theory and Practice. Elsevier, 1996.
6. Smith R.H. Plant Tissue Culture: Techniques and Experiments (3rd ed.). Academic Press, 2012.
7. Stewart C.N. Jr. Plant Biotechnology and Genetics: Principles, Techniques, and Applications. Wiley, 2008.
8. Kumar H.D. A Textbook on Biotechnology (2nd ed.). Affiliated East-West Press, 1998.
9. Gamborg O.L., Phillips G.C. Plant Cell, Tissue and Organ Culture: Fundamental Methods. Springer, 1995.
10. Chawla H.S. Introduction to Plant Biotechnology (3rd ed.). Science Publishers, 2012.

PLANT BIOTECHNOLOGY PRACTICALS

Code: **MJD 12 (P)** Practical Marks : 100 (IA 50+EA50)

List of Practicals

1. Isolation of total genomic DNA from leaves by CTAB method
2. Extraction of total protein from leaves and PAGE analysis.
3. Amplification of a plant gene by polymerase chain reaction
4. Plant Tissue culture technique - Preparation of Media
5. Callus Induction and shoot regeneration.
6. Shoot multiplication
7. Anther culture.
8. Isolation of endophytic bacteria/fungi from plants
9. Microbial population in rhizospheric soil of various crops.
10. Characterization of PGPR in rhizosperic bacreria.

BIOINFORMATICS Theory with practical Paper

Course code: **MJD 13** Total Marks : 100 (IA 25+EA75) Credits: **3(T) +1(P)**

UNIT -I (10 hours)

Bioinformatics: an overview - Introduction to Computational Biology and Bioinformatics; some of the biological problems that require computational methods for their solutions; Role of internet and www in bioinformatics. Biological Databases Acquisition –Primary and Secondary databases, Nucleotide sequence databases.

Types of DNA sequences – genomic DNA, cDNA, recombinant DNA, Expressed sequence tags (ESTs).

UNIT -II (10 hours)

Sequence Analysis – Methods of sequence alignment: Dot plots; Scoring matrices – identify matrix, genetic code matrices (GCM); Substitution matrices, Percentage accepted Mutation (PAM). Block Substitution Matrices (BLOSUM), dynamic programming algorithms; Needlman-Wunch and Smith Waterman; alignment scores and gap penalties; Database searching (BLAST and FASTA). Multiple Sequence alignment (MSA) – signifiance. Softwares : ClustalW and Meme.

UNIT -III (10 hours)

Phylogenetic analysis – Phylogenetics, cladistics and ontology; Phylogenetic representations – graphs, trees and cladograms; Classification and ontologies; Steps in phylogenetic analysis; Methods of phylogenetic analysis – similarity and distance tables, distance matrix method; Method of calculation of distance matrix (UPGMA, WPGMA); The Neighbor Joining Method; The Fitch/Margoliash method; Steps in constructing alignments and phylogenies; Phylogenetic softwares –PHYLIP

UNIT -IV (15 hours)

Structure prediction: protein- Methods for prediction of secondary and tertiary structures of proteins – knowledge-based structure prediction; fold recognition; ab initio methods for structure prediction, Comparative protein modeling. Identification of motifs and domains, protein family database. RNA structure prediction.

UNIT -V (15 hours)

Applications of bioinformatics in Drug discovery: Finding new drug targets to treat diseases – Pharmacophore identification - Structure based drug design. Mining of sequence data: Mining data from Yeasts. Microarray and genome wide expression analysis: transcriptomes, proteome: Genomics in medicine, disease monitoring, profile for therapeutic molecular targeting.

Course Learning Outcomes (CLO): Students will be able to

1. Apply computational methods to solve biological problems and utilize biological databases effectively.
2. Analyze DNA and protein sequences using alignment methods and sequence analysis tools.

3. Understand phylogenetic analysis techniques and construct phylogenetic trees.
4. Predict protein structures, identify motifs and domains, and explore applications of bioinformatics in drug discovery and genomics.
5. Employ bioinformatics tools for data mining, microarray analysis, and genome-wide expression analysis to contribute to advancements in genomics and personalized medicine.

Reference Books :

1. Mount, D. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press, New York, 2004.
2. Baxevanis, A.D. and Ouellette, B.F. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. John Wiley and Sons, New Jersey, USA, 1998.
3. Lesk, A.M. Introduction to Bioinformatics. First edition, Oxford University Press, UK, 2002.
4. Rastogi, S.C., Mendiratta, N., and Rastogi, R. Bioinformatics: Concepts, Skills and Applications. CBS Publishers, New Delhi, India, 2006.
5. Pevsner, J. Bioinformatics and Functional Genomics. John Wiley & Sons, 2015.
6. Durbin, R., Eddy, S.R., Krogh, A., and Mitchison, G. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. Cambridge University Press, 1998.
7. Westhead, D.R., Parish, J.H., and Twyman, R.M. Bioinformatics: Instant Notes. Garland Science, 2003.
8. Bergeron, B.P. Bioinformatics Computing. Prentice Hall, 2002.
9. Claverie, J.M., and Notredame, C. Bioinformatics for Dummies. Wiley Publishing, 2003.
10. Attwood, T.K., and Parry-Smith, D.J. Introduction to Bioinformatics. Addison Wesley Longman, 1999.

BIOINFORMATICS PRACTICALS

Code: MJD 13 **(P)** Practical Marks : 100 (IA 50+EA50)

List of Practicals

1. Open access bibliographic resources and literature databases: PubMed, BioMed Central
2. Nucleic acid sequence databases: GenBank, EMBL, DDBJ;
3. Protein sequence databases: Uniprot-KB: SWISS-PROT, TrEMBL
4. Genome Databases at NCBI, EBI, TIGR, SANGER
5. Sequence file formats: GenBank, FASTA, GCG, MSF.
6. Pairwise sequence alignment: BLAST
7. Multiple sequence alignment: ClustalW, MEGA
8. Protein structure database: PDB, Rasmol.
9. Sequence editing and manipulation: Bioedit and Sequence manipulation suite.

PHARMACEUTICAL BIOTECHNOLOGY

Theory with practical Paper

Course code: **MJD 14** Total Marks : 100 (IA 25+EA75) Credits: **3(T) +1(P)**

UNIT -I (10 hours)

Definition and scope of Pharmaceutical Biotechnology, sources of drugs, classification of pharmacological agents (based on chemistry, mode of action, dosage forms), route of administration, absorption and bioavailability of drugs, distribution and liver detoxification metabolism and drug excretion.

UNIT -II (10 hours)

General classes and properties of phytopharmaceuticals, Extraction of phytochemicals, Phytochemical screening of medicinal plants. Bioassay guided fractionation methods- TLC, HPTLC, GC, and HPLC, Role of NMR and Mass spectrometry in drug discovery.

UNIT -III (10 hours)

Antimicrobial agents, Antibiotics - source, classification, mode of action, Antimicrobial resistance, and Antimicrobial activity studies (antibacterial, antiviral, antifungal and antiparasitic activity).

Pharmacological Assays - In-vitro assays - chemical (anti-oxidant), Biological (anti- cancerous and assay system based on enzymes and cells), and immunological (RIA and ELISA) - In vivo assays (Anti-inflammatory and Anti-analgesic).

UNIT -IV (15 hours)

Process of drug discovery and development- Target identification and validation, Assay development, lead optimization, pre-clinical testing, clinical trials involved in drug discovery and development, regulatory approvals and phase IV trials, High throughput screening, CPCSEA guidelines, ICMR guidelines for drug testing.

UNIT -V (15 hours)

Vaccines: concept, production and types - Inactivated, Attenuated, toxoid, Recombinant vaccines, Peptide and DNA vaccines, Edible vaccines, nanodrugs.

Recombinant proteins, approved rDNA drugs in market, Probiotics, Nutraceuticals, Economic and legal considerations in Pharmaceutical Biotechnology

Course Learning Outcomes (CLO): Students will be able to

1. Explain the strategies and various steps of the new drug discovery process.
2. Explain the concept of pharmacodynamics and pharmacokinetics.
3. Apply the knowledge of pharmaceutical manufacturing in the production of biopharmaceuticals like antibiotics, vaccines, proteins, and hormones.
4. Carry out the quality control procedures in the production of various biopharmaceuticals and understand the regulatory aspects in the development of pharmaceuticals.

5. Evaluate the applications and economic considerations of biopharmaceuticals, including probiotics, nutraceuticals, and novel vaccine types.

Reference Books :

1. Satoskar R.S., Nirmala N. Rege, and Bhandarkar S. D. Pharmacology and Pharmacotherapeutics (Revised 23rd Edition), Popular Prakashan, Mumbai.
2. Tripathy K. D. Essentials of Medical Pharmacology (6th edition), Jaypee publishers.
3. Shoba Rani R. Hiremath, Textbook of Industrial Pharmacy, Orient Longman Pvt Ltd, 2008.
4. Crommelin Daan J. A., Sindelar D. Robert (3rd edition) Pharmaceutical Biotechnology: Fundamentals and Applications, CRC Press, 2007.
5. Remington, The Science and Practice of Pharmacy (22nd Edition), Pharmaceutical Press, 2012.
6. Walsh, G. Biopharmaceuticals: Biochemistry and Biotechnology (2nd Edition), Wiley-Blackwell, 2013.
7. Gennaro, A. R. Remington: The Science and Practice of Pharmacy (21st Edition), Lippincott Williams & Wilkins, 2005.
8. Aggarwal, S. Essentials of Industrial Pharmacy, CRC Press, 2018.
9. Katzung, B.G. Basic and Clinical Pharmacology (14th Edition), McGraw-Hill Medical, 2018.
10. Ahuja, S. Handbook of Bioanalysis and Drug Metabolism, Academic Press, 2005.

PHARMACEUTICAL BIOTECHNOLOGY PRACTICALS

Code: MJD 14 **(P)** Practical Marks : 100 (IA 50+EA50)

List of Practicals

1. Preparation of different methods of medicinal plant extracts.
2. Antibacterial activity.
3. Antifungal activity.
4. Total antioxidant activity.
5. Phytochemical screening of Primary metabolites.
6. Phytochemical screening of Secondary metabolites.
7. Separation of medicinal plant extracts by chromatography.
8. Estimation of ascorbic acid in multivitamin formulations.

MARINE BIOTECHNOLOGY Theory with Practical Paper

Course code: **MJD 15** Total Marks : 100 (IA 25+EA75) Credits: **3(T) + 1 (P)**

UNIT -I (10 hours)

The marine ecosystem and its functioning: intertidal, estuarine, salt marsh, mangrove, coral reef, coastal & deep sea ecosystems. Hydrothermal vents - biodiversity of organisms. Marine microbes - unculturable bacteria, occurrence, characteristics and exploitation,
Barophilic organisms and their potential gene application for Marine Biotechnology Industry

UNIT -II (10 hours)

Bioactive compounds from marine organisms, GFP, RFP characteristics and their applications, Green mussel adhesive protein, Marine hydrocolloids - Agar, Agarose, Chitosan, Chitin, Alginate, Carrageen and its applications, Marine enzymes and their applications in food processing, Marine Pharmaceuticals – Zinconotide, Dolostain, Bryostain.

UNIT -III (10 hours)

Aquaculture - Culturing of shrimp, edible mollusks, oysters, pearl oysters, sea cucumbers. Culture of live feed organisms - brine shrimp, rotifers, marine algae. Techniques for identification of bacterial & viral pathogens in aquaculture Methods of diagnosis of SEMBV, MBV and Vibrio diagnosis, Probiotic bacteria and their importance in aquaculture; Vaccines in aquaculture: Fish, shrimps & prawns

UNIT -IV (15 hours)

Chromosome manipulation in aquaculture – hybridization; Ploidy induction; Gynogenesis, Androgenesis and sex reversal in commercially important fishes; Cryopreservation of fish gametes and embryo; Transgenic fishes - Antifreeze and metalothionine gene.

UNIT -V (15 hours)

Biofouling, biofilms, corrosion and antifouling treatment. Ballast water: consequences & management. Red tides: causative organisms and control. Control of oil spills and bioremediation.

Course Learning Outcomes (CLO): Students will be able to

1. Explain the fundamentals of the marine ecosystem and deep-sea organisms.
2. Understand the maintenance and growth of commercially important marine organisms and their feed organisms.
3. Gain insight into the concepts and techniques of genetically modified fishes for ornamental and commercial purposes.
4. Understand the concept of biofouling and antifouling, including their maritime economic impact.
5. Apply biotechnological approaches for the sustainable management of marine resources and the development of marine-based products.

Reference Books :

1. Fingerman, Milton, and Nagabhushanam, R. Recent Advances in Marine Biotechnology, Vol. 8. Science Publisher, 2003.
2. Kim, Se-Kwon. Springer Handbook of Marine Biotechnology. Springer Handbooks, 2014.
3. Pillay, T. V. R., and Kutty, M. N. Aquaculture: Principles and Practices, 2nd edition. Blackwell Publishing, 2005.
4. Atlas, Ronald M., and Bartha, Richard. Microbial Ecology: Fundamentals and Applications, 4th edition. Benjamin Cummings, 1997.
5. Laboratory Manual on Methodologies for Assessing Biodiversity in Estuaries, Mangroves, and Coastal Waters. Annamalai University.
6. Munro, Paul D. Marine Microbial Ecology, Cambridge University Press, 2005.
7. Lalli, Carol M., and Parsons, Timothy R. Biological Oceanography: An Introduction, 2nd edition. Butterworth-Heinemann, 2006.
8. Levings, Colin D., and Browne, Robert B. Marine and Estuarine Ecosystem Processes. Springer, 2011.
9. Bardach, John E., Ryther, John H., and McLarney, William O. Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms. Wiley-Interscience, 1972.
10. Gosling, Elizabeth. Marine Bivalve Molluscs. Wiley-Blackwell, 2003.

MARINE BIOTECHNOLOGY PRACTICALS

Code: **MJD 15 (P)** Practical Marks : 100 (IA 50+EA50)

List of Practicals

1. Biochemical tests for identification of Marine bacteria.
2. Measurement of growth of microorganisms.
3. Plankton analysis.
4. Isolation, characterization and antagonistic effects of probiotic bacteria against fish pathogens.
5. Identification of Shrimp/Oysters/Sea cucumber (Spotters)
6. Estimation of Ammonia from shrimp pond
7. Disease identification in shrimps and fishes.
8. Isolation of chitin and chitosan from shrimp waste.

GENOMICS & PROTEOMICS Theory Paper

Course code: **MID 06** Total Marks : 100 (IA 25+EA75) Credits: 4 **(T)**

UNIT -I (10 hours)

Definition: Genome organizations, Principles of gene expression, C-value paradox, Genome mapping – Physical mapping and Genetic mapping, Chromosome walking, Linkage analysis

UNIT -II (10 hours)

Comparative genomics - genome annotation and analysis, Genome-based search for mutations.

UNIT -III (10 hours)

. Functional genomics: protein-nucleic acid interactions, RNA interference, Microarrays, Sequencing – Maxam Gilbert and Sanger's methods, Next Generation Sequencing technologies, whole genome sequencing.

UNIT -IV (15 hours)

Proteomics – Introduction, Protein detection & Methods of Analysis of Proteins, Protein purification and Separation techniques, Two dimensional PAGE for proteome analysis; Image analysis of 2D gels

UNIT -V (15 hours)

Protein characterization – MALDI-TOF and Peptide mass finger printing, Protein sequencing, Protein-protein interactions (Two hybrid interaction screening), Protein arrays, Applications of proteome analysis to drug development.

Course Learning Outcomes (CLO): Students will be able to

1. Explain the properties of genetic materials and storage and processing of genetic information.
2. Analyze genomic data.
3. Explain biological phenomena based on comparative genomics.
4. Design transcriptomics and proteomics experiments for studying differential gene expression and related analysis.
5. Utilize advanced proteomics techniques for protein characterization and understand their applications in drug development.

Reference Books :

1. Terence A. Brown, Genomes 2, 2nd edition, Garland Science Publishing, 2002.
2. Old R.W. & Primrose S. B, Principles of Gene Manipulation – An Introduction to Genetic Engineering, 5th edition, Blackwell Publishers, 2000.
3. Helen Kreuzer and Adrianne Massey, Recombinant DNA and Biotechnology, 2nd edition, ASM Press, 2001.
4. Primrose S.B. & Twyman R.M., Principles of Genome Analysis and Genomics, 3rd edition, Blackwell Publishing, 2003.

5. Liebler, Daniel C., Introduction to Proteomics: Tools for the New Biology, Humana Press, 2002.
6. Campbell, A. Malcolm, and Heyer, Laurie J., Discovering Genomics, Proteomics, and Bioinformatics, 2nd edition, Benjamin Cummings, 2007.
7. Twyman, Richard M., Principles of Proteomics, 2nd edition, Garland Science, 2013.
8. Pevsner, Jonathan, Bioinformatics and Functional Genomics, 3rd edition, Wiley-Blackwell, 2015.
9. Alberts, Bruce , Molecular Biology of the Cell, 6th edition, Garland Science, 2014.
10. Simpson, Richard J., Proteins and Proteomics: A Laboratory Manual, Cold Spring Harbor Laboratory Press, 2002.

SEMESTER VII

MEDICAL BIOTECHNOLOGY Theory with Practical Paper

Course code: **MJD 16** Total Marks : 100 (IA 25+EA75) Credits: **3(T) +1(P)**

UNIT -I (10 hours)

Introduction – Origin, significance & worldwide market of Medical Biotechnology. Revolution in clinical diagnosis, Antibody and Nucleic Acid Hybridization techniques, Imaging techniques (Nanodiagnosis).

UNIT -II (10 hours)

Genetic & Metabolic Disorders – Introduction, Classification, Impact of genetic diseases on human health - Chromosome errors - Down syndrome, Klinefelter's and Turner's syndrome. Metabolic disorders – Phenylketonuria, Homocystinuris, Mucopolysaccharidosis, Gangliosidosis, Gaucher's disease, Diabetes, Hemophilia and sickle cell anemia. Treatment of Genetic diseases - prenatal diagnosis, Genetic Counseling - Ethical, Legal and Social Issues.

UNIT -III (10 hours)

. Revolution in treatment – Recombinant DNA technology for human insulin, Hepatitis B vaccine. Therapeutic proteins and peptides – Erythropoietin, Tissue plasminogen activator, clotting factor VIII. Antibody Engineering and Therapeutic Antibodies. Phage therapy.

UNIT -IV (15 hours)

Cancer - Molecular, cellular and genetic basis of cancer, tumor virus and oncogenes, tumor suppressor genes and mechanism of action of p53 proteins. Stem Cells - Sources and types of stem cells, Stem cell transplant and its types, Potential targets for stem cell treatment, Therapeutic applications of stem cells, Regenerative medicine and Stem cell ethics.

UNIT -V (15 hours)

Gene therapy- basic approaches and types of gene therapy, vectors used in gene therapy, application of gene therapy in medicine. Nanobiotechnology - Introduction, types and structures of nanoparticles, biosynthesis of nanoparticles, application of nanoparticles in treatment.

Course Learning Outcomes (CLO): Students will be able to

1. Explain insights about genetic diseases and also about the molecular aspects related to human disease.
2. Gain new insights into molecular mechanisms of nucleic acid and gene therapy.
3. Gain knowledge about therapeutic recombinant proteins and immunotherapy for the treatment of different diseases.
4. Understand the applications of stem cell technology and regenerative medicine in medical biotechnology.
5. Utilize advanced techniques in medical biotechnology for diagnosis, treatment, and therapeutic development.

Reference Books :

1. Glick B.R. and Pasurank..Molecular biotechnology – Principle and Applications of Recombinant DNA- J.I.(4th edition), ASM Press. 2010.
2. Anthony D. Ho, Hoffman. R, and Esmail D. Zanjani, Stem Cell Transplantation (4th edition), Wiley – liss publishers, 2006.
3. Hornyak.
4. Jogdand. S. N. Medical Biotechnology –, (4th edition), Himalayan publishing house, 2004.
5. Chaudhury, S., & Dash, A. Therapeutic Proteins and Peptides, CRC Press, 2015.
6. Holliger, P., & Hudson, P.J. Engineering Bispecific Antibodies, Springer, 2012.
7. Lanza, Robert, et al. Essentials of Stem Cell Biology, 3rd edition, Academic Press, 2013.
8. Gupta, R.C. Repurposing of FDA-Approved Drugs for Neurological and Neuropsychiatric Disorders: Rethinking the Potential of Off-Label Uses, Academic Press, 2015.
9. Kay, Mark A. Gene Therapy: Therapeutic Mechanisms and Strategies, 3rd edition, CRC Press, 2015.
10. Zhang, L., & Webster, T.J. Nanotechnology for Cancer Therapy, Springer, 2016.

MEDICAL BIOTECHNOLOGY PRACTICALS

Code: MJD 16 **(P)** Practical Marks : 100 (IA 50+EA50) Credits: 1

List of Practicals

1. Biochemical test for identification of bacteria
2. Extraction and separation of Antigen proteins from Bacteria & protozoa
3. Estimation of blood glucose.
4. Estimation of cholesterol in blood.
5. Estimation of iron in blood.
6. Biological synthesis of nanoparticles
7. Detection of plasmodium pathogen using peripheral smear
8. Widal test.

INDUSTRIAL BIOTECHNOLOGY Theory with Practical Paper

Course code: **MJD 17** Total Marks : 100 (IA 25+EA75) Credits: **3(T) +1(P)**

UNIT -I (10 hours)

Overview of Industrial Biotechnology: Scope, importance, and applications, Microorganisms: Selection, isolation, and genetic modification, Principles of fermentation for chemical and bioactive compound production, Media formulation: Designing optimal growth media

UNIT -II (10 hours)

Production Processes: Ethanol fermentation, optimization, and recovery, Biosynthesis of organic acids (citric, acetic, gluconic acids), Solvent production (glycerol, acetone, butanol), Antibiotic production (penicillin, streptomycin, tetracycline).

UNIT -III (10 hours)

Specialized Fermentations: Amino acid production (lysine, glutamic acid), Biofuel production (biodiesel, bioethanol from agro-wastes), Mushroom cultivation (edible and medicinal), Single Cell Protein (SCP) production.

UNIT -IV (15 hours)

Advanced Techniques: Formulating complex fermentation media, Batch and continuous sterilization processes, Fermenter design and operation for microbial and cell culture, Downstream processing: Recovery and purification techniques.

UNIT -V (15 hours)

Industrial Applications: Production of enzymes, vitamins, solvents, bioactive, Biopolymers (PHAs, cellulose) and their applications, Biofertilizers and biopesticides: Microbial solutions for agriculture, Specialty chemicals (surfactants, steroids, industrial chemicals).

Course Learning Outcomes (CLO): Students will be able to

1. Understand the principles and applications of industrial biotechnology in various industries.
2. Apply knowledge of fermentation principles, media formulation, and sterilization techniques to optimize bioprocesses for chemical production.
3. Demonstrate proficiency in fermenter design, operation, and downstream processing for industrial-scale fermentation.
4. Evaluate the diverse range of products obtained through microbial fermentation and their industrial applications.
5. Develop practical skills in laboratory techniques for industrial bioprocessing and product optimization.

Reference Books :

1. Blanch, Harvey W. Bioprocess Engineering Principles, 3rd edition, Academic Press, 2016.
2. Nielsen, Jens, and John Villadsen. Bioreaction Engineering Principles, 3rd edition, Springer, 2019.
3. Rehm, Hans-Jürgen, and Gerald Reed. Biotechnology, Volume 10: Special Processes, Wiley-VCH, 2001.
4. Lee, Yuan Kun. Bioprocessing for Value-Added Products from Renewable Resources: New Technologies and Applications, Elsevier, 2007.
5. Flickinger, Michael C., and Stephen W. Drew. Encyclopedia of Industrial Biotechnology: Bioprocess, Bioseparation, and Cell Technology, Wiley, 2010.
6. Stanbury, Peter F., Allan Whitaker, and Stephen J. Hall. Principles of Fermentation Technology, 3rd edition, Butterworth-Heinemann, 1999.
7. Stephanopoulos, George, et al. Metabolic Engineering: Principles and Methodologies, Academic Press, 1998.
8. Brock, Thomas D. Biotechnology: A Textbook of Industrial Microbiology, 2nd edition, Sinauer Associates, 1994.
9. Ratledge, Colin, and Bjorn Kristiansen. Basic Biotechnology, 3rd edition, Cambridge University Press, 2006.
10. Flickinger, Michael C. Industrial Microorganisms: Basic and Applied Molecular Genetics, CRC Press, 2019.

INDUSTRIAL BIOTECHNOLOGY PRACTICALS

Code: MJD 17 **(P)** Practical Marks : 100 (IA 50+EA50) Credits: 1

List of Practicals

1. Preparation of growth media for microbial cultures used in industrial fermentation.
2. Optimisation of culture media for industrial microbial cultures.
3. screening of microorganisms from natural sources for their industrial potential.
4. Biosynthesis of citric acid using Aspergillus niger
5. Biosynthesis of Acetic Acid Production
6. Production of Butanol and Acetone by Fermentation of Clostridium species
7. Fermenter design and operation for microbial and cell culture applications.
8. Bioethanol Production from Agro-Wastes
9. Single Cell Protein (SCP) Production
10. Production of industrial enzymes like amylase and protease.

AGRICULTURAL BIOTECHNOLOGY Theory with Practical Paper

Course code: **MJD 18** Total Marks : 100 (IA 25+EA75) Credits: **3(T) +1(P)**

UNIT -I (10 hours)

microbes in soil fertility and plant-microbe interactions., Exploration of microbial applications in agriculture, including bioremediation and biocontrol agents.

UNIT -II (10 hours)

Nutrient Cycles: Exploration of carbon, nitrogen, phosphorus, and sulfur cycles in soil., Biological Nitrogen Fixation: Symbiotic, associative, and asymbiotic nitrogen fixation, including the role of Azolla, blue-green algae, and mycorrhiza.

Soil Health Management: Strategies for maintaining soil health through microbial interventions and sustainable agricultural practices.

UNIT -III (10 hours)

Marker-Assisted Selection (MAS): Use of molecular markers in plant breeding, MAS in backcrossing, heterosis breeding, and gene introgression.

Transgenic Crops: Principles of transgenic breeding, genetic modification in agriculture, and the ecological impact of transgenic plants.

Genome Editing Technologies: Applications of CRISPR/Cas9 and other genome editing tools in crop improvement and trait modification.

UNIT -IV (15 hours)

Principles of Organic Farming: Organic farming practices, including crop rotation, composting, and biological pest control.

Integrated Farming Systems: Integration of crop farming with livestock rearing, aquaculture, and agroforestry for sustainable agriculture.

Agroecology and Biodiversity: Understanding agroecosystems, promoting biodiversity, and enhancing ecosystem services in agricultural landscapes.

UNIT -V (15 hours)

Economic Perspectives in Agriculture: Principles of agro-economics, cost-benefit analysis, and market dynamics in agricultural biotechnology. Innovative Technologies: Exploration of emerging technologies such as precision agriculture, vertical farming, and digital agriculture in improving agricultural productivity and sustainability.

Course Learning Outcomes (CLO): Students will be able to

1. Demonstrate an understanding of microbial diversity and its significance in agriculture.
2. Apply marker-assisted selection techniques and transgenic breeding methods for crop improvement.
3. Evaluate the principles and practices of organic and integrated farming systems for sustainable agriculture.
4. Analyze the economic implications of agricultural biotechnology and innovative technologies in agroecosystems.
5. Develop practical skills in soil analysis, microbial enumeration, and agricultural field assessment.

Reference Books :

1. Brady, Nyle C., and Ray R. Weil. The Nature and Properties of Soils, 15th

edition, Pearson, 2017.
2. Nair, P. K. R. Agroecological Innovations: Increasing Food Production with Participatory Development, Earthscan, 2007.
3. Arora, Naveen K., et al. Advances in Plant Breeding Strategies: Breeding, Biotechnology and Molecular Tools, Springer, 2015.
4. Altieri, Miguel A., and Clara I. Nicholls. Agroecology and the Search for a Truly Sustainable Agriculture, United Nations University Press, 2005.
5. Paul, Elizabeth A., and Francis Clark. Soil Microbiology, Ecology, and Biochemistry, 4th edition, Academic Press, 2014.
6. Rehman, Abdul, et al. Soil Health and Intensification of Agroecosystems, CRC Press, 2017.
7. Van Ittersum, Martin K., et al. Ecosystem Services for Agriculture: Nature's Solution to Pest Control, Springer, 2013.
8. Wani, Shabir H., et al. Plant Microbiome: Stress Response, Springer, 2018.
9. Stolton, Sue, et al. Agroecology for Food Security and Nutrition: Proceedings of the FAO International Symposium, Routledge, 2018.
10. De Datta, S. K. Principles and Practices of Rice Production, John Wiley & Sons, 1981.

AGRICULTURAL BIOTECHNOLOGY PRACTICALS

Code: MJD 18 **(P)** Practical Marks : 100 (IA 50+EA50) Credits: 1

List of Practicals

1. Determination of Soil pH by pH Meter
2. Determination of Soil Moisture Using the Gravimetric Method
3. Enumeration of Bacteria from Vermicompost Soil and Wash
4. Enumeration of Fungi from Vermicompost Soil and Wash
5. Determination of Soil Organic Matter Content Using the Walkley-Black Method
6. Determination of the Amount of Plant-Available Phosphorus in the Soil by Olsen Method (for Alkaline Soils)
7. Determination of Soil Carbonates Using Acid Titration Method
8. Isolation of Soil Metagenomes
9. Agricultural Field Visit

MOLECULAR DIAGNOSTICS & FORENSIC SCIENCE Theory Paper

Course code: **MID 08** Total Marks : 100 (IA 25+EA75) Credits: 4 **(T)**

UNIT -I (10 hours)

Introduction to Molecular Diagnostics, Definition, scope, and significance. Molecular Biology Techniques: DNA/RNA extraction and purification, Polymerase Chain Reaction (PCR) and its variants (qPCR, RTPCR), Gel electrophoresis and blotting techniques. Genetic and Genomic Analysis, DNA sequencing methods (Sanger, NextGeneration Sequencing), Genotyping and SNP analysis, Clinical Applications, Applications in infectious diseases, genetic disorders, and oncology

UNIT -II (10 hours)

In Situ Hybridization, Fluorescence in situ hybridization (FISH), CRISPR and Genome Editing, Principles and techniques of CRISPR/Cas9, Proteomics and Metabolomics, Mass spectrometry and protein identification, Point of care Diagnostics, Rapid diagnostic tests, Lateral flow assays

UNIT -III (10 hours)

Introduction to Forensic Science, Definition, scope, and history, Crime Scene Investigation, Principles and biological evidence preservation, Forensic Biology and Serology, Blood, semen, and saliva analysis, Forensic Toxicology, Analysis of drugs, alcohol, and poisons.

UNIT -IV (15 hours)

DNA Profiling and Fingerprinting, Techniques for DNA profiling (STR, VNTR) Forensic Genomics, Mitochondrial DNA analysis, Y-chromosome analysis, Population Genetics and Statistical Analysis, Allele frequency databases, Legal and Ethical Issues, Admissibility of DNA evidence in court.

UNIT -V (15 hours)

Interdisciplinary Applications, Integration of molecular diagnostics in forensic science, Use of forensic techniques in clinical diagnostics, Case Studies, Analysis of landmark cases using molecular diagnostics and forensic science

Course Learning Outcomes (CLO): Students will be able to

1. Grasp the basics of molecular diagnostic techniques and their clinical applications.
2. Explore advanced molecular diagnostic methods including CRISPR and proteomics.
3. Understand the principles of forensic science and crime scene investigation.
4. Acquire skills in DNA profiling and forensic genomics, including legal and ethical considerations.
5. Apply interdisciplinary approaches integrating molecular diagnostics into forensic science and clinical diagnostics.

Reference Books :

1. Buckingham, L., & Flaws, M. (2016). Molecular Diagnostics: Fundamentals, Methods, and Clinical Applications (3rd ed.). F.A. Davis Company.

2. James, S. H., & Nordby, J. J. (2014). Forensic Science: An Introduction to Scientific and Investigative Techniques (4th ed.). CRC Press.
3. Alberts, B., et al. (2014). Molecular Biology of the Cell (6th ed.). Garland Science.
4. Wilson, K., & Walker, J. (2010). Principles and Techniques of Biochemistry and Molecular Biology (7th ed.). Cambridge University Press.
5. Houck, M. M. (2009). Essentials of Forensic Science. Academic Press.
6. Coleman, W. B., & Tsongalis, G. J. (2016). Diagnostic Molecular Pathology: A Guide to Applied Molecular Testing (2nd ed.). Academic Press.
7. Butler, J. M. (2009). Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers. Academic Press.
8. Rapley, R., & Whitehouse, D. (Eds.). (2007). Molecular Forensics. Wiley.
9. Karmakar, R. N. (2012). Principles of Forensic Medicine and Toxicology. Academic Publishers.
10. Kennedy, S. (2011). PCR Troubleshooting and Optimization: The Essential Guide. Caister Academic Press.

DEVELOPMENTAL BIOLOGY Theory Paper

Course code: **MID 09** Total Marks: 100 (IA 25+EA75) Credits: **3(T) +1(P)**

UNIT -I (10 hours)

Basic concepts of development biology - Cell fate and commitment; Mechanisms of development commitment, mosaic and regulative development, maintenance of differentiation, pattern formation and compartments, morphogenesis

UNIT -II (10 hours)

Vegetative and Reproductive anatomy of Plants: Root apical meristem – Root cap, Root hairs, Root architecture; Shoot apical meristem- vascular tissue, Shoot
architecture; Leaf-structure and types; Flower- structure, sepal and petal, stamens, carpels, nector; Pollen and ovules- structure of pollen, embryo sac, pollination and fertilization; seed- definition, seed coat, endosperm, embryo; fruit- fruit structure, indehiscent fruits, seed dispersal.

UNIT -III (10 hours)

Plant Embryology: Anther structure and development, anther wall, tapetum-types and function, Microsporogenesis - Successive division, dehiscense of anther; microsporangium-structure of pollen grain, development, nemec phenomenon. Megasoprangium - structure of ovule, types and development of ovule. Megasoprogenesis - female gamete structure and development; Double fertilization process, porogamy, chalozogamy, mesogamy.
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UNIT -IV (15 hours)

Animal development - Gametogenesis – Spermatogenesis: formation of spermatids - multiplication phase, growth phase, maturation phase, spermiogenesis, formation of head of spermatozoan, changes in nucleus, acrosome formation, tail formation and other events, structure of sperm cell. Oogenesis – multiplication phase, growth phase – previtellogenesis, Growth of nuclear substance, gene amplification, vitellogenesis, cortical differentiation, maturation of egg, menstrual cycle, structure of ovum.

UNIT -V (15 hours)

Fertilization: Acrosome reaction, fertilization, fertilization membrane formation, post fertilization changes, zygote. Cleavage and gastrulation: Cleavage, blastula, morula, gastrulation, formation of three germ layers – ectoderm, endoderm and mesoderm.

Course Learning Outcomes (CLO): Students will be able to

1. Understand the fundamental concepts of developmental biology including cell fate, commitment, and mechanisms of development commitment.
2. Describe the anatomy of plants, including the structure of roots, shoots, leaves, flowers, pollen, ovules, seeds, and fruits.

3. Explain the processes and events involved in plant embryology, including anther and ovule development, microsporogenesis, megasporogenesis, and double fertilization.
4. Analyze animal development processes, including gametogenesis, spermatogenesis, oogenesis, fertilization, cleavage, and gastrulation, and the formation of three germ layers.
5. Discuss the role of genetics and environmental factors in developmental biology and apply this knowledge to understand developmental abnormalities and diseases.

Reference Books :

1. Gilbert, S. F. (2016). Developmental Biology (11th ed.). Sinauer Associates.
2. Wolpert, L., Tickle, C., & Martinez-Arias, A. (2015). Principles of Development (5th ed.). Oxford University Press.
3. Wilson, L., & Klug, W. S. (2019). Developmental Biology (9th ed.). Pearson.
4. Moore, K. L., Persaud, T. V. N., & Torchia, M. G. (2019). The Developing Human: Clinically Oriented Embryology (11th ed.). Elsevier.
5. Kalthoff, K. (2011). Analysis of Biological Development (1st ed.). Springer.
6. De Robertis, E. M., & Sasai, Y. (2013). A Biological Introduction to Embryology (1st ed.). Wiley-Blackwell.
7. Hardin, J., & Moody, S. A. (2019). Developing Animal Models for Embryonic and Genetic Disease (1st ed.). Springer.
8. Slack, J. M. W. (2019). Essential Developmental Biology (4th ed.). Wiley.
9. Carlson, B. M. (2014). Human Embryology and Developmental Biology (5th ed.). Mosby.
10. Patten, B. M. (2014). Human Embryology (7th ed.). McGraw-Hill Education.

SEMESTER VIII

NANOTECHNOLOGY Theory Paper

Course code: **MJD 19** Total Marks : 100 (IA 25+EA75) Credits: **3(T) +1(P)**

UNIT -I (10 hours)

Introduction to Nanotechnology: Definition and Historical milestones. Scale and Size: Understanding nanometres and their significance, Comparison with other scales (macro, micro). Nanostructures in Biological Systems: Proteins, DNA and Biomimetic nanostructures.

UNIT -II (10 hours)

: Properties and Synthesis of Nanomaterials: Physical properties, Chemical properties, Mechanical properties, Optical properties, Quantum effects. Synthesis of Nanomaterials: Top down and bottom-up approaches. Common synthesis methods: Solgel, chemical vapor deposition.

UNIT -III (10 hours)

. Characterization Techniques: Microscopy: Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), Spectroscopy: UV Vis Spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), Raman Spectroscopy. Xray Techniques: Xray diffraction (XRD).,

UNIT -IV (15 hours)

Applications of Nanotechnology: Electronics: Nanotransistors, Quantum dots, Nanosensors. Energy: Solar cells, Fuel cells, Batteries. Environment: Water purification, Air filtration, Environmental sensors. Medicine: Drug delivery systems, Diagnostic tools, medical imaging. cancer therapy, Biosensors for biomolecules and pathogens detection, Nanotechnology in DNA sequencing, protein analysis and tissue engineering

UNIT -V (15 hours)

Nanobiotechnology and Ethical Aspects: Nanobiotechnology Techniques Bioconjugation, Nanoparticle synthesis using biological methods, Safety Concerns: Toxicity of nanomaterials, Environmental and health impacts, Regulatory Frameworks: Guidelines and Policies for safe use and disposal of nanomaterials. future prospects in nanotechnology and nanobiotechnology

Course Learning Outcomes (CLO): Students will be able to

1. Learn basics like definitions, history, properties, synthesis, and characterization of nanomaterials.
2. Study various uses of nanotechnology in electronics, energy, environment, and medicine.
3. Understand the intersection of nanotechnology and biotechnology, including natural nanostructures and applications like nanomedicine.
4. Assess societal, ethical, safety, and regulatory aspects of nanotechnology.

5. Explore emerging trends and future prospects in nanotechnology research and applications.

Reference Books :

1. Poole Jr., C. P., & Owens, F. J. (2003). Introduction to Nanotechnology. John Wiley & Sons.
2. Kulkarni, S. K. (2019). Nanotechnology: Principles and Practices. CRC Press.
3. Niemeyer, C. M., & Mirkin, C. A. (2004). Nanobiotechnology: Concepts, Applications and Perspectives. Wiley-VCH.
4. Hunt, G., & Mehta, M. (2018). Nanotechnology: Risk, Ethics and Law. Earthscan.
5. Feynman, R. P. (2012). There's Plenty of Room at the Bottom: An Invitation to Enter a New Field of Physics. Basic Books.
6. Kumar, C. S. S. R. (2017). Nanomaterials for Medical Diagnosis and Therapy. Wiley.
7. Rao, C. N. R., & Müller, A. (Eds.). (2007). Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience. Wiley-VCH.
8. Andrews, D. L., & Scholes, G. D. (Eds.). (2014). Excitons in Nanoscale Systems. Springer.
9. Bharat, B. (2015). Nanotechnology Applications for Clean Water. William Andrew.
10. Sozer, N., & Kokini, J. L. (2009). Nanotechnology and Functional Foods: Effective Delivery of Bioactive Ingredients. Wiley-Blackwell.

ENZYME TECHNOLOGY Theory with Practical Paper

Course code: **MJD 20** Total Marks : 100 (IA 25+EA75) Credits: **3(T) +1(P)**

UNIT -I (10 hours)

Introduction to Enzymes: General introduction and historic background, General Terminology, Nomenclature, and Classification of Enzymes, Criteria of purity of enzymes: Specific activity, Enzyme units: Katal and IU, Enzyme activity: chemical nature of enzymes, Protein nature of enzymes and Non-protein enzymes: Ribozymes and DNAzymes, Metalloenzymes and metal-activated enzymes, Coenzymes and Cofactors: Prosthetic group

UNIT -II (10 hours)

Enzyme Catalysis: Lock and key, Induced fit, and Transition state Hypotheses, , Mechanism of enzyme catalysis: Acid-base catalysis, covalent catalysis, Metal ion catalysis, Proximity and orientation effects, Mechanism of Serine proteases: Chymotrypsin, Lysozyme, Carboxypeptidase A, and Ribonuclease, Proenzymes (Zymogens)

UNIT -III (10 hours)

Enzyme Kinetics and Inhibition: Kinetics of a single-substrate enzyme-catalyzed reaction: Michaelis-Menten Equation, Km, Vmax, L.B Plot, Turnover number, Kcat, Kinetics of Enzyme Inhibition and Allosteric enzymes, Factors affecting enzyme activity: Concentration, pH, and temperature, Reversible Inhibition: Competitive, Non-competitive, Uncompetitive, Mixed, Substrate, Allosteric, and Product Inhibition, Irreversible Inhibition

UNIT -IV (15 hours)

Enzyme Regulation: Feedback Regulation, Allosteric Regulation, Reversible Covalent Modification, and Proteolytic Activation, Enzymes in the cell: localization, compartmentalization of metabolic pathways, enzymes in membranes, concentrations, Mechanisms of enzyme degradation: lysosomal and non-lysosomal pathways, examples

UNIT -V (15 hours)

Industrial and Clinical Uses of Enzymes (Applied Enzymology): Industrial Enzymes: Thermophilic enzymes, amylases, lipases, enzymes in industry, enzymes used in various fermentation processes, cellulose-degrading enzymes, Metal-degrading enzymes, Clinical enzymes: Enzymes as thrombolytic agents, Anti-inflammatory agents, streptokinase, asparaginase, Isoenzymes like CK and LDH, Transaminases (AST, ALT), Cholinesterases, Phosphatases, Immobilization of enzymes, Enzyme Engineering and site-directed mutagenesis

Course Learning Outcomes (CLO): Students will be able to

1. Describe the basic concepts, nomenclature, and classification of enzymes, including their chemical nature and roles as catalysts.
2. Explain various hypotheses and mechanisms of enzyme catalysis, including specific examples like serine proteases and proenzymes.

3. Apply principles of enzyme kinetics, inhibition, and factors affecting enzyme activity to interpret and predict enzyme behavior.
4. Describe the regulation of enzyme activity through feedback mechanisms, allosteric regulation, and covalent modifications, including enzyme localization and degradation.
5. Understand the practical applications of enzymes in both industrial and clinical settings, including enzyme engineering and immobilization techniques.

Reference Books :

1. Price, N. C., & Stevens, L. (1999). Fundamentals of Enzymology: Cell and Molecular Biology of Catalytic Proteins (3rd ed.). Oxford University Press.
2. Fersht, A. (1999). Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding (3rd ed.). W. H. Freeman and Company.
3. Segel, I. H. (1993). Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems. Wiley-Interscience.
4. Nelson, D. L., & Cox, M. M. (2017). Lehninger Principles of Biochemistry (7th ed.). W. H. Freeman and Company.
5. Berg, J. M., Tymoczko, J. L., & Gatto, G. J. (2006). Biochemistry (6th ed.). W. H. Freeman and Company.
6. Voet, D., Voet, J. G., & Pratt, C. W. (2016). Fundamentals of Biochemistry: Life at the Molecular Level (5th ed.). Wiley.
7. Cornish-Bowden, A. (2013). Fundamentals of Enzyme Kinetics (4th ed.). Wiley-Blackwell.
8. Boyer, R. F., & Boyer, P. D. (2001). The Enzymes (3rd ed.). Academic Press.
9. Dixon, M., & Webb, E. C. (1979). Enzymes (3rd ed.). Academic Press.
10. Voet, D., Voet, J. G., & Pratt, C. W. (2016). Principles of Biochemistry (5th ed.). Wiley.

ENZYME TECHNOLOGY PRACTICALS

Code: MJD 20 **(P)** Practical Marks : 100 (IA 50+EA50) Credits: 1

List of Practicals

1. Screening of microorganisms for enzyme production.
2. Effect of pH on enzyme activity.
3. Effect of Temperature on enzyme activity.
4. Ammonium sulphate precipitation of enzymes
5. Partial purification of enzymes by dialysis.
6. Colorimetric assay for enzyme activity
7. Determination of Km and Vmax of the enzymes.
8. Electrophoretic separation of isoenzymes.

BIOLOGICAL DATA ANALYSIS Theory with Practical Paper

Course code: **MJD 21** Total Marks : 100 (IA 25+EA75) Credits: **3(T)**

UNIT -I (10 hours)

Basic Statistics for Biological Data Analysis: Descriptive statistics: mean, median, mode, variance, standard deviation, Probability concepts and distributions: Normal, Binomial. Hypothesis testing: p-values, significance levels , Parametric tests: t-test, ANOVA. Non-parametric tests: Wilcoxon test, Mann-Whitney U test

UNIT -II (10 hours)

Introduction to R Programming: Setting up R and RStudio, R syntax and data structures: vectors, data frames, Writing R scripts, Data manipulation with `dplyr`, Plotting with `ggplot2`, Statistical tests: `t.test()`, `wilcox.test()`, Linear regression with `lm()`

UNIT -III (10 hours)

. Introduction to Python for Biological Data Analysis: Installing Python and Jupyter Notebook, Python libraries: NumPy, pandas, Matplotlib, Python syntax and data structures, Data manipulation with pandas, Data cleaning and preprocessing, Descriptive statistics with pandas, Plotting with Matplotlib,

UNIT -IV (15 hours)

Advanced Data Analysis Techniques: Generalized linear models (GLMs), Logistic regression, Clustering techniques: k-means, Dimensionality reduction: Principal Components Analysis (PCA), Time series analysis: decomposition, forecasting

UNIT -V (15 hours)

Genomic Data Analysis and Advanced Topics: Bioconductor for genomic analysis, Genomic workflows, Single cell RNA sequencing, Simulation and resampling methods: bootstrapping, permutation tests

Course Learning Outcomes (CLO): Students will be able to

1. Understand and apply basic statistical concepts to biological data.
2. Perform data manipulation and visualization using R programming.
3. Conduct data analysis and visualization with Python.
4. Implement advanced data analysis techniques such as GLMs, logistic regression, clustering, and PCA.
5. Apply genomic data analysis methods and advanced topics such as single-cell RNA sequencing and resampling techniques.

Reference Books :

1. Crawley, M. (2014). Statistics: An Introduction Using R (2nd ed.). Wiley.
2. Wickham, H., & Grolemund, G. (2017). R for Data Science (1st ed.). O'Reilly Media.
3. McKinney, W. (2017). Python for Data Analysis (2nd ed.). O'Reilly Media.
4. Irizarry, R. A. (2019). Introduction to Data Science: Data Analysis and

Prediction Algorithms with R (1st ed.). CRC Press.
5. Gentle, J. E. (2009). Computational Statistics (1st ed.). Springer.
6. Lander, J. P. (2014). R Cookbook (2nd ed.). O'Reilly Media.
7. VanderPlas, J. (2016). Python Data Science Handbook (1st ed.). O'Reilly Media.
8. Zuur, A. F., Ieno, E. N., & Smith, G. M. (2007). Analysing Ecological Data (1st ed.). Springer.
9. Wickham, H. (2009). ggplot2: Elegant Graphics for Data Analysis (1st ed.). Springer.
10. McKinney, W., & White, T. (2012). Python for Data Analysis (1st ed.). O'Reilly Media.

BIOLOGICAL DATA ANALYSIS PRACTICALS

Code: MJD 21 **(P)** Practical Marks : 100 (IA 50+EA50) Credits: 1

List of Practicals

1. Installation of R and Python
2. Calculate mean, median, mode, for biological dataset using R
3. Calculate and interpret variance, and standard deviation for biological data using R
4. Generate and plot Normal and Binomial distributions using sample data using Python, NumPy, Matplotlib
5. Perform t-tests and ANOVA on biological sample data to test hypotheses Using R
6. Conduct Non-parametric Tests Wilcoxon and Mann-Whitney U tests on given datasets using Python, SciPy
7. Data Manipulation transform a biological dataset.in R, dplyr
8. Data Visualization (scatter plots, histograms) to visualize biological data in R, `ggplot2`

STEM CELL & CANCER BIOLOGY Theory Paper

Course code: **MJD 22** Total Marks : 100 (IA 25+EA75) Credits: 4 **(T)**

UNIT -I (10 hours)

Introduction to Stem Cells: Definition and types (Embryonic, adult, iPSCs), Properties: Self-renewal and differentiation, Stem Cell Niches: Microenvironment and signalling pathways, Regulation, Differentiation and Mechanisms

UNIT -II (10 hours)

Culture and Maintenance: Isolation, culturing methods, markers, Therapeutics: Applications in regenerative medicine, Therapy for neurodegenerative and cardiovascular diseases, Ethical and Regulatory Considerations: Issues and frameworks

UNIT -III (10 hours)

Sustaining proliferative signalling, evading growth suppressors, Cell Biology: Growth, division mechanisms, genetic mutations, Tumour Microenvironment: Interactions, angiogenesis, metastasis

UNIT -IV (15 hours)

Oncogenes and Tumor Suppressors genes and functions. Cell Cycle and Apoptosis: Regulation in cancer, apoptosis in cancer cell survival, Cancer Stem Cells: Characteristics and implications for therapy

UNIT -V (15 hours)

Stem Cell Applications in Cancer Therapy: Understanding and treatment approaches, Targeted Therapies: Based on molecular characteristics, Immunotherapy and personalized medicine, Diagnostic and Prognostic Tools: Biomarkers, advances in detection and monitoring,

Course Learning Outcomes (CLO): Students will be able to

1. Demonstrate an understanding of the fundamental concepts and principles of stem cell biology and cancer biology.
2. Evaluate the ethical and regulatory considerations involved in stem cell research and therapeutic applications.
3. Analyze the molecular and cellular mechanisms underlying cancer development and progression.
4. Assess the potential applications of stem cell research in cancer therapy and regenerative medicine and its current research trends.
5. Interpret the interactions between stem cells and the tumor microenvironment, including their implications for cancer therapy.

Reference Books :

1. Lodish, H., Berk, A., & Zipursky, S. L. (2000). Molecular Cell Biology. W. H. Freeman.
2. Weinberg, R. A. (2013). The Biology of Cancer. Garland Science.
3. Lanza, R., Langer, R., & Vacanti, J. (2013). Principles of Tissue Engineering.

Academic Press.
4. Verfaillie, C. M. (2009). Stem Cells and Regenerative Medicine. Springer.
5. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the Cell. Garland Science.
6. Hanahan, D., & Weinberg, R. A. (2014). Hallmarks of Cancer: The Next Generation. Cell Press.
7. Trounson, A., & DeWitt, N. D. (2016). Stem Cell Therapies: Opportunities for Ensuring the Quality and Safety of Clinical Offerings. National Academies Press.
8. Wicha, M. S., & Stemmler, H. J. (2008). Targeting Breast Cancer Stem Cells: Insights into the Mechanisms of Breast Cancer Stemness and Therapeutics. Springer.
9. Clarke, M. F., Dick, J. E., Dirks, P. B., Eaves, C. J., Jamieson, C. H., Jones, D. L., & Visvader, J. E. (2006). Cancer Stem Cells—Perspectives on Current Status and Future Directions: AACR Workshop on Cancer Stem Cells. Cancer Research.
10. Currle, D. S., & Huse, J. T. (2010). Glioma Stem Cells: Methods and Protocols. Humana Press.

ENTREPRENEURIAL DEVELOPMENT, & IPRS, BIOSAFETY AND BIOETHICS Theory Paper

Course code: **MJD 23** Total Marks : 100 (IA 25+EA75) Credits: 4 **(T)**

UNIT -I (10 hours)

Ethics/bioethics: Introduction to ethics/bioethics, Framework for ethical decision making. Animal rights/welfare. Ethical, Legal and Social Implications (ELSI) of biotechnological products and techniques. Social and ethical implications of biological weapons

UNIT -II (10 hours)

Biosafety and biosecurity framework: Roles and responsibilities of IBSC, RCGM in biosafety and biosecurity regulation; Source of biosafety and biosecurity risks, Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety and Biosecurity risk, assessment and management; Bio-containment principles and practices; Applicable national guidelines; Compliance adherences accidents and emergency managements.

UNIT -III (10 hours)

International instruments on Biosafety Regulation: Cartagena Protocol and supplementary protocols; Implementation bodies; National focal points; Responsibility of nation as a party to these instruments; Impact on research, international trade and travel.

UNIT -IV (15 hours)

Intellectual property rights: Introduction to intellectual property and its rights – types: patents, copyrights, trademarks, design rights, geographical tag – importance of IPR – patentable and non-patentable – patenting life – legal protection of biotechnological inventions. Agreements and Treaties: History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments

UNIT -V (15 hours)

Patent filing procedures: National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting– disclosure/non-disclosure; Financial assistance for patenting-introduction to existing schemes, Patent licensing and agreement Patent infringement-meaning, scope, litigation, case studies

Course Learning Outcomes (CLO): Students will be able to

1. Understand and apply the principles of GLP and GMP to ensure quality and compliance in research and industry.
2. Evaluate and implement ethical and biosafety practices in biotechnology.
3. Navigate the patenting process, manage intellectual property, and understand IPR conventions.
4. Develop entrepreneurial skills in demand surveying, product identification, process design, and business resource management within the legal and regulatory framework.

5. Analyze the economic and societal impacts of biotechnological innovations and entrepreneurial ventures.

Reference Books :

1. Sandy Weinberg. (2007). Good Laboratory Practice Regulations. 4th Edition. CRC Press.
2. Sidney H. Willig. (2016). Good Manufacturing Practices for Pharmaceuticals. 6th Edition. CRC Press.
3. CDC and NIH. (2009). Biosafety in Microbiological and Biomedical Laboratories. 5th Edition. U.S. Department of Health and Human Services.
4. Deborah E. Bouchoux. (2016). Intellectual Property Rights. 5th Edition. Cengage Learning.
5. Robert Patrick Merges and John Fitzgerald Duffy. (2017). Patent Law and Policy: Cases and Materials. 7th Edition. Carolina Academic Press.
6. Jay P. Kesan and Gideon Parchomovsky. (2017). Biotechnology and Software Patent Law: A Comparative Review of New Developments. Edward Elgar Publishing.
7. Carlos M. Correa. (2007). Trade Related Aspects of Intellectual Property Rights: A Commentary on the TRIPS Agreement. Oxford University Press.
8. Antony Taubman. (2012). The TRIPS Agreement: Drafting History and Analysis. 4th Edition. Sweet & Maxwell.
9. Ryan Abbott. (2015). The Reasonable Robot: Artificial Intelligence and the Law. Cambridge University Press.
10. Ruth L. Okediji. (2016). Copyright Law in an Age of Limitations and Exceptions. Cambridge University Press.