Annamalai University
(Accredited with 'A+' Grade by NAAC)

Faculty of Science
Department of Biochemistry and Biotechnology
(Supported by UGC-SAP and DST-FIST)

Regulations, Curricula and Syllabus-2023-2024 onwards

M. Sc. BIOTECHNOLOGY (2 YEAR)
(TANSCHE Syllabus)
Programme Code: SBIO22

Annamalai University

Faculty of Science

DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY

M. Sc. Biotechnology (TANSCHE syllabus)

Programme Code: SBIO22

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

1. **Definitions and Nomenclature**

1.1 **University** refers to Annamalai University.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2. Programme Offered and Eligibility Criteria:

The Department of Biochemistry and Biotechnology offers a Two-Year M. Sc. in Biotechnology programme. A pass in B.Sc. Biotechnology / Biochemistry / Microbiology / Chemistry / Botany / Zoology with not less than 50% of marks in Part–III and Chemistry, Botany, Zoology or any other science subjects as two allied subjects accepted by the Syndicate of Annamalai University as equivalent thereto are eligible for admission.

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

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

4. Programme Duration

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

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

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

5. Programme Structure

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

5.2 Core courses

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

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

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

5.3 Project

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

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

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

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

5.4 Elective courses

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

5.5 Internship/Industrial Activity (Experiential Learning)

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

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

5.5.3 Experiential learning is categorized as non-core course.

5.6 Industry/Entrepreneurship

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

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

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

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

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

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

5.8.4 Extension activity shall be conducted outside the class hours.

5.8.5 Extension activity is categorized as non-core course.

5.9 Value Added Course (VAC)

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

5.10 Online Courses

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

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

5.11 Credit Distribution: The credit distribution is organized as follows:

Component	Course	Credits
Part A	**Core (Theory)**	**45**
	Core (Practical)	**12**
	Project with Viva voce	**7**
Part B (i)	**Elective (Generic/Discipline Centric)**	**18**
Part B (ii)	**Internship/Industrial Visit**	**02**
Part B (iii)	**Skill Enhancement Course/Professional Competency Skill**	**06**
Part C	**Extension Activity**	**01**
	TOTAL CREDITS	**91**

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

5.12 Credit Assignment

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

1 Credit is defined as

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

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

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

6 Attendance

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

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

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

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

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

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

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

7 Mentor-Mentee System

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

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

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

8 Examinations

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

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

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

8.4 Continuous Internal Assessment Tests

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

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

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

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

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

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

8.5 End Semester Examinations (ESE)

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

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

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

9 Evaluation

9.1 Marks Distribution

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

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

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

9.2 Assessment of CIA Tests

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

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

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

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

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

9.3 Assessment of End-Semester Examinations

9.3.1 Evaluation for the ESE is done by internal examiners.

9.4 Assessment of Project/Dissertation

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

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

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

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

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

9.4.6 The marks shall be distributed as follows:

Continuous Internal Assessment (25 Marks)		**End Semester Examination (75 Marks)**	
Review-I - 10	Review-II -15	Project / Dissertation Evaluation	Viva voce
		50	25

9.5 Assessment of Value-added Courses

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

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

9.6 Passing Minimum

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

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

10. Conferment of the Master's Degree

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

11. Marks and Grading

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

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

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

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

where, C_i is the Credit earned for the Course i in any semester;

$G_i$is the Grade Point obtained by the student for the Course i and

n is the number of Courses passedin that semester.

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

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

Where, C_i is the Credit earned for the Course i in any semester;

$G_i$is the Grade Point obtained by the student for the Course i and

n is the number of Courses passedin that semester.

m is the number of semesters.

11.5 Evaluation:

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

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

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

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

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

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

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

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

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

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

CGPA × 9.5 = Percentage

11.7 **Course-Wise Letter Grades**

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

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

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

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

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

12. Provision for Withdrawal from the End Semester Examination

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

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

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

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

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

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

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

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

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

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

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

Template for

PG Programme

Semester–I	Credit	Hours	Semester-II	Credit	Hours	Semester-III	Credit	Hours	Semester–IV	Credit	Hours
Core-I	5	4	Core-IV	5	4	Core-VII	5	4	Core-XI	5	4
Core-II	5	4	Core-V	5	4	Core-VIII	5	4	Core-XII	5	4
Core – III	4	16	Core – VI	4	14	Core – IX	5	4	Project with viva voce	7	17
Elective -I Discipline Centric	3	3	Elective– III Discipline Centric	3	3	Core – X	4	13	Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	3	3
Elective-II: Generic	3	3	Elective -IV: Generic	3	3	Elective - V Discipline Centric	3	3	Skill Enhancement course / Professional Competency Skill	2	2
			Skill Enhancement I	2	2	Skill Enhancement II	2	2	Extension Activity	1	-
						Internship/ Industrial Activity	2	-			
TOTAL	**20**	**30**	**TOTAL**	**22**	**30**	**TOTAL**	**26**	**30**	**TOTAL**	**23**	**30**
Total Credit Points -91											

Department of Biochemistry and Biotechnology

M. Sc. Biotechnology (Two Year) Programme (TANSCHE Syllabus)

Programme Code: SBIO22

Curricula and Scheme of Examination

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

Course Code	Course Title	Hours/ Week			C	Marks		
		L	T	P		CIA	ESE	Total
Semester-I								
23BITC101	Core 1: Biochemistry	4	0		5	25	75	100
23BITC102	Core 2: Molecular Cell Biology	4	0		5	25	75	100
23BITP103	Core 3: Practical I: Biochemistry, Molecular Cell Biology and Molecular Genetics	0	0	16	4	25	75	100
23BITE104	Elective 1 : (Discipline Centric): Enzymology	3	0		3	25	75	100
23BITE105	Elective 2: (Generic): Bioinstrumentation	3	0		3	25	75	100
		30			20			
Semester-II								
23BITC201	Core 4: Genetic Engineering	4	0		5	25	75	100
23BITC202	Core 5: Plant and Animal Biotechnology	4	0		5	25	75	100
23BITP203	Core 6: Practical II: Molecular Biology, Genetic Engineering, Plant and Animal Biotechnology			14	4	25	75	100
23BITE204	Elective 3: (Discipline Centric): Pharmaceutical Biotechnology	3	0		3	25	75	100
23BITE205	Elective 4: (Generic): Environmental Biotechnology	3	0		3	25	75	100
23BITS207	Skill Enhancement Course 1 : SEC 1 : Advanced Molecular Biology	2	0		2	25	75	100
		30			22			
Semester-III								
23BITC301	Core 7: Bioinformatics	4	0		5	25	75	100

23BITC302	Core 8: Immunology	4	0		5	25	75	100
23BITC303	Core 9: Bioprocess Technology	4	0		5	25	75	100
23BITP304	Core 10: Practical III – Bioinformatics, Immunology and Bioprocess Technology	0	0	13	4	25	75	100
23BITE305	Elective 5 : (Discipline Centric): Nanobiotechnology	3	0		3	25	75	100
23BITS307	Skill Enhancement Course 2: SEC 2: Gene Manipulation Technology	2	0		2	25	75	100
23BITI308	Internship/Industrial Activity	0			2	25	75	100
		30			26			
Semester-IV								
23BITC401	Core 11: Research Methodology	4	0		5	25	75	100
23BITC402	Core 12: Biostatistics	4	0		5	25	75	100
23BITD403	Project work with viva voce	0	0	17	7	25	75	100
23BITE404	Elective 6: (Discipline Centric/Generic): Stem Cell Biology	3	0		3	25	75	100
23BITS406	Skill Enhancement Course 3: SEC 3/Professional Competency Skill: Methods in Genomics and Proteomics	2	0		2	25	75	100
23BITX407	Extension Activity	0			1	25	75	100
		30			23			
	Total Credits	**120**			**91**			

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

COURSE	NOs.	CREDITS
Core (Theory)	**9**	**45**

Core (Practical)	**3**	**12**
Elective (Generic/Discipline Centric)	**6**	**18**
Skill Enhancement Course/Professional Competency Skill	**3**	**6**
Project	**1**	**7**
Internship/Industrial activity	**1**	**2**
Extension Activity	**1**	**1**
TOTAL CREDITS		**91**

ELECTIVE COURSES
(GENERIC/DISCIPLINE CENTRIC)

S. No.	Course Code	Course Title	Hours/ week			C	Marks		
			L	T	P		CIA	ESE	Total
1.	23BITE104	Enzymology	3	0	0	3	25	75	100
2.	23BITE105	Bioinstrumentation	3	0	0	3	25	75	100
3.	23BITE106	Molecular Genetics	3	0	0	3	25	75	100
4.	23BITE204	Pharmaceutical Biotechnology	3	0	0	3	25	75	100
5.	23BITE205	Environmental Biotechnology	3	0	0	3	25	75	100
6.	23BITE206	Regulatory Affairs and International Standards	3	0	0	3	25	75	100
7.	23BITE305	Nanobiotechnology	3	0	0	3	25	75	100
8.	23BITE306	Molecular Developmental Biology	3	0	0	3	25	75	100
9.	23BITE404	Stem Cell Biology	3	0	0	3	25	75	100
10.	23BITE405	Bioethics, Human Rights and Social Issues	3	0	0	3	25	75	100

GENERIC ELECTIVES
(FOR OTHER MAJOR STUDENTS)

S. No.	Course Code	Course Title	Hours/ week			C	Marks		
			L	T	P		CIA	ESE	Total
1.	23SBITN01	Tissue Engineering	3	0	0	3	25	75	100

Department of Biochemistry and Biotechnology

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

(Based on Revised Bloom's Taxonomy)

Programme: M.Sc : Two Year PG **Semester: All**

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

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

(Answer ALL of the questions)

1. Define /Choose/ Relate……
2. What / Why / How?
3. Multiple Choices a. b. c. d.
4. Multiple Choices a. b. c. d.
5. Match the following i - a ii - b iii - c iv - d v - …..
6. Match the following i - a ii - b iii - c iv - d v - …..

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

(Answer any THREE of the questions)

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

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

(Answer any TWO of the questions)

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

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

(Answer any ONE of the questions)

14. Discuss….
15. Summarize….

ANNAMALAI UNIVERSITY

Department of Biochemistry and Biotechnology

Pattern of question paper for END semester examinations

(Based on Revised Bloom's Taxonomy)

Year: I

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

Course Code: **Course Name:**

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

Part-A (Level-K1/ Level-K2) **Marks: (10x2=20)**

(Answer ALL of the questions)

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

Part-B (Level-K3/ Level-K4) **Marks: (8x5=40)**

(Answer any EIGHT of the questions)

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

Part-C (Level-K5) **Marks: (3x10=30)**

(Answer any THREE of the questions)

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

Part-D (Level-K6)* **Marks: (1x10=10)**

(Answer any ONE of the questions)

25. Design….
26. Develop…

ANNAMALAI UNIVERSITY

Department of Biochemistry and Biotechnology
Year: II

Programme: M.Sc Two Year PG Programme **Semester: III / IV**

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

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

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

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

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

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

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

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

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

M. Sc. Biotechnology (TWO YEAR) PROGRAMME

[End Semester Examinations]

Bloom's Taxonomy - Questions Conforming to Levels K1 to K6

	I Year (Two year PG)					**II Year (Two Year PG)**			
	Level	**Part**	**Questions & Marks**	**Total Marks**		**Level**	**Part**	**Questions & Marks**	**Total Marks**
	K1	**A**	5 x 2	10		K1	**A**	5 x 2	10
	K2		5 x 2	10		K2		5 x 2	10
	K3	**B**	4 x5	20		K3	**B**	2 x 5	10
	K4		4 x5	20		K4		4 x 5	20
	K5	**C**	3 x 10	30		K5	**C**	3 x10	30
	K6	**D**	1 x 10	10		K6	**D**	2x 10	20
				100					**100**

PROGRAMME OUTCOMES (POs)

After the successful completion of the M. Sc. Biotechnology (2 year) Degree Programme, the graduates will be able to:

PO1:	Domain knowledge: Demonstrate knowledge of basic concepts, principles and applications of the specific science discipline.
PO2:	Resource Utilisation. Cultivate the skills to acquire and use appropriate learning resources including library, e-learning resources, ICT tools to enhance knowledge-base and stay abreast of recent developments.
PO3:	Analytical and Technical Skills: Ability to handle/use appropriate tools/techniques/equipment with an understanding of the standard operating procedures, safety aspects/limitations.
PO4:	Critical thinking and Problem solving: Identify and critically analyse pertinent problems in the relevant discipline using appropriate tools and techniques as well as approaches to arrive at viable conclusions/ solutions.
PO5:	Project Management: Demonstrate knowledge and scientific understanding to identify research problems, design experiments, use appropriate methodologies, analyse and interpret data and provide solutions. Exhibit organisational skills and the ability to manage time and resources.
PO6:	Individual and team work: Exhibit the potential to effectively accomplish tasks independently and as a member or leader in diverse teams, and in multidisciplinary settings.
PO7:	Effective Communication: Communicate effectively in spoken and written form as well as through electronic media with the scientific community as well as with society at large. Demonstrate the ability to write dissertations, reports, make effective presentations and documentation.
PO8:	Environment and Society: Analyse the impact of scientific and technological advances on the environment and society and the need for sustainable development.
PO9:	Ethics: Commitment to professional ethics and responsibilities.
PO10:	Life-long learning: Ability to engage in life-long learning in the context of the rapid developments in the discipline.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

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

PSO1	Demonstrate an understanding of biological principles and processes occurring in living systems.
PSO2	Apply the knowledge in biotechnology for industrial, pharmaceutical, medical and agricultural applications and find solutions for biotechnological problems.
PSO3	Use current biochemical and molecular techniques to undertake experiments, interpret results and draw conclusions.
PSO4	Use software tools for sequence alignment and structure prediction and data acquisition for genome and proteome analysis.
PSO5	Understand personal and social responsibilities related to modern biotechnological research and be aware of the ethical issues in biotechnology and intellectual property rights and take up entrepreneurial ventures.

SEMESTER - I

Semester	23BITC101: BIOCHEMISTRY	L	T	P	C
I		4	0	0	5

Learning Objective (LO):

LO	To comprehend the structure-function relationship of various biomolecules and understand the principles of energy production in cells in relation to metabolic pathways.

Course Objectives

1	To learn the physical and chemical nature of biomolecules
2	To learn various types of biomolecules
3	To develop knowledge on intermediary metabolism of carbohydrates, proteins and lipids
4	To teach the succinct features of enzymology
5	To develop knowledge in clinical biochemistry

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Identify the nature of solvents and solutions concerning pH and its importance (K1-K3)
CO2	Classify carbohydrates, proteins, lipids and nucleic acids (K2 and K4)
CO3	Identify the motifs by which proteins interact with DNA (K1-K3, K5 and K6)
CO4	Describe the intermediates and enzymes involved in intermediary metabolism (K1-K4)
CO5	Develop succinct knowledge in clinical biochemistry (K1, K2 and K5)

Unit 1 Solutions, Buffers and Carbohydrates

pH, pK, acid, base. Buffers- Henderson- Haselbach equation, biological buffer system – Phosphate buffer system, protein buffer system, bicarbonate buffer system, amino acid buffer system and Hb buffer system. Water, Carbohydrates: Nomenclature, classification, structure, chemical and physical properties of carbohydrates. Metabolism: glycogenesis, glycogenolysis, gluconeogenesis, pentose phosphate pathway

Unit 2 Lipids: A Succinct View

Lipids: Nomenclature, classification, structure, chemical and physical properties of fatty acids. Metabolisms: biosynthesis of fatty acids, triglycerols, phospholipids, glycol lipids. Cholesterol biosynthesis, bile acids and salt formation. Eicosanoids, sphingolipids and steroid hormones.

Unit 3 Overview of Metabolism

Bioenergetics – concept of energy, principle of thermodynamics, relationship between standard free energy and equilibrium constant, ATP as unit of free energy in biological systems. Biological oxidation: Electron transport chain, oxidative phosphorylation, glycolysis, citric acid cycle, Cori cycle, glyoxalate pathway. Oxidation of fatty acids- mitochondrial and peroxisomal β-oxidation, α and β-oxidation, oxidation of unsaturated and odd chain fatty acids, ketone bodies. Photosynthesis, urea cycle, hormonal regulation of fatty acids and carbohydrates metabolisms, Mineral metabolism

Unit 4 Amino Acids and Proteins

Amino acids and protein: Nomenclature, classification, structure, chemical and physical properties of amino acids and proteins. Metabolism: Biosynthesis of amino acids. Degradation of proteins, nitrogen metabolisms and carbon skeleton of amino acids. Inborn error metabolisms (brief account only)

Unit 5 Nucleic Acids

Nucleic acids: Nomenclature, classification, structure, chemical and physical properties of purine and pyrimidines; *de novo* and salvage synthesis of purines, pyrimidine bases, nucleosides and nucleotides. Catabolism of purines and pyrimidines bases. Synthetic analogues of nitrogenous bases

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Nelson, DL and Cox MM, (2
2. 017) *Lehninger Principles of Biochemistry*, 7thed. Freeman, NewYork.
3. Voet, D, Voet JG, and Pratt CW (2018). *Fundamentals of Biochemistry*. 5th ed. Wiley, New York.
4. Rodwell, VW, et al. (2018) *Harper's Illustrated Biochemistry*. 31st ed. McGraw Hill, New York.
5. Berg, JM, Tymoczko, JL, Stryer, GJ, (2023) *Biochemistry*. 10th Ed. Macmillan Education, London.

Supplementary Reading

1. Blackburn, GM, et al. (2006) *Nucleic acids in Chemistry and Biology*. 3rd ed. Royal Soc Chem, Cambridge, UK
2. Ochs RS (2021) *Biochemistry* 2nd Ed. CRC Press, Boca Raton.

Reading List (Online)

1. https://bio.libretexts.org/Bookshelves/Biochemistry/Book%3A_Biochemistry
2. https://www.thermofisher.com/in/en/home/life-science/protein- biology/
3. https://www.open.edu/openlearn/science-maths- technology/science/biology/nucleic-acids-and-chromatin/content-section- 3.4.2
4. https://www.genome.gov/genetics-glossary/Cell-Membrane
5. https://nptel.ac.in/content/storage2/courses/102103012/pdf/mod3.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	2	3	3	2	3	3	3	3	2	2	3
CO2	3	3	3	3	3	3	2	3	2	3	3	3	2	3	2
CO3	3	3	2	3	2	3	3	2	3	3	3	3	3	2	3
CO4	3	3	1	3	3	2	2	3	2	3	3	3	2	3	2
CO5	3	3	2	3	3	2	2	3	2	3	3	3	3	3	2

Semester	23BITC102: MOLECULAR CELL BIOLOGY	L	T	P	C
I		4	0	0	5

Learning Objective (LO):

LO	To learn in detail about the molecular organization of cells, cell division and elements of molecular biology

Course Objectives

1	To familiarize various aspects of cell and molecular biology
2	To understand coordinated functions of various cell organelles
3	To develop knowledge on various aspects of molecular biology
4	To teach the succinct features of DNA replication and transcription
5	To develop knowledge in translation and regulation of gene expression

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Comprehend cellular histological organisation (K1 and K3)
CO2	Understand the organizational and functional aspects of cells and organelles (K1, K2 and K4)
CO3	Learn cell-cell communication as well as interaction with outside environment through transport of molecules (K1, K2 and K6)
CO4	Learn how the gene expression is regulated in prokaryotes and eukaryotes (K3-K5)
CO5	Appreciate the molecular events of epigenetics (K1-K4)

Unit-1 Cell and Tissue Organization

Molecular organization of prokaryotic and eukaryotic cells. Structure and functions of subcellular organelles, nucleus and nucleolus. Mitochondrial biogenesis. Cell motility and shape of the cells - the actin, myosin, dynamics of actin assembly, microtubules and intermediate filaments, microtubule dynamics and associated proteins, kinesin, dynein and intracellular transport. Types of tissues - Epithelium – organization and types, cconnective tissue. The basement membrane.

Unit-2 Membrane Composition and Transport

Composition of membranes - the lipid bilayer, peripheral and integral proteins. The fluid mosaic model. Brief account of membrane rafts. Endocytosis and exocytosis.

Membrane transport: types. Diffusion - passive and facilitated. General classes of transport systems - uniport, symport, antiport. Active transport - primary and secondary. The P-type ATPases (Na^+-K^+ ATPase), F-type ATPases (ATP synthases), ABC transporters, ionophores, aquaporins, ion-channels (ligand-gated and voltage-gated). Signal mediated transport through nuclear pore complexes.

Unit-3 Cell-cell Adhesion and Secretory Pathway

Major classes of cell junctions - anchoring, tight and gap junctions. Major families of cell adhesion molecules (CAMs) - cadherins, integrins. Collagen and noncollagen components (laminin, fibronectins, proteoglycans and hyaluronan) of extracellular matrix. Cell-matrix adhesion and communication.

Overview of secretory pathway, translocation of secretory proteins across the ER Membrane. Golgi and post-Golgi protein sorting and proteolytic processing. Receptor-mediated endocytosis and the sorting of internalized proteins. Molecular mechanisms of vesicular traffic.

Unit-4 Cell Division, Differentiation, Cell Cycle and Cell Death

Molecular events of mitosis and meiosis. Cell differentiation. The cell cycle: phases, regulation by cyclins and cyclin-dependent kinases, checkpoints. Cell cycle control in mammalian cells. Role of multiple Cdks and cyclins in mammalian cell cycle. Molecular basis of eukaryotic cell cycle, Regulation and cell cycle check points.

Cancer Biology: Multistage cancer development Mitogens, carcinogens, oncogenes and proto-oncogenes, tumor suppressor genes-Rb, p 53, Apoptosis and significance of apoptosis.

Cell death: types – Necrosis - causes and mechanism. Apoptosis: morphology, mitochondrial and death receptor pathways. Differences between apoptosis and necrosis. Autophagic cell death.

Unit-5 Cell Signaling

Fundamental concepts and general features of cell signaling. Endocrine, paracrine, autocrine signaling and juxtracrine signaling. Types of receptors. Nuclear, cytosolic and transmembrane receptors. G-protein coupled receptors. Second messengers: cAMP, cGMP, diacylglycerol, inositol triphosphate and Ca^{2+}. Receptor tyrosine kinases - ras-raf-MAP kinase and JAK-STAT pathways. Ataxia-telangiectasia. Mutated (ATM) signaling.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Nelson DL, Cox MM (2017) *Lehninger principles of biochemistry* 7th Ed. Freeman Publishers, New York.
2. Rodwell VW et al. (2018) *Harper's Illustrated Biochemistry*, 31st Ed, McGraw Hill, New York.
3. Krebs JE et al. (2017) *Lewin's Genes XII*, Jones and Barlett, Burlington.
4. Watson JD et al. (2017) *Molecular biology of the gene* 7th Ed. Pearson, London.
5. Lodish R et al. (2016) *Molecular cell biology* 8th Ed. Freeman Publishers, New York.
6. Alberts B et al. (2022) *Molecular biology of the cell* 7th Ed. W.W. Norton and Co. Manhattan.

Supplementary Reading

1.Alberts B et al. (2014) *Molecular Biology of the Cell*. 6th ed. Garland Sci, New York.

2. Alberts B et al. (2023) *Essential cell biology* W. W. Norton Co. Manhattan.

Reading List (Online)

1. Swayam- Molecular biology course by Dr.Nayan K. Jain, Gujarat University
2. Swayam- Cell Biology by Dr K. Sanatombi
3. NPTEL - Molecular Cell Biology by Prof.D. Karunagaran
4. https://www.coursera.org/courses?query=molecular%20biology
5. https://www.cdc.gov/labtraining/training-courses/basic-molecular-biology/index.html

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	2	3	3	2	3	3	3	2	3	2	2
CO2	3	3	2	3	3	2	3	3	2	3	3	3	2	3	3
CO3	3	2	1	2	2	3	3	2	3	3	3	2	3	2	2
CO4	3	3	2	2	3	2	3	3	2	3	3	3	2	2	3
CO5	3	3	2	3	3	2	3	3	2	3	3	3	2	3	3

Semester	23BITP103: PRACTICAL I BIOCHEMISTRY, MOLECULAR CELL BIOLOGY AND MOLECULAR GENETICS	L	T	P	C
I		0	0	16	4

Learning Objective (LO):

LO	To quantitate biomolecules and isolation of DNA and RNA from various biological sources and learn the techniques of molecular cell biology and molecular genetics

Course Objectives

1	Familiarize on basic concepts of qualitative analysis of amino acids and cell culture technique
2	Provide an insight into estimation of DNA
3	Inculcate knowledge on estimation of RNA
4	Teach the concepts of bacterial transformation and conjugation
5	Educate on the various factors affecting enzyme activity

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Analyze amino acids by qualitative and quantitative methods (K1-K3)
CO2	Estimate nucleic acid by chemical methods (K2 and K4)
CO3	Identify and examine various types of cells (K1-K3, K5 and K6)
CO4	Examine different tissue types and learn bacterial transformation and conjugation (K1-K4)
CO5	Evaluate the factors affecting enzyme activity (K1, K2 and K5)

Biochemistry

1. Determination of chlorophyll a, chlorophyll b and total chlorophyll by Arnon method
2. Qualitative analysis of amino acids
3. Quantitative estimation of amino acids by ninhydrin method
4. Estimation of DNA by diphenylamine method.
5. Estimation of RNA by orcinol method.
6. Identification of tissue types, phases of cell division.
7. Microscopic examination of epithelial cells, plant cells.
8. Isolation of mitochondria from cells
9. Effect of pH on enzyme activity (amylase).
10. Effect of temperature on enzyme activity (amylase).
11. Effect of substrate concentration on enzyme activity (amylase) and determination of Km value.
12. Enzyme immobilization using alginate beads

Molecular Cell Biology

1. Tissue culture techniques: Surface sterilisation techniques, media preparation and storage, serum inactivation.
2. Staining of cell cultures and observations under microscope.
3. Cell count and mitotic index.

Text Books

1. *Manual of Biochemistry*. Tata McGraw-Hill Education, New Delhi
2. Becker WM et al. (2009) *The World of the Cell*, 7th ed. Pearson/Benjamin-Cummings, Boston, USA.
3. Gowenlock, AH. (2006) *Varley's Practical Clinical Biochemistry.* CBS Press, New Delhi.
4. Hofmann A, Clokie SS (2018) *Wilson and Walker's Principles and techniques of Biochemistry and Molecular Biology* 8th Ed. Cambridge University Press, Cambridge, UK.
5. Agarwal S, Khan S (2019) *Advanced lab practices in biochemistry and molecular biology*, Wiley India, Bengaluru.
6. Haque MR (2023) *A practical book of biochemistry* ATBS Publishers, New Delhi.

Supplementary Reading

1. Gupta RC, Bhargava S (2022) *Practical biochemistry* CBS Publishers, New Delhi.
2. Dutta K, Raj M (2022) *Cell biology: including practical* Ashok Publications, New Delhi.
3. Gupta R, Makhija S (2018) Cell biology: practical manual, Prestige Publishers, New Delhi.

Reading List (Online)

1. https://www.researchgate.net/publication/313745155_Practical_Bio chemistry
2. https://doi.org/10.1186/s13020-018-0177-x
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5368116/
4. https://www.life.illinois.edu/biochem/455/Lab%20exercises/2Photometry/
5. https://ijpsr.com/bft-article/determination-of-total-flavonoid-and-phenol
6. https://skyfox.co/wp-content/uploads/2020/12/Practical-Manual-of-Biochemistry.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	3	3	2	1	3	3	3	2	1	2
CO2	3	3	3	3	3	3	3	1	2	3	3	3	1	2	1
CO3	3	3	3	3	3	3	3	2	1	3	3	3	2	2	2
CO4	3	3	3	3	3	3	3	1	1	3	3	3	2	1	1
CO5	3	3	3	3	3	3	3	2	2	3	3	3	1	3	2

Semester	ELECTIVE 1: (DISCIPLINE CENTRIC)	L	T	P	C
I	23BITE104: ENZYMOLOGY	3	0	0	3

Learning Objective (LO):

LO	To acquire knowledge on classification, kinetics, mechanism of action, regulation and applications of enzymes

Course Objectives

1	Introduction to the theory and practice of enzymology
2	Inculcate knowledge on mechanisms of catalysis and factors affecting catalysis
3	To impart knowledge on the kinetics of enzyme catalysed reactions in the absence and presence of inhibitors
4	To develop knowledge on different techniques of enzyme immobilisation
5	To explicate about designer enzymes

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the characteristics, classification, isolation and assay of enzymes (K1,K2 and K5)
CO2	Analyse the factors that influence enzyme kinetics (K1 – K4 and K5)
CO3	Evaluate the mechanisms and regulation by enzyme modulation (K1-K3 and K4)
CO4	Translate the basic concepts of enzymology to industrial and medical applications (K1, K2, K5 and K6)
CO5	Highlight the use of enzymes in industries and biomedicine (K1 – K3)

Unit 1 Enzyme Catalysis

Introduction to enzymes and features of catalysis: a short history of the discovery of enzymes and how they became powerful biochemical tools. Holoenzyme, apoenzyme, cofactors, coenzyme, prosthetic groups, classification and nomenclature, specificity of enzyme action-group specificity, absolute specificity, substrate specificity, stereochemical specificity. Active site, identification of amino acids at the active site-trapping of ES complex, identification using chemical modification of amino acid side chains and by site-directed mutagenesis.

Mechanisms of enzyme catalysis: acid-base catalysis, covalent catalysis, electrostatic catalysis, metal ion catalysis, proximity and orientation effects, Low barrier H-bonds, structural flexibility. Mechanism of action of chymotrypsin

Unit 2 Enzyme Purification

Enzyme techniques: Isolation and purification of enzymes - Importance of enzyme purification, methods of purification- choice of source , extraction, fractionation methods-based on size or mass (centrifugation, gel filtration); based on polarity (ion-exchange chromatography, electrophoresis, isoelectric focusing, hydrophobic interaction chromatography); based on solubility (change in pH, change in ionic strength); based on specific binding sites (affinity chromatography), choice of methods, criteria of purity of enzymes. Enzyme units - Katal, IU. Measurement of enzyme activity - discontinuous, continuous, coupled assays; stopped flow method and its applications. Isoenzymes and their separation by electrophoresis with special reference to LDH

Unit 3 Enzyme Kinetics I

Thermodynamics of enzyme action, activation energy, transition-state theory, steady-state kinetics and pre-steady-state kinetics. Single substrate enzyme catalyzed reactions -assumptions, Michaelis-Menten and Briggs-Haldane kinetics, derivation of Michaelis-Menten equation. Double reciprocal (Lineweaver-Burk) and single reciprocal (Eadie-Hofstee) linear plots, their advantages and limitations. Analysis of kinetic data- determination of Km, Vmax, kcat and their physiological significance, Importance of kcat/Km. Enzyme inhibition: irreversible inhibition. Reversible inhibition-competitive, uncompetitive, non-competitive, mixed and substrate inhibition. Michaelis-Menten equation in the presence of competitive, uncompetitive and non-competitive inhibitors. Graphical analysis - diagnostic plots for the determination of inhibition type. Therapeutic use of enzyme inhibitors-aspirin, statins (irreversible inhibitors), methotrexate (competitive inhibitor), etoposide (non-competitive inhibitor), camptothecin (uncompetitive inhibitor).

Unit 4 Enzyme Kinetics II

Allosteric enzymes: cooperativity, MWC and KNF models of allosteric enzymes, Sigmoidal kinetics taking ATPase as an example. Regulation of amount and catalytic activity by extracellular signal, transcription, stability of mRNA, rate of translation and degradation, compartmentation, pH, temperature, substrate concentration, allosteric effectors, covalent modification. Regulation of glycogen synthase and glycogen phosphorylase. Feedback inhibition-sequential, concerted, cumulative, enzyme-multiplicity with examples.

Bi-substrate reactions: Single Displacement reactions (SDR) (ordered and random bi mechanisms), double displacement reactions (DDR) (ping pong mechanism), examples, Cleland's representation of bisubstrate reactions, graphical analysis (diagnostic plots) to differentiate SDR from DDR.

Unit 5 Enzyme Technology

Immobilization of enzymes – methods - reversible immobilization (adsorption and affinity binding), Irreversible immobilization (covalent coupling, entrapment and microencapsulation, crosslinking, advantages and disadvantages of each method, Properties of immobilized enzymes. Designer enzymes- ribozymes and deoxyribozymes, abzymes, synzymes. Enzymes as therapeutic agents-therapeutic use of asparaginase and streptokinase. Application of enzymes in industry- industrial application of rennin, lipases, lactases, invertase, pectinases and papain.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Palmer T, Bonner PL (2008) *Enzymes* 2nd Ed. Horwood Publishing Ltd. Cambridge, UK.
2. Buchholz K et al. (2012) *Biocatalysts and Enzyme Technology* 2nd Ed. Wiley-Blackwell, New Jersey, USA
3. Pandey A et al. (2010) *Enzyme Technology* Springer, Berlin, Germany.
4. Nelson DL, Cox MM (2017) *Lehninger Principles of Biochemistry* 7th Ed. Freeman, New York, USA
5. Balasubramanian D et al. (2004) *Concepts in Biotechnology* 2nd Ed. Cambridge University Press, Cambridge, UK
6. Smith C (2020) *Essentials of enzymology* Larsen and Keller Publications, New York.

Supplementary Reading

1. Dixon M, Webb DC (2014) *Enzymes* 2nd Ed. Elsevier, Amsterdam, Netherlands.
2. Smith JE (2009) *Biotechnology* 5th Ed. Cambridge University Press, Cambridge, UK.
3. Warton CW (2013) *Molecular enzymology* Springer, Berlin.
4. Murphy A (2022) *Practical enzymology*, Murphy and Moore Publishing, New York.

Reading List (Online)

1. https://ocw.mit.edu/high-school/biology/exam-prep/chemistry-of-life/enzymes/
2. https://onlinecourses.swayam2.ac.in/cec20_bt20/preview
3. https://mooc.es/course/enzymology/
4. https://dth.ac.in/medical/courses/biochemistry/block-1/1/index.php
5. https://www.lecturio.com/medical-courses/enzymes-and-enzyme kinetics.course#/
6. https://www.nature.com/articles/nrd.2017.219
7. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4934206/

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	3	2	3	3	2	**3**	**3**	3	3	2	3
CO2	3	2	2	3	2	3	3	3	3	3	3	3	3	3	3
CO3	3	2	3	2	3	2	3	3	2	3	3	3	3	2	3
CO4	3	3	2	3	2	3	3	3	3	3	3	3	3	3	3
CO5	3	2	3	2	3	2	3	3	2	3	3	3	3	2	3

Semester	ELECTIVE 2: (GENERIC)	L	T	P	C
I	23BITE105: BIOINSTRUMENTATION	3	0	0	3

Learning Objective (LO):

LO	To develop comprehensive knowledge on techniques of Biochemistry and Molecular Biology

Course Objectives

1	To understand the various techniques used in biochemical investigation and microscopy
2	To explain chromatographic techniques and their applications
3	To explain electrophoretic techniques
4	To comprehend the spectroscopic techniques and demonstrate their applications in biochemical investigations
5	To acquire knowledge on radiolabelling techniques and centrifugation

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the instrument components, principles and applications of spectroscopy and radioisotope techniques (K1 and K5)
CO2	Exhibit a knowledge base in handling chromatographic techniques (K3 and K5)
CO3	To differentiate the principles of paper, ion exchange, gel and affinity chromatography (K3 and K5)
CO4	Apply the knowledge on centrifugation and radioisotope techniques (K1,K2 and K5)
CO5	Apprehend knowledge on 2D gel electrophoresis and microchip electrophoresis (K1, K2 and K5)

Unit 1 Spectroscopy

Laws of absorption. Absorption spectrum. Principle, instrumentation and applications of UV-visible spectrophotometry, spectrofluorimetry and luminometry. Atomic spectroscopy-principle and applications. Brief outline of the principles and biological applications of NMR and ESR, ORD and CD.

Unit 2 Radioisotope Techniques and Microscopy

Nature and units of radioactivity. Solid and liquid scintillation counting, quenching, scintillation cocktails and sample preparation. Autoradiography. Applications of radioisotopes in biology. Radiation hazards.

Microscopy- basic principles, and components of light, bright field, phase contrast, and fluorescence microscopy. Electron microscopy - principle, preparation of specimens for TEM and SEM. Confocal microscopy. Atomic Force Microscopy (basic concepts).

Unit 3 Electrophoresis and Blotting Techniques

Electrophoresis: General principles, support media. Electrophoresis of proteins - SDS-PAGE, isoelectric focusing, 2-D PAGE. Cellulose acetate electrophoresis. Electrophoresis of nucleic acids - agarose gel electrophoresis, PFGE (pulsed-field gel electrophoresis). Electrophoretic mobility shift assay. Blotting techniques: Southern, Northern and Western blotting.

Unit 4 Chromatography

General principles of partition and adsorption chromatography. Principle, instrumentation and applications of thin layer and gas chromatography. Principle, procedure, and applications of ion-exchange, molecular exclusion, and affinity chromatography. HPLC- principle, instrumentation and applications.

Unit 5 Centrifugation

Basic principles of sedimentation. Types of rotors. Low-speed and high-speed centrifuges. Analytical and preparative ultracentrifuge - instrumentation and applications. Subcellular fractionation by differential centrifugation. Density-gradient centrifugation- rate zonal and isopycnic.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Hofmann A, Clokie SS (2018) *Wilson and Walker's Principles and techniques of Biochemistry and Molecular Biology* 8th Ed. Cambridge University Press, Cambridge, UK.
2. Upadhyay U, Nath S (2010) *Biophysical chemistry principles and techniques* Himalaya Publishers, New Delhi.
3. Boyer R (2009) *Modern Experimental Biochemistry,* 3rd Ed, Pearson Education, Inc. New York.
4. Robyt JF, White BJ (2015) Biochemical techniques theory and practice CBS Publishers, New Delhi.

Supplementary Reading

1. Freifelder DM (1983) *Physical Biochemistry - Applications to Biochemistry and Molecular Biology, 2nd Ed,* WH Freeman Publishers, New York.
2. Lampman P, Vyvyan K (2015) *Introduction to spectroscopy,* 5th Ed Cengage Learning, Boston.
3. Fanali S et al. (2023) *Liquid chromatography: fundamentals and instrumentation* Elsevier, Amsterdam.

Reading List (Online)

1. https:// http://ecoursesonline.iasri.res.in/course/view.php?id=282
2. https:// https://www.academia.edu/41290495/
3. https://www.edouniversity.edu.ng/oerrepository/articles/techniques_in_biochemical_research
4. ttps://www.researchgate.net/publication/336210597Fundamentals_of_Biochemical_Methods
5. https://www.su.se/polopoly_fs/1.622041.1660576721!/columnholder/

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	2	3	3	2	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Semester	ELECTIVE: (GENERIC/DISCIPLINE CENTRIC)	L	T	P	C
I	23BITE106: MOLECULAR GENETICS	3	0	0	3

Learning Objective (LO):

LO	To gain an insight into the storage, transfer and translation of genetic information at molecular level in prokaryotic and eukaryotic systems and understand the molecular nature of heredity

Course Objectives

1	Familiarize on basic concepts of genome complexity and DNA replication
2	Provide an insight into mutations and recombination
3	Inculcate knowledge on transcription and translation
4	Teach the concepts of alleles and chromosome mapping
5	Educate on recent advances in extrachromosomal heredity

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Comprehend genome complexity and the steps in replication (K2 and K3)
CO2	Appreciate repair mechanisms and the consequences of DNA mutations and recombination (K1-K4)
CO3	Figure out the steps in transcription and the significance of post transcriptional processing (K2-K5 and K6)
CO4	Gain in-depth knowledge on alleles and chromosome mapping (K2 and K5)
CO5	Understand the mechanisms involved in extrachromosomal heredity (K4-K6)

Unit 1 Genome Complexity and DNA Markers

Genes and chromosomes, Colinearity of Genes and Proteins, Genetic code, Identification of DNA as the genetic material. The complexity of eukaryotic genome (introns, exons, repetitive DNA sequence, gene duplication and pseudogenes). DNA markers -VNTR, STR, microsatellite, SNP and their detection techniques

Unit 2 DNA Replication

Replication of DNA, gene expression and regulation in prokaryotes and eukaryotes. Mutation: Spontaneous and virus induced mutation, radiation induced mutation. Ionizing radiation, UV radiation. Chromosomal Abnormalities and associated genetic diseases, techniques in the study of chromosomes and their applications, recombination – models

Unit 3 DNA Damage and Repair

DNA damage and repair-internal and external agents causing DNA damages. DNA damages (oxidative damages, depurinations, depyrimidinations, O^6-methylguanines, cytosine deamination, single and double strand breaks). Mechanisms of DNA damage (transition, transversion, frameshift, nonsense mutations). Repair mechanisms (photoreactivation, excision repair, mismatch repair, post replication repair, SOS repair). Discovery: Early experiments of McClintock in maize. Insertion sequences in prokaryotes. Complex transposons (Tn3, Tn5, Tn9 and Tn10). Mechanisms, control consequences and application of transposition by simple and complex elements

Unit 4 Alleles and Chromosome Mapping

Allele frequencies and genotype frequencies, random mating population, Hardy-Weinberg principle, complications of dominance, special cases of random mating – multiple alleles, different frequencies between sexes (autosomal and X-linked) inbreeding, genetics and evolution, random genetic drift, Karyotyping and usefulness of chromosomes in understanding genetic variation, genetics of eukaryotes gene linkage and chromosome mapping.

Unit 5 Extrachromosomal Heredity

Extrachromosomal heredity: Biology of plasmids, their discovery, types and structure of fertility factors and Ti – replication and partitioning, incompatibility and copy number control-natural and artificial plasmid transfer and their applications- human genome project, genomics and modern methodologies in understanding genome.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Nelson DL, Cox MM (2017) *Lehninger principles of biochemistry* 7th Ed. Freeman Publishers, New York.
2. Rodwell VW et al. (2018) *Harper's Illustrated Biochemistry*, 31st Ed, McGraw Hill, New York.
3. Krebs JE et al. (2017) *Lewin's Genes XII*, Jones and Barlett, Burlington.
4. Watson JD et al. (2017) *Molecular biology of the gene* 7th Ed. Pearson, London.
5. Lodish R et al. (2016) *Molecular cell biology* 8th Ed. Freeman Publishers, New York.
6. Alberts B et al. (2022) *Molecular biology of the cell* 7th Ed. W.W. Norton and Co. Manhattan.

Supplementary Reading

1. Watson JD et al. (2006) *Recombinant DNA: genes and chromosomes – a short course* 3rd Ed. Freeman Publishers, New York.
2. Twyman R (2018) *Advanced molecular biology* Garland Science, New York.
3. Strachen T, Read A (2018) *Human molecular genetics* 5th Ed. Garland Science, New York.

Reading List (Online)

1. Molecular Biology Free Online Course by MIT Part 3: RNA Uploaded by edX
2. https://mooc.es/course/molecular-biology/
3. https://onlinecourses.swayam2.ac.in/cec20_ma13/preview
4. https://learn.genetics.utah.edu/
5. https://www.cellbio.com/education.html
6. https://lifescienceinteractive.com/category/molecular-biology/

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	2	1	3	2	1	3	3	3	2	3	2
CO2	3	2	3	2	3	3	3	3	2	3	3	3	3	2	2
CO3	3	3	3	3	3	3	3	2	3	3	3	3	2	3	3
CO4	3	2	2	2	2	2	3	3	3	3	3	3	3	3	2
CO5	3	2	2	2	2	2	3	2	2	3	3	3	2	2	3

SEMESTER - II

Semester	23BITC201: GENETIC ENGINEERING	L	T	P	C
II		4	0	0	5

Learning Objective (LO):

LO	To acquire knowledge on cloning strategies, gene expression analysis, genetic engineering techniques and protein and metabolic engineering.

Course Objectives

1	To master about the basics of genetic engineering tools
2	To comprehend the features of cloning vectors
3	To gain knowledge about genetic engineering strategies
4	To understand selection, screening, and analysis of recombinants
5	To inculcate detailed knowledge about applications of rDNA technology

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the concept of cloning, expression of desired genes, and construction of genomic library (K1-K3 and K4)
CO2	Apply genetic engineering principles to perform gene expression analysis and gene manipulation (K2 and K3)
CO3	Understand the principles and applications of RACE, RAPD and PCR (K1-K3 and K4)
CO4	Apply the knowledge on expression of cloned genes for basic and applied research (K1-K4)
CO5	Comprehend the steps and applications of protein and metabolic engineering (K1, K2 and K5)

Unit 1 Cloning Strategies

Restriction endonucleases- nomenclature and action. Cloning vectors: Cloning in plasmid vectors (pBR322, pUC18). Bacteriophage λ vectors- λ biology, *in vitro* packaging, insertion and replacement vectors. M13 vectors. Cosmids. Expression vectors. BACs and YACs. Methods of ligation of insert and vector- host-organisms for cloning. Genomic and cDNA cloning. Screening methods for recombinants. Genomic libraries: construction, evaluation, growing and storing a genomic library. cDNA libraries: mRNA isolation, cDNA synthesis, construction of a cDNA library.

Unit 2 Expression of Cloned Genes

Factors affecting expression of cloned genes. Expression of cloned genes in bacteria. Fusion proteins, increasing protein stability and secretion. Expression in eukaryotic cells: expression in yeast- yeast vectors. The GAL system, overexpression and secretion of heterologous proteins in yeast. Expression in insect cells: baculovirus system. Mammalian cell expression systems. Tagged proteins and secretion signals. Identification of different hosts for cloned gene expression and factors affecting the expression.

Unit 3 Gene Expression Analysis

Analysis of transcription by northern, RNase protection, RT-PCR, *in situ* hybridization, and primer extension assays. Comparison of transcriptomes by differential screening, subtractive hybridization, differential display, array-based methods and microarray. Reporter genes- types and uses. Translational analysis by western, immunocytochemistry, immunohistochemistry, and 2-D electrophoresis.

Unit 4 Techniques

Extraction and purification of nucleic acids- cell lysis, extraction, precipitation, centrifugation, denaturation, purification, detection and quantification. Probe preparation and screening libraries with gene probes, antibodies, rescreening, subcloning. PCR: basic principles, optimization, applications. Reverse Transcriptase (RT)-PCR, real-time PCR, RACE, RAPD, inverse PCR, ligase chain reaction. Gene knock-in and knock-out technology. Characterization of DNA-protein interaction- Gel retardation assay, DNase I foot printing.

Unit 5 Site-Directed Mutagenesis (SDM), Protein and Metabolic Engineering

SDM-Cassette, oligonucleotide-directed mutagenesis, PCR-based methods. Use of SDM for protein engineering to improve enzymes and therapeutic proteins. Protein engineering by directed evolution and DNA shuffling. Metabolic engineering: designed overproduction of phenylalanine, novel routes to small molecules. Combinatorial biosynthesis. Synthetic biology (brief outline). Hazards and safety aspects of genetic engineering.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Glick BR et al. (2010) *Molecular Biotechnology: Principles and Applications of Recombinant DNA,* 4th ed. ASM Press, Washington
2. Dale JW et al. (2011) *From Genes to Genomes: Concepts and applications of DNA technology*. 3rd ed. Wiley-Blackwell, New Jersey.
3. Primrose SB, Twyman RM (2002) *Principles of gene manipulation and genomics*. 6th ed. Blackwell, Oxford, UK
4. Nicholl DST (2023) *An introduction to genetic engineering*, Cambridge University Press, Cambridge.

Supplementary Reading

1. Winnacker EL (1987) *From Genes to Clones*. VCH Publishers, Weinheim, Germany
2. Watson JD et al. (2006) *Recombinant DNA: Genes and Genomes-A Short Course*. Freeman, New York.
3. Sandhu SS (2018) *Recombinant DNA technology* I K International Publishers, New Delhi.

Reading List (Online)

1. https://www2.nau.edu/fpm/bio205/Sp-10/chapter-10.pdf
2. https://fcen.uncuyo.edu.ar/catedras/techniques-in-genetic-engineering.pdf
3. https://www.gordon.edu/download/pages/Salem-Genetic%20Engineering2003.pdf
4. https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000002BI/
5. http://genok.no/wp-content/uploads/2013/04/Chapter-4.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	2	3	3	3	2	3	3	3	3	3	2
CO2	3	2	1	2	3	2	3	2	3	3	3	3	3	2	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	2	2	2	2	2	3	2	2	3	3	3	3	2	2
CO5	3	2	2	2	2	2	3	2	2	3	3	3	3	2	3

Semester	23BITC202: PLANT AND ANIMAL BIOTECHNOLOGY	L	T	P	C
II		4	0	0	5

Learning Objective (LO):

LO	To learn about fundamentals of plant tissue culture, and acquire knowledge on recombinant DNA technology to produce genetically modified plants as well as to understand the right to protect intellectual property and patenting.

Course Objectives

1	Familiarize on basic concepts of plant tissue culture
2	Provide an insight into gene delivery methods
3	Inculcate knowledge on techniques in transgenesis
4	Teach the concepts of gene manipulation
5	Educate on recent advances in transgenic plants

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand and learn the techniques for culturing tissues, single cell, protoplast and anther culture and adopt methods of sterilization and cryopreservation (K1 and K3)
CO2	Learn gene transfer methods and molecular marker assisted selection (K1, K2 and K4)
CO3	Evaluate the production and benefits of genetically modified plants (K1, K2 and K6)
CO4	Apply rDNA technology for crop improvement (K3-K5)
CO5	Recognize the importance of protection of new knowledge and patenting of innovations in research (K1-K4)

Unit 1 Plant Tissue Culture

Introduction of plant tissue culture, composition of media, micropropagation, organogenesis, somatic embryogenesis, haploid and triploid production, protoplast isolation and fusion, hybrid and cybrid, synthetic seed production. Secondary metabolites in plants - phytochemicals- glycosides and flavonoids; anthocyanins and coumarins - lignans, terpenes, volatile oils and saponins; carotenoids and alkaloids: biogenesis, therapeutic applications

Unit 2 Transgenic Plants

Plant Transformation. Direct transformation by electroporation and particle gun bombardment. *Agrobacterium*, Ti plasmid vector. Theory and techniques for the development of new genetic traits, conferring resistance to biotic and abiotic. Plant engineering towards the development of enriched food products, plant growth regulators; Molecular Marker aided breeding: RFLP maps, Linkage analysis, RAPD markers, STS microsatellite, SCAR, SSCP, QTL. Map based cloning and molecular marker assisted selection.

Unit 3 Animal Biotechnology I

Animal health disease diagnosis, hybridoma technique, monoclonal antibodies, application of probes for disease diagnosis of existing and emerging animal diseases. Prophylaxis - vaccines, oral vaccines, DNA vaccines in animal disease. Cell culture: primary and established culture; organ culture; tissue culture

Unit 4 Animal Biotechnology II

Disaggregation of tissue and primary culture; cell separation, slide and coverslip cultures, flask culture, test tube culture techniques, cell synchronization, cryo preservation. Scaling up of animal cell culture, cell line and cloning micromanipulation and cloning, somatic cell cloning. Karyotyping; measuring parameters for growth, measurement of cell death, apoptosis and its determination, cytotoxicity assays

Unit 5 Transgenic Animals and Techniques in Animal Biotechnology

Nuclear magnetic resonance methods of monitoring cell metabolism culturing animal cells in fluidised bed reactors. Application of animal cell culture for *in vitro* testing of drugs, production of human and animal viral vaccines and pharmaceutical proteins. Culture scale up and mass production of biologically important compounds. Harvesting of products, purification and assays. Transgenic animals: Production and application; transgenic animals in livestock improvement, transgenic animals as model for human diseases; Stem cells- properties, types, therapy, prospects and ethics in stem cell research.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Smith RH (2013) *Plant Tissue Culture*. 3rd ed. Elsevier, Amsterdam, Netherlands.
2. Primrose S et al. (2002) *Principles of Gene Manipulation.* 6th ed. Blackwell Science, New Jersey.
3. Glick BR et al. (2010) *Molecular Biotechnology: Principles and Applications of Recombinant DNA.* 4th ed. ASM Press, Washington.
4. Watson JD et al. (2006) *Recombinant DNA: Genes and Genomes-A short course. 3rd ed*. Freeman, New York.
5. Anderson R (2023) *Plant biotechnology and transgenic plants*, White Press Academic, New Orleans.
6. Hofmann A, Clokie S (2018) *Wilson and Walker's Principles and techniques of Biochemistry and Molecular Biology.* 8th ed. Cambridge University Press, Cambridge, UK.
7. Singh BD (2012) *Biotechnology. Expanding horizons*. Kalyani Publishers, New Delhi.

Supplementary Reading

1. Slater A (2008) *Plant Biotechnology: The Genetic Manipulation of Plants*. 2nd ed. Oxford Univ Press, Oxford, UK.
2. Freshney, RI (2010) *Culture of animal cells: A Manual of Basic Technique*. 6th ed. Wiley-Liss, New Jersey.
3. Verma AS, Singh A (2020) *Animal biotechnology: models in discovery and translation*, Elsevier, Amsterdam.

Reading List (Online)

1. https://pravara.in/wp-content/themes/twentyseventeen/essentials
2. https://bcrti.co.in/digitallibrary/includeFolder/noticeFolder/211111032202117.pdf
3. https://www.davuniversity.org/images/files/study-material/
4. https://croplife.org/wp-content/uploads/2015/02/CL_Biotech101_A4_Book_FA_2016.pdf
5. http://80.191.248.6:8080/dl/Plant%20biotechnology%20and%20genetics
6. https://luvas.edu.in/downloads/pdf/animal-biotechnology.pdf
7. https://ucanr.edu/sites/UCCE_LR/files/155896.pdf
8. https://www.iitg.ac.in/rakhi_chaturvedi/pdf/books/30-herbal%20medicine.pdf
9. https://www.saasta.ac.za/Media-Portal/download/bio_fs01.pdf
10. https://nap.nationalacademies.org/read/10418/chapter/3

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	2	3	2	3	3	2	3	3	2	2	2	3
CO2	3	3	2	3	2	3	3	3	3	3	3	3	3	3	2
CO3	3	3	3	2	3	2	3	3	2	3	3	3	2	2	3
CO4	3	3	2	3	3	2	3	3	3	3	3	3	3	3	3
CO5	3	3	3	2	2	3	3	2	2	3	3	3	3	2	2

Semester	23BITP203: PRACTICAL II MOLECULAR BIOLOGY, GENETIC ENGINEERING, PLANT AND ANIMAL BIOTECHNOLOGY	L	T	P	C
II		0	0	14	4

Learning Objective (LO):

LO	To isolate and analyze nucleic acids and proteins by molecular biology techniques, plant tissue culture and animal cell culture techniques

Course Objectives

1	Familiarize on basic concepts of nucleic acid isolation from various biological sources
2	Provide an insight into electrophoresis of DNA, RNA and proteins
3	Inculcate knowledge on western blotting technique
4	Teach the concepts of southern and western hybridization
5	Educate on protoplast isolation and culture

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Gain knowledge on nucleic acid isolation from various biological sources (K2 and K3)
CO2	Analyze nucleic acids isolated from various sources by electrophoresis (K1-K4)
CO3	Separate proteins in biological samples by SDS-PAGE and study protein abundance by western blotting (K2-K5 and K6)
CO4	Elucidate the techniques of protoplast isolation and culture (K3 and K5)
CO5	Undertake PCR analysis and know about real time qPCR (K4-K6)

Molecular Biology and Genetic Engineering

1. Isolation of bacterial chromosomal and plasmid DNA and characterization by electrophoresis
2. DNA electrophoresis in agarose gel and determination of molecular size
3. RNA isolation and cDNA synthesis
4. Thermal denaturation of DNA
5. UV absorption spectrum of proteins and nucleic acids- demonstration
6. Restriction enzyme digestion of bacterial plasmid DNA

Demonstration

1. Separation of proteins by SDS-PAGE and western hybridization
2. DNA electrophoresis in agarose gel and southern hybridization
3. RT-PCR
4. Real-time qPCR

Plant and Animal Biotechnology

1. Plant tissue culture techniques: preparation of stock solutions of MS basal medium and plant growth regulator stocks.
2. Effect of plant growth regulators on various explants for callus induction.
3. Steps in micro propagation (demonstration)
4. Protoplast isolation and culture.
5. Isolation of lymphocytes and viability testing by trypan blue dye exclusion test.
6. Animal cell culture techniques: Surface sterilization techniques, media preparation and storage, membrane filtration, serum inactivation.
7. Estimation of protein, DNA and RNA from cultured cells.
8. MTT assay for cell viability
9. Demonstration of apoptosis in cultured cell

Text Books

1. Sambrook J Russell DW (2006) *Molecular cloning: a laboratory manual Vol 1,2 & 3*, CSHL Press, New York
2. Pal GK, Pal P (2006) *Textbook of Practical Physiology*, 2nd ed. Orient Blackswan, Hyderabad, India
3. Work TS, Work E (2009) *Laboratory techniques in biochemistry and molecular biology.* North-Holland Pub. Co. Amsterdam.
4. Sarma PV(2021) *A practical textbook of genetic engineering in bacteria*, MJP Publishers, New Delhi.
5. Singh BR, Kumar R (2022) Practical techniques in molecular biotechnology, Cambridge University Press, Cambridge.

Supplementary Reading

1. Rani A (2015) *Practical plant biotechnology and genetics* New India Publishers, New Delhi.
2. Verma AS (2015) *Laboratory manual for biotechnology* S Chand Publishing, New Delhi.

Reading List (Online)

1. https://www.urmc.rochester.edu/MediaLibraries/URMCMedia/labs
2. https://www.academia.edu/1265636/Practical_Immunology_4th_ed
3. https://www.researchgate.net/publication/275045725_Practical_Immunology-A_Laboratory_Manual
4. https://www.uomustansiriyah.edu.iq/media/lectures
5. https://fcen.uncuyo.edu.ar/catedras/techniques-in-genetic-engineering.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2	3	3	3	3	3	2	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	2	2	3	3	3	3	2	3
CO5	3	3	3	3	3	3	3	2	2	3	3	3	3	2	3

Semester	ELECTIVE 3: (DISCIPLINE CENTRIC)	L	T	P	C
II	23BITE204: PHARMACEUTICAL BIOTECHNOLOGY	3	0	0	3

Learning Objective (LO):

LO	To know the basic concepts in pharmaceutical industry and to understand drug development, approval process and manufacturing of biopharmaceuticals.

Course Objectives

1	To inculcate knowledge about basics of pharmaceutical biotechnology
2	To comprehend about hybridoma technology and production of drugs
3	To inculcate knowledge about drug metabolism and manufacturing
4	To elucidate about biochemistry and actions of biopharmaceuticals
5	To inculcate acquaintance about drug development and approval

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the scope of pharmaceutical biotechnology (K1-K3)
CO2	Understand pharmacokinetics, metabolism and dynamics of drugs (K2 and K4)
CO3	Apply the manufacturing principles in formulation of drugs and biopharmaceuticals (K1-K3, K5 and K6)
CO4	Comprehend the production of recombinant proteins, enzymes and carbohydrate and nucleic acid based biopharmaceuticals (K1-K4)
CO5	Explain the regulatory aspects in drug development and drug approval (K1, K2 and K5)

Unit 1 Introduction

Introduction to concepts and technologies in pharmaceutical biotechnology and industrial applications. Biosensors- working and applications of biosensors in pharmaceutical industries; pharmacology and ethnopharmacology: Scope, applications and importance. Sources of biopharmaceuticals – yeast, animal cell cultures, bacteria, fungi, plants and animals. Shelf life of protein-based pharmaceuticals.

Routes of drug administration, absorption of drugs. Bioavailability – factors influencing absorption and bioavailability. Drug distribution-plasma protein binding, placental transfer, blood-brain barrier.

Unit 2 Protein Engineering

Scientific, technical and economic aspects of vaccine research and development, preparation of bacterial vaccines, toxoids, viral vaccine and antitoxins, storage conditions and stability of vaccines, recombinant DNA technology, application of rDNA technology and genetic engineering in the production of: (i) interferon (ii) vaccines - hepatitis- B (iii) hormones – Insulin. Brief introduction to protein engineering, therapeutic proteins, production of enzymes- general consideration – amylase, catalase, peroxidase, lipase, protease, penicillinase, methods of enzyme immobilization and applications

Unit 3 Hybridoma Technology and Production of Drugs

Hybridoma technology - production, purification and applications, formulation of biotech products - rituximab, introduction to microbial biotransformation and applications, study of the production of – penicillin, citric acid, Vitamin B12, glutamic acid and griseofulvin. Somatic gene therapy, xenotransplantation in pharmaceutical biotechnology, large scale production fermenter design and its various controls, Biosafety in pharmaceutical industry

Unit 4 Biopharmaceuticals

Pharmacological activity of plant drugs, phytochemicals in modern pharmacology; biochemistry and pharmacology of atropine, caffeine ephedrine, opioids, taxol, *Vinca* alkaloids, synthetic substitutes for therapeutically active plant constituents; drug improvement by structure modification and biotransformation. Criteria for pharmacological evaluation of drugs.

Unit 5 Clinical Pharmacology

Drug therapy, therapeutic situation, benefits and risk of use of drugs, mechanism of drug action, therapeutic efficacy, therapeutic index, tolerance, dosage forms and routes of drug action, factors affecting drug action; adverse drug reactions and drug poisoning-classification and causes of ADR; principle clinical manifestations and treatment of ADR, general principles of management of drug poisoning; antidotes, classification of drugs.

Strategies for new drug discovery, lead compound, combinatorial approaches to drug discovery, pre-clinical and clinical trials. Phase I, II and III. Regulatory authorities – Food and Drug Administration (USA), national regulatory authorities in India.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Gilman et al. (2011) *Goodman and Gilman's The Pharmacological basis of therapeutics,* 12th Ed. Macmillan Publishing Co. New York.
2. Satoskar V et al. (2015) *Pharmacology and Pharmacotherapeutics*, 24th Ed. Popular Prakashan, Mumbai.
3. Kayser O, Muller RH (2004) *Pharmaceutical Biotechnology- Drug Discovery and Clinical Applications,* Wiley, New Jersey.
4. Klefenz H (2002), *Industrial Pharmaceutical Biotechnology,* Wiley, New Jersey.
5. Uddin P, Pathak MK (2021) *Pharmaceutical biotechnology*, IP Innovative publishers, New Delhi.

Supplementary Reading

1. Spada S, Walsh G (2004) *Directory of Approved Biopharmaceuticals*, CRC Press, Boca Raton, US.
2. Shargel L et al. (2012) *Applied Biopharmaceuticals and Pharmacokinetics,* 6th ed, McGraw-Hill, New York.
3. Offermanns S, Rosenthal W (2021) *Encyclopaedia of molecular pharmacology* Springer, Berlin.

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	3	2	3	3	3	3	3	2	3	3	2
CO2	3	2	3	2	3	2	3	3	3	3	3	1	3	3	1
CO3	3	3	2	3	3	1	3	3	3	3	3	2	3	3	2
CO4	3	2	2	2	3	2	3	3	3	3	3	2	3	3	2
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Semester	ELECTIVE 4: (GENERIC)	L	T	P	C
II	23BITE205: ENVIRONMENTAL BIOTECHNOLOGY	3	0	0	3

Learning Objective (LO):

LO	To acquire knowledge on environmental biotechnology and its applications

Course Objectives

1	Familiarize on several spheres of environmental biotechnology
2	Provide an insight into applications of biotechnology to environment
3	Inculcate knowledge on professional activities of environmental biotechnology
4	Teach the concepts of biodiversity and its importance
5	Educate on importance of environmental biotechnology to provide healthy environment

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the factors specific concepts and terminology of environmental biotechnology (K1 and K3)
CO2	Apprehend the uses of microorganisms in the prevention of all types of pollution (K1, K2 and K4)
CO3	Understand the technologies, tools and techniques of environmental biotechnology (K1, K2 and K6)
CO4	Use of microorganisms as diagnostic agents (K3-K5)
CO5	Know the new strategies of bioremediation (K1-K4)

Unit 1 Pollution

Environmental pollution: basic concepts and global issues-global warming and acid rain. Pollution measurements- air and water. Biosensor in environmental monitoring. Bioremediation of environmental pollutants in soil and water- oils, heavy metals and detergents. Biofouling and biosensors**.**

Unit 2 Waste water treatment

Waste treatment: wastewater treatment: physical, chemical and biological treatment processes. Various industrial effluent treatment methods- sugar, distillery, dairy, tannery and pharmaceutical industries. Solid wastes: types and characteristics. Solid waste disposal-landfilling incineration. Biogas from solid waste. Composting and vermicomposting. Parameters for composting.

Unit 3 Bioremediation

Bioremediation: introduction of bioremediation advantages and applications; types of bioremediations. Microbial remediation of phenolics-sewage nutrients (phosphate and nitrate). Impact of bioremediation in the petroleum industry, paper industry, marine oil pollutants and chemical industry. Phytoremediation-advantages and applications (agriculture).

Unit 4 Biocorrosion, Biometallurgy and Biodegradation

Biocorrosion and microbial mediated recovery: microbial corrosion and its control (petroleum industry and cooling tower system). Biometallurgy- bioleaching- application, biotechnology approaches for heavy metal elimination from effluents. Bio-mediated recovery of metals (gold and platinum). Recovery of petroleum-MEOR-biosurfactant. Biodegradation: biodegradation of organic pollutants: mechanisms and factors affecting biodegradation. Pollution problems and biodegradation of simple aliphatic, aromatic, polycyclic aromatic hydrocarbons, halogenated hydrocarbons, azo dyes, lignin and pesticides. Bioenergy.

Unit 5 Soil and Agricultural Biotechnology

Soil microbiota-growth, ecological adaptations, interactions among soil microorganisms, biogeochemical role of microorganisms. Microorganisms and soil fertility. Microbial degradation of xenobiotics in the environment. Oil spill clean-up. Bioremediation of contaminated soil and waste lad. Biofertilizers-definition, types and application methods. Biopesticides in integrated pest management – *Bacillus* and baculoviruses and biocontrol agents. Biodegradable plastics.

Current Streams of Thought
The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Borem W et al. (2010) *Understanding Biotechnology*. Pearson, London.
2. Singh BD (2012) *Biotechnology*. Kalyani Publishers, New Delhi.
3. Ratledge A Kristiansen V (2006) *Basic Biotechnology*. 3rd ed. Cambridge University Press, Cambridge, UK.
4. Gupta PK (2010) *Elements of Biotechnology*. 2nd ed. Rastogi Publication, New Delhi.
5. Scragg A (2005) *Environmental Microbiology*. 2nd ed. American Society for Microbiology, Washington.
6. Ahmed N (2014) *Industrial and Environmental Biotechnology*. Horizon Scientific Press, London.
7. Hodkiewicz S (2022) *Environmental biotechnology principles and applications*, White Press, London.

Supplementary Reading

1. Flickinger E, Drew C (1999) *Encyclopedia of Bioprocess Technology. 5 vol*. John Wiley & Sons, New Jersey.
2. Gupta RK, Singh SS (2021) *Environmental biotechnology: a new approach*, Daya Publishing House, New Delhi.
3. Primrose S et al. (2002) *Principles of Gene Manipulation.* 6th ed. Blackwell Science, New Jersey.

Reading List (Online)
1. https://www2.hcmuaf.edu.vn/data/quoctuan/Environmental%20Biotechnology
2. https://www.teriin.org/sites/default/files/2020-11/2018EE03-%20Course%20material.pdf
3. https://content.kopykitab.com/ebooks/2016/04/6425/sample/sample_6425.pdf
4. https://www.wiley.com/en-us/Environmental+Biotechnology%3A+Theory
5. https://www.accessengineeringlibrary.com/content/book/9781260441604

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	2	2	3	3	3	3	2	3	2	3	3
CO2	3	3	3	2	3	3	3	3	2	3	3	3	3	2	3
CO3	3	3	2	2	3	2	3	3	2	3	2	3	2	2	2
CO4	3	3	3	3	2	3	3	3	2	3	3	3	3	3	3
CO5	3	3	2	3	2	2	3	3	3	3	2	3	3	2	3

Semester	ELECTIVE: (DISCIPLINE CENTRIC/ELECTIVE)	L	T	P	C
II	23BITE206: REGULATORY AFFAIRS AND INTERNATIONAL STANDARDS	3	0	0	3

Learning Objective (LO):

LO	To develop comprehensive knowledge on fundamentals of regulatory requirement in industries and about the regulatory affairs.

Course Objectives

1	To understand the basic requirements of establishing laboratory for testing samples
2	To explain the scientific and technical knowledge about various food preservation techniques
3	To elucidate about packing of food materials and various parameters observed during packaging
4	To comprehend the testing of food materials
5	To acquire knowledge on food safety management system and good hygienic practices

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the basics of food testing laboratory(K1 and K5)
CO2	Exhibit a knowledge base in food preservation technology (K3 and K5)
CO3	To differentiate the principles of food packaging technology (K3 and K5)
CO4	Apply the knowledge on food microbiology and testing (K1,K2 and K5)
CO5	Apprehend knowledge on HACCP and food safety management (K1, K2 and K5)

Unit 1 Food Testing Laboratory and Laboratory Safety

Understand the requirements for setting up a laboratory for the legal defensibility of analytical data. The ideal structure design, environment, layout for microbiological testing and Air handling etc., Introduction about accreditation, different accreditation bodies (NABL, APLAC, ILAC), Requirements for ISO/IEC 17025:2017, documentation, pre-requisites for accreditation, management requirements, technical requirements, measurement of traceability, Laboratory safety: Personnel and laboratory hygiene, emergency planning, general hazards in a food laboratory, safety equipment, storage of chemicals, acids, flammables etc, handling and biological spills and waste disposal.

Unit 2 Food Preservation Technology

Heat: Principles of heat transfer, blanching, Pasteurization, heat sterilization, thermal extrusion, cooking. Water removal: Forms of water in foods, sorption of water in foods, water activity, drying and evaporation technology. Temperature reduction: Chilling, freezing, Radiation: Ionizing radiation, microwave, use of chemicals: Class-I and Class-II preservatives, smoke other chemical additives, new non-thermal methods: High hydrostatic pressure, modified atmosphere, high intensity pulsed electric fields, intense pulsed light, oscillating magnetic fields, hurdle technology, ultrasonic and ohmic heating etc.

Unit 3 Food Packaging Technology

Effect of environment on food stability: light, oxygen, water, temperature, sensitivity to mechanical damage and attack by biological agents, different packaging materials used for food packaging and their properties including barrier properties, strength properties, optical properties: Glass, metals, paper, plastics, biodegradable and edible films and coatings aseptic packaging and combinations, selection of packaging material and design for various food commodities including fresh produce (fruits and vegetables), milk and milk products (dairy), cereal, pulses, oil, meat, fish, poultry, water and processed foods, evaluation of quality and safety of packaging materials- different testing procedures.

Unit 4 Food Microbiology and Testing

Introduction of food microbiology: Morphology and structure of microorganisms in foods (yeast and mold, bacteria and viruses), important genera of mold, yeast, bacteria (Gram positive and Gram negative, facultative aerobic and anaerobic, endospore forming bacteria and non-sporulating bacteria), bacterial groups (lactic acid, acetic acid, butyric acid etc.,), thermophilic, proteolytic, coliforms, faecal coliforms, enteric pathogens and emerging microbes, sources of microorganisms in food chain (raw materials, water, air, equipment etc) and microbiological quality of foods. Microbial growth characteristics: Reproduction and growth (fission, generation time optimum growth, growth curve etc).

Unit 5 HACCP and Food Safety Management Systems

ISO 22000: Importance of implementing a HACCP (Hazard Analysis Critical Control Point) system and how it can be applied to various products. Prerequisite programs, HACCP principles, some limitation of HACCP food safety objective (FSO). Food safety audits: Management review, audit certification and importance. Good manufacturing practices (GMP), Good hygienic practices (GHP), Food safety plan, food safety management risk analysis. Traceability food products recall and sanitation.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Liu D (2021) *Molecular Food Microbiology* CRC Press, Boca Raton.
2. Wang Y et al. (2017) *Food spoiling microorganisms: ecology and control* CRC Press, Boca Raton.
3. Jan S (2013) *Elements of food science* Nipa Publishers, New Delhi.
4. Skariyachan S, Abhilash M (2012) *Introduction to food biotechnology* CBS Publishers, New Delhi.

Supplementary Reading

1. Megh R et al. (2022) *Advances in food processing: novel processing and preservation* CRC Press, Boca Raton.
2. Ray RC et al. (2022) *Lactic acid bacteria in food biotechnology* Elsevier, Amsterdam.
3. Guida A (2022) *Biosafety measures, technology risks and the world trade organisation* Taylor and Francis Publishing, New York.

Reading List (Online)

1. http://students.aiu.edu/submissions/r3N5R8_nutrition%20food%20biotechnology.pdf
2. https://www.researchgate.net/publication/Food_Biotechnology_Benefits_and_Concerns
3. https://foodinsight.org/wp-content/uploads/2003/03/Biotech-Guide.pdf
4. https://core.ac.uk/download/pdf/83604141.pdf
5. http://ndl.ethernet.edu.et/bitstream/123456789/78629/1/%28Biol%203132%29.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	2	3	3	2	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Semester	SKILL ENHANCEMENT COURSE 1: SEC 1:	L	T	P	C
II	23BITS207: ADVANCED MOLECULAR BIOLOGY	2	0	0	2

Learning Objective (LO):

LO	To gain an insight into the storage, transfer and translation of genetic information at molecular level in prokaryotic and eukaryotic systems and understand the intricate molecular mechanisms of gene expression regulation.

Course Objectives

1	Familiarize on basic concepts of genome complexity and DNA replication
2	Provide an insight into mutations and recombination
3	Inculcate knowledge on transcription and translation
4	Teach the concepts of genetic code
5	Educate on recent advances in regulation of gene expression

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Comprehend genome complexity and the steps in replication (K2 and K3)
CO2	Appreciate repair mechanisms and the consequences of DNA mutations and recombination (K1-K4)
CO3	Figure out the steps in transcription and the significance of post transcriptional processing (K2-K5 and K6)
CO4	Gain in-depth knowledge on genetic code, mechanism of protein synthesis and protein sorting (K2 and K5)
CO5	Understand the mechanisms involved in gene expression regulation at transcriptional, translational and epigenetic levels (K4-K6)

Unit 1 Chromatin and Genome Complexity

The central dogma of molecular biology. The *E. coli* chromosome and DNA-binding proteins. Plasmids - classification and properties. Eukaryotic chromatin: nucleosomes, 30 nm fiber and higher order chromatin structure. Concept of the gene. Definitions of the following: gene, cistron, coding region (ORF), transcription unit, untranslated region (UTR), pseudogenes, euchromatin and heterochromatin. Typical structure of protein-coding genes in prokaryotes and eukaryotes.

Unit 2 Replication, Repair and Recombination

Meselson and Stahl experiment. Enzymes and proteins involved in replication: helicases, SSB, topoisomerases, DNA polymerases, DNA ligase. DNA replication in bacteria and eukaryotes: initiation, elongation, termination. DNA damage by physical and chemical agents. DNA repair - photoreactivation, excision repair, mismatch repair, SOS response, double strand break repair.

Unit 3 Transcription and Post-Transcriptional Processing

Transcription in *E. coli:* RNA polymerase subunit structure, promoter sequence steps in transcription - template recognition, initiation, elongation and termination (intrinsic and ρ-dependent). Transcription in eukaryotes: RNA pol I, II and III: subunit structure, transcription factors, promoters, inhibitors. Mechanism of RNA pol II transcription: preinitiation complex formation, transcription initiation (activator proteins, mediator, chromatin recruitment), elongation, termination.

Classes of introns. Post-transcriptional processing of prokaryotic and eukaryotic rRNA, and tRNA. and eukaryotic mRNA.

Unit 4 Genetic Code and Translation

The genetic code: general features. Mitochondrial genetic code. Mutations: point mutations and frameshift mutations. Suppressor mutations - nonsense and missense suppression.

Mechanism of protein synthesis in bacteria and eukaryotes: amino acid activation, initiation, elongation and termination. Inhibitors of protein synthesis. Post-translational modifications.

Unit 5 Regulation of Gene Expression

Basic principles of gene regulation - levels of gene expression, definition of housekeeping genes, and inducible genes, upregulation, downregulation. Regulation of gene expression in prokaryotes: *lac* operon Regulation of gene expression in eukaryotes: Transcriptional regulation by steroid hormone receptors, phosphorylation (STAT proteins), alternative splicing. Epigenetic gene regulation: DNA methylation, histone acetylation and deacetylation.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Nelson DL, Cox MM (2017) *Lehninger principles of biochemistry* 7th Ed. Freeman Publishers, New York.
2. Rodwell VW et al. (2018) *Harper's Illustrated Biochemistry*, 31st Ed, McGraw Hill, New York.
3. Krebs JE et al. (2017) *Lewin's Genes XII*, Jones and Barlett, Burlington.
4. Watson JD et al. (2017) *Molecular biology of the gene* 7th Ed. Pearson, London.
5. Lodish R et al. (2016) *Molecular cell biology* 8th Ed. Freeman Publishers, New York.
6. Alberts B et al. (2022) *Molecular biology of the cell* 7th Ed. W.W. Norton and Co. Manhattan.

Supplementary Reading

1. Watson JD et al. (2006) *Recombinant DNA: genes and chromosomes – a short course* 3rd Ed. Freeman Publishers, New York.
2. Twyman R (2018) *Advanced molecular biology* Garland Science, New York.

Reading List (Online)

1. Molecular Biology Free Online Course by MIT Part 3: RNA Uploaded by edX
2. https://mooc.es/course/molecular-biology/
3. https://onlinecourses.swayam2.ac.in/cec20_ma13/preview
4. https://learn.genetics.utah.edu/
5. https://www.cellbio.com/education.html
6. https://lifescienceinteractive.com/category/molecular-biology/

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO 4	PSO5
CO1	3	2	2	3	2	1	3	2	1	3	3	3	2	3	2
CO2	3	2	3	2	3	3	3	3	2	3	3	3	3	2	2
CO3	3	3	3	3	3	3	3	2	3	3	3	3	2	3	3
CO4	3	2	2	2	2	2	3	3	3	3	3	3	3	3	2
CO5	3	2	2	2	2	2	3	2	2	3	3	3	2	2	3

SEMESTER III

Semester		L	T	P	C
III	23BITC301: BIOINFORMATICS	4	0	0	5

Learning Objective (LO):

LO	To learn the principles and applications of bioinformatics

Course Objectives

1	To inculcate knowledge about basic concepts of bioinformatics
2	To comprehend about basics of sequence alignment
3	To inculcate knowledge about bioinformatics for genome sequencing
4	To elucidate about molecular visualization tools
5	To inculcate acquaintance about medical applications of bioinformatics

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the basic concepts of bioinformatics (K1, K3 and K4)
CO2	Comprehend sequence alignment basics (K2)
CO3	Apply the modern methods for genome sequencing (K1-K3 and K6)
CO4	Apply structural bioinformatics tools to predict and elucidate protein structures and map protein- protein interactions (K4 and K5)
CO5	Retrieve, align, analyze and interpret sequence and structural data from databases (K5 and K6)

Unit 1 Introduction

Database concepts, introduction to internet and its application, introduction to bioinformatics, protein and nucleotide databases, information retrieval from biological databases, sequence alignment and database searching-similarity searches using BLAST and FASTA. Artificial intelligence: Introduction to biological neural network, motivation for artificial neural network (ANN), big data analysis - DNA/RNA/protein sequence or structure data, gene expression data, protein-protein interaction (PPI) data, pathway data and gene ontology (GO) data

Unit 2 Basics of Sequence Alignments

Sequence alignment basics, match, mismatch, similarity, scoring an alignment, gap penalty, protein vs DNA alignments, dot-matrix alignment, pairwise alignment. Global and local alignment algorithms, multiple sequence alignment-progressive alignment and iterative alignment algorithms, consensus sequence, patterns and profiles, database searching: Pairwise alignment based rigorous algorithm (Smith and Waterman) and Heuristic algorithms (FASTA and Blast). Multiple sequence alignment-based database searching. PSI- Blast, PAM and Blosum matrices

Unit 3 Bioinformatics and Genome Sequencing

Bioinformatics for genome sequencing, EST Clustering and analyses, finding genes in prokaryotic and eukaryotic genomes, regulatory sequence analysis, bioinformatics for genome maps and markers, bioinformatics for understanding genome variation, protein structure-X-ray crystallography, the protein databank and the PDBSum-SCOP, CATH, DALI and HSSP; visualization of molecular structures-RasMol and Pymol; protein secondary structure prediction, fold recognition; transmembrane topology prediction

Unit 4 Molecular Visualization Tools

Molecular visualization tools. Rasmol, Chime and Spdb viewer. Structure analysis tools. VAST and DALI, structural biology - homology modeling, bioinformatics for micro array designing and transcriptional profiling, bioinformatics for metabolic reconstruction, bioinformatics for phylogenetic analysis

Unit 5 Medical Applications of Bioinformatics

Medical application of bioinformatics. Disease genes, drug discovery. History. Steps in drug discovery. Target identification. Target validation. QSAR. Lead identification. Preclinical pharmacology and toxicology. ADME. Drug designing. Rational drug design. Computer aided drug design. Ligand based approach. Target based approach.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Lesk A (2014) *Introduction to Bioinformatics* 4th Ed. Oxford University Press, Oxford, UK.
2. Balamurugan S et al. (2021) *Computation in bioinformatics: multidisciplinary applications* Wiley, New Jersey.
3. Singh V, Kumar A (2021) *Advances in bioinformatics* Springer, Berlin.
4. Lesk AM (2002) *Introduction to bioinformatics* Oxford University Press, Oxford.
5. Pevsner J (2003) *Bioinformatics and functional genomics* Elsevier, Amsterdam.
6. Wang V et al. (2023) *Bioinformatics : sequence analysis and parallel computing* De Gruyter Press, Berlin.

Supplementary Reading

1. Gibas C (2013) *Developing Bioinformatics Computer Skills*, 2nd Ed. O'Reilly Associates, Massachusetts, USA.
2. Ouellette B (2004) *Bioinformatics. A Practical Guide to the Analysis of Genes and Proteins*. 3rd Ed. Wiley Interscience, New Jersey.
3. Lin S et al. (2022) *Bioinformatics methods: omics to next generation sequencing* CRC Press, Boca Raton.

Reading List (Online)

1. https://www.researchgate.net/publication/283084372
2. https://www.lkouniv.ac.in/site/20200329161234146 7kuaum_yadav_Bioinformatics.pdf
3. http://bioinformaticsinstitute.ru/sites/default/files/lapidus_1_0.pdf
4. https://www.gene-quantification.de/wishart-proteomics-bioinformatics-1.pdf
5. http://bioinformaticsinstitute.ru/sites/default/files/lapidus_1_0.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	2	3	2	3	3	2	3	2	3	3
CO2	3	3	3	3	3	3	3	3	2	3	3	3	3	2	3
CO3	3	3	3	3	3	2	3	2	2	3	2	3	2	3	3
CO4	3	3	3	3	3	3	3	2	2	3	3	3	3	2	3
CO5	3	3	3	3	3	2	3	2	2	3	2	3	2	3	3

Semester	23BITC302: IMMUNOLOGY	L	T	P	C
III		4	0	0	5

Learning Objective (LO):

LO	To acquire a comprehensive knowledge on cells of the immune system, immunoprotection and immunochemical techniques

Course Objectives

1	To master about immune cell types, antigens and antibodies
2	To comprehend the features of types of immunity and vaccines
3	To gain knowledge on antibody diversity and transplantation
4	To elucidate about hypersensitivity and tumor immunology
5	To inculcate detailed knowledge on immunotechniques

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Describe the components of immune system and the role of cells and organs in immune response (K1 and K2)
CO2	Learn the latest developments in vaccine production and effector mechanisms (K3)
CO3	Understand in depth the abnormal immunologic manifestation in transplantation and hypersensitivity and the genetic mechanisms in antibody diversity (K2 and K4)
CO4	Gain a clear view of immunological mechanisms with a focus on management of diseases cancer, AIDS and autoimmune disorders (K2- K4)
CO5	Comprehend the principle and application of various techniques ranging from immunodiffusion to ELISA, RIA and flow cytometry (K1-K4 and K6)

Unit 1 Immune Cell Types, Antigens and Antibodies

Central and peripheral lymphoid organs. Bone marrow, thymus. Lymph node, spleen and mucosal associated lymphoid tissue. Cells of the lymphoreticular system. T-Cells, B-Cells, mononuclear phagocytes, dendritic cells, granulocytes, NK cells, mast cells. Antigens definition antigenicity, antigenic determinants, haptens and epitopes. Antibodies - structure, classification, functions, Isotypes, allotypes and idiotypes. Complement system- components, nomenclature, activation of complement, classical pathway and alternate pathway. Biological functions of complement.

Unit 2 Types of Immunity and Vaccines

Types of immunity - innate and acquired immunity, Antigen recognition - T-cell and B-cell receptor complexes, antigen processing and presentation. Interaction of T and B-cells. Immunological memory, effector mechanisms: phagocytosis, cell mediated cytotoxicity, antibody dependent cell mediated cytotoxicity.

Immunization practices - active and passive immunization. Vaccines - killed, attenuated-toxoids. Recombinant vector vaccines - DNA vaccines, synthetic peptide vaccines. Production and applications of polyclonal and monoclonal antibodies. Genetically engineered antibodies. AIDS - pathogenesis. Tumor immunology - tumor antigens, cancer immunotherapy.

Unit 3 Antibody Diversity and Transplantation

Antibody diversity - mechanisms contributing to diversity- somatic recombination, rearrangement and generation of antibody diversity. Class switching. MHC complex- gene organisation - HLA genes class I and II antigens. Histocompatibility testing, cross matching. MHC and disease association. Transplantation-types - graft versus host reactions. Immunosuppressive agents.

Unit 4 Hypersensitivity, Immune Disorders and Tumor Immunology

Hypersensitivity - definition and classification - type I to type V (brief account only). Autoimmunity and autoimmune disease - SLE. AIDS- pathogenesis, diagnosis and treatment. Tumor immunology - immune surveillance, tumor antigens, immune response to tumors, cancer immunotherapy.

Unit 5 Immunotechniques

Immunochemical techniques - production of antibodies - polyclonal and monoclonal antibodies. Applications of Mab. Immunodiffusion techniques, immunoprecipitation, RIA, ELISA, fluorescence immune-assay, avidin-biotin mediated assay, immunohistochemistry, immunoelectrophoresis, immunoblotting. Complement fixation test. Flow cytometry.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Punt J, Stranford S (2018) *Kuby Immunology* 8th Ed. WH Freeman & Co, New York.
2. Abbas AK et al. (2018) *Cellular and Molecular Immunology* 9th Ed. Elsevier, Berlin.
3. Murphy KM et al. (2017) Janeway's *Immunology: the immune system* 8th Ed. Garland Science, New York.
4. Coico R, Sunshine G (2015) *Immunology: A short Course* 7th Ed. Wiley, New Jersey.
5. Flajnik M et al. (2022) *Paul's fundamental immunology* 8th Ed. Wolters, Kluwel Publishers, Philadelphia.

Supplementary Reading

1. Delves, PJ et al. (2017) *Roitt's Essential Immunology*, 13th Ed. Willey-Blackwell Sci. New Jersey.
2. Rich RR et al. (2022) *Clinical immunology principles and practice* Elsevier, Amsterdam.
3. Abbas A et al. (2021) *Cellular and molecular immunology* 10th Ed. Elsevier, Amsterdam.

Reading List (Online)

1. https://apps.who.int/iris/bitstream/handle/10665/58891/WHO/
2. https://hmmcollege.ac.in/uploads/3._Immunology.pdf
3. http://www.helmberg.at/immunology.pdf
4. https://booksite.elsevier.com/samplechapters/9780443073267/9780443073267.pdf
5. https://aacijournal.biomedcentral.com/articles/10.1186/s13223-018-0278-1

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3	2	3	3	2	3	2	3	2	2	3
CO2	3	3	2	3	2	3	3	3	3	3	3	3	3	3	3
CO3	3	2	1	2	3	2	3	3	2	3	2	3	3	2	3
CO4	3	3	2	1	2	3	3	3	3	3	3	3	3	3	3
CO5	3	2	1	2	3	2	3	3	2	3	2	3	3	3	3

Semester	23BITC303: BIOPROCESS TECHNOLOGY	L	T	P	C
III		4	0	0	5

Learning Objective (LO):

LO	To acquire a comprehensive knowledge on bioprocess technology

Course Objectives

1	To master about the basis of bioprocess engineering
2	To comprehend the features of reactors in fermentation
3	To gain knowledge on the stages of fermentation
4	To elucidate about scale up and scaled down processes
5	To inculcate detailed knowledge on downstream processing

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Describe the essential features of fermentation and microbial culture (K1 and K2)
CO2	Learn the latest developments in the design of bioreactors (K3)
CO3	Understand in depth the recovery process (K2 and K4)
CO4	Gain a clear view of downstream processing (K2- K4)
CO5	Comprehend the principle and application of development of commercially important products (K1-K4 and K6)

Unit 1 Bioprocessing

Fermentation - Introduction and types. Isolation and screening of industrially important microbes. Maintenance of strains. Strain improvement - mutant selection, recombination, metabolite production by rDNA technology. Inoculum source - seed culture; development of inoculum of yeast, bacteria and fungi. Process development. Bioreactors - design, function and types. Aerobic and anaerobic fermentation. Essential criteria for culture media, media components, media formulation, media optimization. Antifoaming devices. Analysis of batch, fed-batch and continuous bioreactors.

Unit 2 Fermentation

Introduction to Bioprocess - Basic operations involved in bioprocesses. Screening of industrially important microbes. Isolation and maintenance of microbes. Inoculum development - Microbial growth and death kinetics.

Fermentation processes - Types of fermentation and fermenters - Batch, fed batch and continuous fermentation. Media for fermentation. Solid substrate, surface and submerged fermentation - Sterilization aeration, agitation, Monitoring and control of parameters (temperature, pH) in fermentation process - Aerobic and anaerobic fermentation.

Unit 3 Downstream Processing

Downstream processing: Stages: separation of microbial cells and solid matter, solid-liquid separation, release of intracellular compartments, concentration of biological products, purification-membrane filtration, precipitation, adsorption and chromatography, process centrifugation, dialysis, reverse osmosis, ultrafiltration, preservation and stabilization, crystallization and drying. Storage and packaging. Product formulation. Treatment of effluent and disposal. Monitoring of downstream processing.

Unit 4 Industrial Production

Production of alcohol (ethanol), acids (citric acid, lactic acid and acetic acid), solvents (acetone, butanol and glycerol), antibiotics (penicillin, cephalosporine), amino acids (lysine, aspartate, glutamic acid and threonine) and vitamins B2 and B12). Commercial production of fructose. Enzymes used for commercial purposes and their industrial production. Whole cell immobilization and industrial applications.

Unit 5 Biotransformation

Biotransformation: general principles, biotransformation of D-sorbitol to L-sorbose, biotransformation of antibiotics, and steroids. Metabolic engineering: designed overproduction of phenylalanine. Single cell protein- microorganisms and substrates for SCP production, steps in SCP production and recovery, nutritional and safety evaluation, advantages.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Moser A (2020) *Bioprocess technology* Springer-Verlag, Berlin.

2. Stanbury PF et al. (2017) *Principles of fermentation technology* Elsevier, Amsterdam.

3. Lambert R (2022) *Bioprocess engineering* Kaufman Press, Wilmington.

4. Durga PMP (2014) *Fermentation technology* Wiley India, New Delhi.

5. Reddy SM (2017) *Basic fermentation technology* New Age Publishers, New Delhi.

6. Das D, Pandit S (2021) *Industrial biotechnology* CRC Press, Boca Raton.

Supplementary Reading

1. McNeil B, Harvey LM (2015) *Practical fermentation technology* Wiley India, New Delhi.

2. Berenjian A (2019) *Essentials in fermentation technology* Springer, Berlin.

Reading List (Online)

1. https://gdcboysang.ac.in/About/droid/uploads/Bioprocess%20Technology.pdf

2. https://www.academia.edu/42900838/Introduction_to_Bioprocess_Technology

3. https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SBT1301.pdf

4. https://www.researchgate.net/publication/319987789/BIOPROCESS_TECHNOLOGY

5. https://www.mlsu.ac.in/econtents/1808_Bioprocessengg.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3	2	3	3	2	3	2	3	2	2	3
CO2	3	3	2	3	2	3	3	3	3	3	3	3	3	3	3
CO3	3	2	1	2	3	2	3	3	2	3	2	3	3	2	3
CO4	3	3	2	1	2	3	3	3	3	3	3	3	3	3	3
CO5	3	2	1	2	3	2	3	3	2	3	2	3	3	3	3

Semester	23BITP304: PRACTICAL III	L	T	P	C
III	BIOINFORMATICS, IMMUNOLOGY AND BIOPROCESS TECHNOLOGY	0	0	13	4

Learning Objective (LO):

LO	To learn Southern blotting, Northern blotting and immunodiagnostics methods

Course Objectives

1	Familiarize on the methods of bioinformatics
2	Provide an insight into prediction of signal sequence
3	Inculcate knowledge on immunodiagnosis
4	Teach the concepts of counter current electrophoresis
5	Educate on bioassays of cytokines

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the basics of identification of various immune cells (K1 and K3)
CO2	Elucidate various methods of immunodiagnostics (K1, K2 and K4)
CO3	Undertake the electrophoretic (PAGE) profile of human serum (K1, K2 and K6)
CO4	Isolation of IgG molecule from serum (K3-K5)
CO5	Training on the bioassays of cytokines (K1-K4)

Bioinformatics

1. Sequence retrieval from GenBank
2. Sequence retrieval from Uniport
3. Sequence similarity search – sequence similarity search using BLAST
4. ORF gene search – GenScan
5. Sequence translation using ExPASy translate tool
6. Prediction of signal sequence suing SignalP online tool

Immunology

1. Identification of various immune cells from human peripheral blood.
2. Lymphocyte separation and identification
3. Determination of lymphocyte viability by trypan blue method
4. WBC counting
5. Electrophoretic profile of human serum in native PAGE
6. Preparation of cellular antigen – human RBC
7. Preparation of antigen-adjuvent mixture for production of polyclonal antibody
8. Isolation of IgG molecule from serum
9. Radial Immunodiffusion
10. Ouchterlony Immunodiffusion
11. Immunoelectrophoresis
12. Counter current immunoelectrophoresis.
13. Bioassays for cytokines
14. ELISA (Demonstration)

Immunodiagnostics (any three):

1. Immunodiagnostics: CRP
2. Immunodiagnostics: ASO
3. Immunodiagnostics: Widal
4. Immunodiagnostics: RA
5. Immunodiagnostics: Blood grouping and typing
6. Immunodiagnostics: hCG

Bioprocess Technology (Demonstration)

1. Conservation of bacteria by lyophilization
2. Production of penicillin and determination of penicillin activity
3. Use of alginate for cell immobilization

Text books

1. Chowdhury MR (2014) *Laboratory manual for molecular genetics* Athiti Books, New Delhi.
2. Pali V (2016) *Practical handbook of genetics* Kalyani Publishers, New Delhi.
3. Kaliaperumal K et al. (2017) *Practical immunology: a laboratory manual* Lap Lambert Publishing, Saarland, Germany.
4. Hay FC, Westwood OMR (2002) *Practical immunology* Wiley-Blackwell, New Jersey.
5. McNeil B, Harvey L (2008) *Practical fermentation technology* Wiley, New Jersey.
6. Bisswanger H (2019) *Practical immunology* Wiley, New Jersey.

Supplementary Reading

1. Banerjee BK (2011) *Problems in genetics, molecular genetics and evolutionary genetics* New Central Book Agency, New Delhi.
2. Thatoi H et al. (2017) *Practical biotechnology: principles and protocols* IK International, New Delhi.
3. Low LWY, Tammi MT (2023) *Practical bioinformatics for beginners: from raw sequence analysis to machine learning applications* WSPC Publishers, New Jersey.

Reading List (Online)

1. https://www.researchgate.net/publication/343636082_Practical_manual
2. http://www-personal.umd.umich.edu/~poelkers/OelkersMolbiolmanualUMD2016.pdf
3. https://www.urmc.rochester.edu/frelinger-lab/documents/Immunology-Lab-Manual.pdf
4. https://www.researchgate/275045725_Practical_Immunology-A_Laboratory_Manual
5. https://webstor.srmist.edu.in/web_assets/2021/18BTC106J-lab-manual.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	2	3	3	2	3
CO3	3	3	3	3	3	3	3	3	2	3	3	3	3	2	3
CO4	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3
CO5	3	3	3	3	3	3	3	3	2	3	3	3	3	2	3

Semester	ELECTIVE 5: (DISCIPLINE CENTRIC)	L	T	P	C
III	23BITE305: NANOBIOTECHNOLOGY	3	0	0	3

Learning Objective (LO):

LO	To learn the essentials and implications of nanobiotechnology

Course Objectives

1	Familiarize on the basis of nanobiotechnology
2	Provide an insight into nanoparticle-based drug delivery
3	Inculcate knowledge on nanomaterials and their applications
4	Teach the concepts of nanofabrication
5	Educate on the applications of nanobiotechnology

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the basics of nanobiomaterials (K1, K2 and K3)
CO2	Learn the process of preparation of nanobiomaterials (K2 and K4)
CO3	Understand the applications of nanobiomaterials (K1-K3, K5 and K6)
CO4	Elucidate the role of nanomaterials in diagnosis and therapy (K1-K4)
CO5	Understand the pros and cons of nanotoxicology (K1, K2 and K5)

Unit 1 Nanobiomaterials

Introduction to nanotechnology- scientific revolution, Feynman's vision, classification of nanobiomaterials -types of nanomaterials – nanoparticles, nanotubes, nanowires, nanofibers, size dependent variation in the properties of nanomaterials, nature's nanophenomena.

Unit 2 Preparation of Nanobiomaterials

Preparation of nanomaterials, top down and bottom-up approaches, biosynthesis, nanobiomaterials- polymer, ceramic, metal based nanobiomaterials, carbon based nanomaterials, DNA based nanostructures, protein based nanostructures, quantum dots, magnetic nanoparticles, nanofibers, hydrogels, films and scaffolds.

Unit 3 Application of Nanomaterials

Application of nanomaterials in bone substitutes and dentistry, food and cosmetic applications, bio-sensors and lab-on-a-chip, bio-devices and implantable devices, bioremediation, nanomaterials for anti-microbial coating – medical implants and paints, application of nanotechnology in textile industry.

Unit 4 Nanomaterials, Diagnosis and Therapy

Nanomaterials for diagnosis and therapy, implications of drug delivery, nano-carriers for application in medicine, polymeric nanoparticles as drug carriers, drug release mechanism, targeted drug delivery using nanocarriers, nanoparticle technologies for cancer therapy and diagnosis, point of care and personalized medicine, magnetic nanoparticles for imaging and hyperthermia.

Unit 5 Nanotoxicology

Nanotoxicology, portals of entry of the nanoparticles into the human body, biotoxicity of nanoparticles, nanoparticles in mammalian systems and health threats, biological response and cellular interaction of implant materials and scaffolds, risk assessment and safety regulation of nanoparticles.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Abd-Elsalam K (2021) *Green synthesis of silver nanomaterials* Elsevier, Amsterdam.
2. Al-Khayri JM (2021) *Nanobiotechnology* Springer, Berlin.
3. Craig E (2019) *Nanomaterials: an introduction to properties, synthesis and applications* Larsen and Keller Education, New York.
4. Saxena A et al. (2023) *Nanobiotechnology: principles and applications* Bentham Books, Sharjah.

Supplementary Reading

1. Kim J-C et al. (2021) *Smart nanomaterials in biomedical applications* Springer, Berlin.
2. Barabadi H (2022) *Pharmaceutical nanobiotechnology for targeted therapy* Springer, Berlin.
3. Buushan I et al. (2020) *Nanomaterials and environmental biotechnology* Springer, Berlin.

Reading List (Online)

1. https://www.aist.go.jp/Portals/publications/pamphlet/today/nanotechnology_e.pdf
2. https://web.pdx.edu/~pmoeck/phy381/intro-nanotech.pdf
3. https://www.researchgate.net/publication/303413206_What_is_nanotechnology
4. https://old.amu.ac.in/emp/studym/100016644.pdf
5. https://meddocsonline.org/ebooks/ebook-nanotechnology/2019.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	2	3	3	2	3	3	2	3	2	3	3
CO2	3	3	3	2	3	2	3	3	3	3	3	2	2	2	3
CO3	3	3	2	3	3	3	3	2	3	3	2	3	3	3	3
CO4	3	3	3	2	3	2	3	3	3	3	3	2	3	2	3
CO5	3	3	2	3	2	3	3	2	3	3	2	3	2	3	3

Semester	ELECTIVE: (DISCIPLINE CENTRIC/GENERIC)	L	T	P	C
III	23BITE306: MOLECULAR DEVELOPMENTAL BIOLOGY	3	0	0	3

Learning Objective (LO):

LO	To learn about fundamentals of molecular aspects of developmental biology

Course Objectives

1	Familiarize on structure and function of developmental biology
2	Provide an insight into basic fertilization process of animals
3	Inculcate knowledge on functions of embryonic development process
4	Teach the concepts of organ development of vertebrate animals
5	Educate on recent advances in impact of gene developmental biology and developmental disorders

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand and learn the basics of developmental biology (K1 and K3)
CO2	Learn the process of fertilization (K1, K2 and K4)
CO3	Evaluate the development process in *Xenopus* and chick (K1, K2 and K6)
CO4	Learn about the concepts of vertebrate development (K3-K5)
CO5	Recognize the importance of development process in *Drosophila* and developmental disorders (K1-K4)

Unit 1 Basics of Developmental Biology

Definition and scope of developmental biology. History and the origin of developmental biology – cell theory, mosaic and regulative development. Gametogenesis - spermatogenesis and oogenesis. Structure of sperm and oocyte. important signaling pathways in vertebrate development, discovery of induction, basic concepts of developmental biology – cell division, cell differentiation, signaling, patterning; model systems: vertebrates model organism – *Xenopus laevis*, chicken, mammals, invertebrate model organism- *Drosophila melanogaster*.

Unit 2 Fertilization

Fertilization - definition, mechanism of fertilization in mammal and sea urchin. Types of fertilization. Nieuwkoop center, Molecular role of organizer. Early embryonic development of vertebrates and invertebrates: structure of the gametes – the sperm, the egg; cleavage and gastrulation; axes and germ layers; morphogenesis – cell adhesion, cleavage and formation of blastula, gastrulation, neural tube formation, cell migration; axis specification in *Drosophila.*

Unit 3 *Xenopus* and Chick Development

Cleavage in *Xenopus*, chick and mammals, regulation of cleavage cycle. Morphogenetic movements, Gastrulation in *Xenopus*, chick and mammals. Fate maps. General concepts of organogenesis: development of chick limb- development and patterning of vertebrate limb, proximal – distal and dorso – ventral axis formation, homeobox genes in patterning.

Unit 4 Vertebrate Development

Vertebrate Development: Formation of the neural tube, myogenesis, and hematopoiesis. Mechanism of vertebrate eye development. Postembryonic development: growth – cell proliferation, growth hormones; ageing – genes involved in alteration in timing of senescence; regeneration – epimorphic regeneration of reptile (salamander) limb, requirement of nerves for the proliferation of blastema cells; embryonic stem cells and their applications.

Unit 5 Development Process in *Drosophila* and Developmental Disorders

Drosophila Maternal effect genes, induction at single cell level - differentiation of photoreceptors in ommatidia. Developmental disorders- Spina bifida, anencephaly, and craniorachischises, Cyclopia.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Weber M (2022) *Philosophy of developmental biology* Cambridge University Press, Cambridge.
2. Chipman AD (2021) *Cellular processes in segmentation* CRC Press, Boca Raton.
3. Sokol SY (2021) *Amphibian models of development and disease* Academic Press, Massachusetts
4. Gilbert SF, Barresi MJF (2016) *Developmental biology* Sinauer Associates, Massachusetts
5. Hazarika G (2022) *Developmental biology* Ashok Books, New Delhi.

Supplementary Reading

1. Gilbert S (2021) *Evolutionary developmental biology* Academic Press, Massachusetts
2. Roosevelt L (2019) *Developmental biology: diverse aspects* Syrawood Publishing House, New York.

Reading List (Online)

1. http://bgc.ac.in/pdf/study-material/developmental-biology-7th-ed-sf-gilbert.pdf
2. https://www.researchgate.net/publication/309032743_Developmental_biology
3. https://www.amherst.edu/media/view/343230/original/0-INTRODUCTION%2011.pdf
4. https://application.wiley-vch.de/books/sample/3527338217_c01.pdf
5. https://www.academia.edu/17308552/CELL and_ developmental _biology

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3	2	3	3	2	3	3	3	3	2	3
CO2	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	2	2	3	3	2	3	3	2	3	3	3	3	2	3
CO4	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3
CO5	3	2	3	2	3	2	3	3	2	3	3	3	3	2	3

Semester	SKILL ENHANCEMENT COURSE 2: SEC 2:	L	T	P	C
III	23BITS307: GENE MANIPULATION TECHNOLOGY	2	0	0	2

Learning Objective (LO):

LO	To develop comprehensive knowledge on the principles and applications of gene manipulation technology

Course Objectives

1	To understand the basics of gene manipulation technology
2	To explain the construction of cDNA libraries
3	To explain about genome sequencing and transcriptomics
4	To comprehend the process of protein engineering
5	To acquire knowledge on applications of gene cloning

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the fundamentals of gene manipulation technology (K1 and K5)
CO2	Exhibit a knowledge on construction of cDNA library (K3 and K5)
CO3	Understand the principles of genome sequencing and transcriptomics (K3 and K5)
CO4	Apply the knowledge about production of pharmacological products (K1, K2 and K5)
CO5	Apprehend knowledge on gene cloning strategies (K1, K2 and K5)

Unit 1 Vectors and Gene Cloning

Basics of gene manipulation technology-restriction enzymes-cutting and joining reactions-vectors-selection of recombinants- factors affecting expression of cloned genes. Expression of cloned genes in bacteria. Fusion proteins, increasing protein stability and secretion. Expression in eukaryotic cells: expression in yeast- yeast vectors. The GAL system, overexpression and secretion of heterologous proteins in yeast.

Unit 2 cDNA Library

Constructions of DNA Libraries- vectors used in the construction of cDNA and genomic DNA libraries- positive selection and subtractive hybridization- preparation of (BAC/YAC library). Genomic libraries: construction, evaluation, growing and storing a genomic library. cDNA libraries: mRNA isolation, cDNA synthesis, construction of a cDNA library.

Unit 3 Genome Sequencing and Transcriptomics – A Succinct View

Genome sequencing and transcriptomics- Sanger's sequencing, whole genome shot gun sequencing- comparative genome sequencing. Transcriptome analysis- DNA microarray-expression of recombinant proteins. Analysis of transcription by northern, RNase protection, RT-PCR, *in situ* hybridization, and primer extension assays. Comparison of transcriptomes by differential screening and microarray

Unit 4 An Overview of Protein Engineering

Protein engineering and pharmaceutical products- site directed mutagenesis- protein analysis-therapeutic protein- vaccines. Mammalian cell expression systems. Tagged proteins and secretion signals. Identification of different hosts for cloned gene expression and factors affecting the expression. Use of SDM for protein engineering to improve enzymes and therapeutic proteins. Protein engineering by directed evolution and DNA shuffling.

Unit 5 Transgenic Animals and Plants

Methods of transformation, codon optimization, host engineering. Strategies of gene delivery, *in vitro* translation, expression in bacteria, yeast, expression in insects and mammalian cells. Applications of gene cloning- creating transgenic animals and plants- reporter genes- animal cloning, gene expression in plants. Hazards and safety aspects of genetic engineering.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Glick BR et al. (2010) *Molecular Biotechnology: Principles and Applications of Recombinant DNA,* 4th ed. ASM Press, Washington
2. Dale JW et al. (2011) *From Genes to Genomes: Concepts and applications of DNA technology*. 3rd ed. Wiley-Blackwell, New Jersey.
3. Primrose SB, Twyman RM (2002) *Principles of gene manipulation and genomics*. 6th ed. Blackwell, Oxford, UK
4. Nicholl DST (2023) *An introduction to genetic engineering*, Cambridge University Press, Cambridge.

Supplementary Reading

1. Winnacker EL (1987) *From Genes to Clones*. VCH Publishers, Weinheim, Germany
2. Watson JD et al. (2006) *Recombinant DNA: Genes and Genomes-A Short Course*. Freeman, New York

Reading List (Online)

1. https://www2.nau.edu/fpm/bio205/Sp-10/chapter-10.pdf
2. https://fcen.uncuyo.edu.ar/catedras/techniques-in-genetic-engineering.pdf
3. https://www.gordon.edu/download/pages/Salem-Genetic%20Engineering2003.pdf
4. https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000002BI/
5. http://genok.no/wp-content/uploads/2013/04/Chapter-4.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3	2	3	3	2	3	3	3	3	2	3
CO2	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	2	2	3	3	2	3	3	2	3	3	3	3	2	3
CO4	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3
CO5	3	2	3	2	3	2	3	3	2	3	3	3	3	2	3

Semester	23BITC401: RESEARCH METHODOLOGY	L	T	P	C
IV		4	0	0	5

Learning Objective (LO):

LO	To learn the importance of research and components of research

Course Objectives

1	Familiarize on basic concepts of research and its methodologies
2	Provide an insight into select appropriate research topic
3	Inculcate knowledge on defining research problem and parameters
4	Teach the concepts of writing a project proposal
5	Educate on organize and conduct research in an appropriate manner

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand research concepts, issues and types and basic knowledge of research (K1, K2 and K4)
CO2	Comprehend the salient features of research planning (K2 and K4)
CO3	Apply the modern methods for planning objectives and research techniques (K1-K3, K5 and K6)
CO4	Detailed knowledge on observation, collection of data, generalization and interpretation (K1-K4)
CO5	Retrieve, align, analyze and interpret data and appropriate writing of thesis and research papers (K1, K2 and K5)

Unit 1 Objectives of Research

Objectives and types of research: motivation and objectives – research methods *vs* methodology. types of research – descriptive *vs*. analytical, applied *vs*. fundamental, quantitative *vs*. qualitative, conceptual *vs*. empirical.

Research methodology - an introduction: meaning of research, objectives of research, types of research, research approaches, importance of knowing how research is done, research process, criteria of good research. Defining the research problem; research design; sampling design; Methods of data collection; processing and analysis of data; sampling fundamentals

Unit 2 Research Formulation

Research formulation – defining and formulating the research problem - selecting the problem - necessity of defining the problem - importance of literature review in defining a problem – literature review – primary and secondary sources – reviews, treatise, monographs- patents – web as a source – searching the web - critical literature review – identifying gap areas from literature review-development of working hypothesis.

Web search: introduction to internet, use of internet and WWW, using search engine like Google, Yahoo, Pubmed, Science direct, Scopus etc, and using advanced search techniques

Review of literature, writing the research report (thesis and publications): Components of research report - title, authors, addresses, abstract, keywords, introduction, materials and methods, results, discussion, summary, acknowledgements and bibliography

Unit 3 Research Design

Research design and methods – research design – basic principles- need of research design —features of good design – important concepts relating to research design – observation and facts, laws and theories, prediction and explanation, induction, deduction, development of models. Developing a research plan - exploration, description, diagnosis, experimentation. Determining experimental and sample designs. Research techniques- microscopy, HPLC, HPTLC, GC-MS, FTIR, SEM/TEM, NMR and AAS.

Unit 4 Data Collection and Analysis

Data collection and analysis: execution of the research - observation and collection of data - methods of data collection – sampling methods- data processing and analysis strategies - data analysis with statistical packages -hypothesis-testing - generalization and interpretation.

Standard Deviation- T test. Analysis of Variance components (ANOVA) for fixed effect model; total, treatment and error of squares, degrees of freedom, confidence interval; ANOVA for random effects model, estimation of variance components, model adequacy checking. Two factor factorial design, basic definitions and principles, main effect and interaction, response surface and contour plots, general arrangement for a two factor factorial design

Unit 5 Data Analysis and Research Ethics

Spreadsheet tool: Introduction to spreadsheet application, features and functions, using formulas and functions, data storing, features for statistical data analysis, generating charts/ graph and other features. Presentation tool: Introduction to presentation tool, features and functions, creating presentation, customizing presentation, showing presentation. Tools used may be Microsoft Power Point, Open Office or similar tool.

Reporting and ethics – structure and components of scientific reports - types of report – technical reports and thesis – significance – different steps in the preparation – layout, structure and language of typical reports. Environmental impacts - ethical issues - ethical committees - commercialization – copy right royalty - intellectual property rights and patent law – trade related aspects of intellectual property rights – reproduction of published material plagiarism-citation and acknowledgement – reproducibility.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Day RA (2006) *How to Write a Scientific Paper* Cambridge University Press, Cambridge
2. C. R. Kothari CR (2004) *Research Methodology: Methods and Techniques* New Age International Publishers, New Delhi.
3. Gurumani N (2013) *Research Methodology: For Biological Sciences* 1st Ed. MJP publishers, New Delhi.
4. Chawla D, Sondhi N (2023) *Research methodology: concepts and cases* Vikas Publishers, New Delhi.
5. Shah D (2023) *Text book of research methodology* Jaypee publishers, Chennai.

Supplementary Reading

1. Nagar N, Vidyarthe P (2023) *Research methodology*, Thakur Publications, New Delhi.
2. Kothari CR, Carg G (2018) *Research methodology: methods and techniques* New Age Publishers, New Delhi.

Reading List (Online)

1. https://ccsuniversity.ac.in/bridge-library/pdf/MPh20Research%20Method-Part1.pdf
2. https://ccsuniversity.ac.in/bridge-library/pdf/Research-Methodology-CR-Kothari.pdf
3. https://www.drnishikantjha.com/papersCollection/Research%20Methodology%20.pdf
4. https://www.researchgate.net//303381524_Fundamentals_of_research_methodology
5. https://euacademic.org/BookUpload/9.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	1	2	3	2	3	3	2	3	3	3	3
CO2	3	3	3	3	2	3	3	3	2	3	3	3	2	3	3
CO3	3	3	3	2	2	3	3	2	2	3	2	3	3	3	3
CO4	3	3	2	3	3	2	3	3	3	3	3	3	3	3	3
CO5	3	3	3	2	3	2	3	2	3	3	2	3	2	3	3

Semester	23BITC402: BIOSTATISTICS	L	T	P	C
IV		4	0	0	5

Learning Objective (LO):

LO	To develop comprehensive knowledge on the methods and applications of biostatistics

Course Objectives

1	To understand the various types of classification of data
2	To explain correlation and regression analysis
3	To explain about distribution and analysis of data
4	To comprehend the tests of significance
5	To acquire knowledge on statistical packages

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the types and classification of data (K1 and K5)
CO2	Exhibit a knowledge base on correlation and regression analysis (K3 and K5)
CO3	To differentiate the methods of distribution of data (K3 and K5)
CO4	Apply the knowledge on handling and analysis of data (K1,K2 and K5)
CO5	Apprehend knowledge on various statistical packages (K1, K2 and K5)

Unit 1 Collection and Classification of Data

Statistics – Scope –collection, classification, tabulation of statistical data – diagrammatic representation – graphs – graph drawing – graph paper – plotted curve –sampling method and standard errors –random sampling – use of random numbers –expectation of sample estimates – means – confidence limits – standard errors – variance. Measures of central tendency – measures of dispersion – skewness, kurtosis, moments

Unit 2 Correlation and Regression Analysis

Correlation and regression – correlation table – coefficient of correlation – Z transformation – regression – relation between regression and correlation. Probability – Markov chains applications – probability distributions – binomial (Gaussian distribution) and negative binomial, compound and multinomial distributions – Poisson distribution

Unit 3 Distribution of Data

Normal distribution – graphic representation. – frequency curve and its characteristics – measures of central value, dispersion, coefficient of variation and methods of computation – Basis of statistical inference – sampling distribution – standard error – testing of hypothesis – null hypothesis –type I and type II errors

Unit 4 Tests of Significance

Tests of significance for large and small samples based on normal, t, z distributions with regard to mean, variance, proportions and correlation coefficient – chi-square test of goodness of fit – contingency tables – c2 test for independence of two attributes – Fisher and Behrens ‘d' test – 2×2 table – testing heterogeneity – r X c table – chi-square test in genetic experiments – partition X 2 – Emerson's method

Unit 5 Analysis of Variance and Statistical Packages

Tests of significance –t tests – F tests – analysis of variance – one way classification – two-way classification, CRD, RBD, LSD. Spreadsheets – data entry –mathematical functions – statistical function – Graphics display – printing spreadsheets – use as a database word processes – databases – statistical analysis packages graphics/presentation packages

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Zar JH (2010) *Biostatistical Analysis 5th Ed.* Printice-Hall, New Jersey.
2. Antonisamy B et al. (2017) *Principles and practice of biostatistics* Elsevier India, New Delhi.
3. Johns E (2023) *Fundamentals of biostatistics* White Press Academic, New Orleans.
4. Ramakrishnan P (2020) *Biostatistics* Saras Publications, New Delhi.

Supplementary Reading

1. Daniel WW, Cross CL (2014) *Biostatistics: basic concepts and methodology* Wiley, New Jersey.
2. Montgomery DC (2022) *Introduction to linear regression analysis* Wiley, New Jersey.

Reading List (Online)

1. https://www.cartercenter.org/resources /env-health-science-students/ln-biostat-hss-final.pdf
2. https://www.evolbiol.ru/docs/docs/large_files/biostatistics.pdf
3. https://www.researchgate.net/publication/339499419_Lecture_notes_on_Biostatistics
4. https://www.uou.ac.in/lecturenotes/science/MSCMT-19/BIOSTATISTICS.pdf
5. https://cbpbu.ac.in/userfiles/file/2020/STUDY_MAT/ZOO/PK%20(2).pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	2	3	3	2	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Semester	ELECTIVE 6: (GENERIC/DISCIPLINE CENTRIC)	L	T	P	C
IV	23BITE404: STEM CELL BIOLOGY	3	0	0	3

Learning Objective (LO):

LO	To develop comprehensive knowledge on fundamentals of stem cell biology

Course Objectives

1	To understand the basic characteristics of stem cells
2	To explain the various types of stem cells
3	To explain about stem cell culture techniques
4	To comprehend the factors influencing stem cell proliferation
5	To acquire knowledge on applications of stem cells

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the basic characteristics of stem cells (K1 and K5)
CO2	Exhibit a knowledge base in types of stem cells (K3 and K5)
CO3	To explain the principles of stem cell culture (K3 and K5)
CO4	Apply the knowledge on signaling pathway in stem cells (K1,K2 and K5)
CO5	Apprehend knowledge on applications of stem cells (K1, K2 and K5)

Unit 1 Introduction

Stem cells - definition, characterization, pluripotency, self-renewal and differentiation. Types of stem cells- embryonic stem cells, adult stem cells and mesenchymal stem cells, adipose stem cells. Proliferation of stem cells.

Stem cell and founder zones in plants –particularly their roots – stem cells of shoot meristems of higher plants. Skeletal muscle stem cell – mammary stem cells – intestinal stem cells – keratinocyte stem cells of cornea – skin and hair follicles –tumour stem cells.

Unit 2 Characteristics of Stem Cells

Stem cell niche, niche specification - *Drosophila* germ line stem cells. Receptors, genes and markers of stem cells. Types of embryonic stem cells, adult stem cell, stem cell biology and therapy. Stem cell culture and potential benefits of stem cell technology.

Germ cells, hematopoietic organs, and kidney, cord blood transplantation, donor selection, HLA matching, patient selection, peripheral blood and bone marrow transplantation. Stem cell techniques: fluorescence activated cell sorting (FACS), time lapse video, green fluorescent protein tagging

Unit 3 Stem Cell Culture

Stem cell isolation and culture techniques. Characterization of stem cells. Types of stem cells: methods of isolation, study of stem cells and their viability IPSC, cancer stem cells. – preservations of stem cell. Embryonic stem cell: Isolation, culturing, differentiation, properties – adult stem cell: Isolation, culturing, differentiation, trans-differentiation, plasticity and properties.

Unit 4 Signaling Pathway in Stem Cells

Stem cell cycle. Chromatin modification and transcriptional regulation, chromatin modifying factors, chromosomal inactivation. JAK -STAT pathway, Ras\Raf pathway, PI3K cell signaling, p53 check points, role of LIF pathway in cell cycle control

Factors influencing stem cell proliferation, physical, chemical and molecular methods for differentiation of stem cells – hormonal role in differentiation.

Unit 5 Applications of Stem Cells

Applications of embryonic stem cells, bone marrow stem cells, adipose derived stem cells and hematopoietic stem cells. Ethics in human stem cell research. Stem cell Therapy for neurodegenerative diseases, spinal cord injury, heart disease, diabetes, burns, skin ulcers, muscular dystrophy and orthopaedic applications. Stem cell policy and ethics, stem cell research: Hype, hope and controversy.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Lanza R, Atala A (2014) *Essentials of stem cell biology* Academic Press, Cambridge.
2. Turksen K (2023) *Stem cell biology and regenerative medicine*, Springer, Berlin.
3. Mummery CL (2021) *Stem cells* Elsevier, Amsterdam.
4. Meyers RA (2013) *Stem cells: from biology to medicine* Wiley-Blackwell, New Jersey.
5. Turner R (2016) *Stem cell biology* Hayle Medical Publishers, New York.

Supplementary Reading

1. Meyers RA (2013) *Stem cells: from biology to therapy* Wiley-Blackwell, New York.
2. El-Hashash A (2016) *Developmental and stem cell biology in health and disease* Bentham Publishers, Sharjah.

Reading List (Online)

1. https://www.law.berkeley.edu/files/stem_cell_day1_part2_shelanski.pdf
2. https://rnlkwc.ac.in/pdf/study-material/zoology/Sem%20VI%20ESC.pdf
3. https://ncmn.unl.edu/Kidambi_NCNM-06-29-11.pdf
4. https://www.etsu.edu/uschool/faculty/tadlockd/documents/new_intro_to_stem_cells.pdf
5. https://www.urmc.rochester.edu/center/documents/teacherstemcellbiology7-23-09.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	2	3	3	2	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Semester	ELECTIVE: (GENERIC/DISCIPLINE CENTRIC)	L	T	P	C
IV	23BITE405: BIOETHICS, HUMAN RIGHTS AND SOCIAL ISSUES	3	0	0	3

Learning Objective (LO):

LO	To learn the principles of bioethics, human rights and intellectual property rights and social issues

Course Objectives

1	To inculcate knowledge about bioethics
2	To comprehend about regulations of clinical trials
3	To inculcate knowledge about biosafety and biological risk assessment
4	To elucidate about IPR and trademarks
5	To inculcate acquaintance about basics of entrepreneurship

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the salient features of bioethics (K1, K3 and K4)
CO2	Comprehend the basics of clinical trials (K2)
CO3	Apply the modern methods for biosafety (K1-K3 and K6)
CO4	Apply the knowledge on IPR and trademarks (K4 and K5)
CO5	Retrieve, align, analyze about entrepreneurship (K5 and K6)

Unit 1 Bioethics

Introduction to bioethics. Need for bioethics in social and cultural issues. Bioethics and GMO's Issues and concerns pertaining to genetically modified foods and food crops, Organisms and their possible health implications and mixing up with the gene-pool. Bioethics in medicine. Protocols of ethical concerns related to prenatal diagnosis, gene therapy, organ transplantation, xenotransplantation, containment facilities for genetic engineering experiments, regulations on field experiments and release of GMO`s labeling of GM foods.

Unit 2 Clinical Trials

Clinical trials –regulations. Bioethics and cloning. Permissions and procedures in animal cloning, human cloning, risks and hopes. Bioethics in research - stem cell research, human genome project, use of animals in research, human volunteers for clinical research, studies on ethnic races. Ethics in patient care, Informed consent.

Unit 3 Biosafety

Biosafety – biological risk assessment. Biological agents and hazard groups. Criteria in biological risk assessment. Guidelines for categorization of genetically modified plants for field test. Regulation-national and international guidelines of biosafety, rDNA guidelines, regulatory requirements for drugs and biologics GLP. Biosafety levels. Safety equipment and biological safety cabinets.

Unit 4 IPR and Trademark

IPR: Introduction to intellectual property rights, patenting – factors for patentability – novelty, non-obviousness, marketability. Procedures for registration of patents. Copyright works, ownership, transfer and duration of copyright. Renewal and termination of copyright. Industrial designs - need for protection of industrial designs. Procedure for obtaining design protection. Infringement, Right of Goodwill, Passing off. Trademarks - Introduction to trademarks. Need for protection of trademarks. Classification of trademarks. Indian trademarks law. Procedural requirements of protection of trademarks

Unit 5 Entrepreneurship

Geographical indications - indication of source and geographical indication. Procedure for registration, Duration of protection and renewal. Infringement, penalties and remedies. Layout-designs of integrated circuits: Conditions and procedure for registration. Duration and effect of registration, protection of plant variety and plant breeders' rights in India. Protection of traditional knowledge, Bioprospecting and biopiracy. India's new IP Policy (2016), Govt of India's steps to promote IPR. Career opportunities in IP. Entrepreneurship: Definition and importance, Characteristics and functions of an entrepreneur.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. D'Souza R (2023) *Textbook of bioethics, medical ethics and health law* Paras Medical Books, Chennai.
2. Nijhawan R (2021) *New drugs and clinical drug rules* Kalyani Publishers, New Delhi.
3. Byers KB, Wooley DP (2017) *Biological safety: principles and practices* ASM Press, Washington.
4. Bently L et al. (2023) *Intellectual property law* Oxford University Press, Oxford.
5. Bhatt A et al. (2023) *Basic biotechniques for bioprocess and bioentrepreneurship* Elsevier, Amsterdam.

Supplementary Reading

1. Lanerolle GD et al. (2023) *Clinical trials and tribulations* Elsevier, Amsterdam.
2. *Laboratory biosafety manual* (2020) World Health Organization, Geneva.

Reading List (Online)

1. https://www.researchgate.net/publication/278600571_Principles_of_biomedical_ethics
2. https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SBB1615.pdf
3. https://www.cdc.gov/labs/pdf/BiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf
4. https://ncdc.gov.in/WriteReadData/l892s/File608.pdf
5. https://www.biotech.co.in/sites/files/2020-01/Bioentrepreneurship-Development.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	2	3	2	3	3	2	3	2	3	3
CO2	3	3	3	3	3	3	3	3	2	3	3	3	3	2	3
CO3	3	3	3	3	3	2	3	2	2	3	2	3	2	3	3
CO4	3	3	3	3	3	3	3	2	2	3	3	3	3	2	3
CO5	3	3	3	3	3	2	3	2	2	3	2	3	2	3	3

Semester	SKILL ENHANCEMENT COURSE 3: SEC 3/PROFESSIONAL COMPETENCY SKILL	L	T	P	C
IV	23BITS406: METHODS IN GENOMICS AND PROTEOMICS	2	0	0	2

Learning Objective (LO):

LO	To learn the principles of genome mapping, sequencing, analysis and editing and also to apply the informatics tools for proteome and genome analysis

Course Objectives

1	To inculcate knowledge about genome mapping and sequencing
2	To comprehend about genome project and post-genome analysis
3	To inculcate knowledge about protein separation and identification
4	To elucidate about the structural and functional proteomics
5	To inculcate acquaintance about bioinformatics

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand the types and uses of gene mapping, molecular markers for mapping and classical and new generation genome sequencing approaches (K1, K3 and K4)
CO2	Comprehend genome projects, post-genome analysis and ELSI (K2)
CO3	Apply the modern methods for separation, identification, quantitation and structural analysis of proteins (K1-K3 and K6)
CO4	Apply structural bioinformatics tools to predict and elucidate protein structures and map protein- protein interactions (K4 and K5)
CO5	Retrieve, align, analyze and interpret sequence and structural data from databases (K5 and K6)

Unit 1 Genome Mapping and Sequencing

Definition of genome and genomics. Types of gene map-genetic, cytogenetic and physical. Molecular markers for mapping-RFLPs, microsatellites and SNPs. Physical mapping – fluorescence *in situ* hybridization, sequence tagged site mapping. Chromosome walking and chromosome jumping – identification of unknown gene of interest.

Unit 2 NGS, Genome Projects and Post-genome Analysis

The human genome project: goals, sequencing technologies, results, potential benefits, ethical, legal and social issues (ELSI). Next-Generation Sequencing. Genome annotation - ORF scanning, similarity searchers. Genome sequence data of *E. coli* and *D. melanogaster*. Post-genome analysis - microarrays, transcriptome, ChIPs, genome editing – CRISPR/Cas9.

Unit 3 Protein Separation, Identification and Quantitation

Proteomics - introduction. Protein separation - general principles. 2D-gel electrophoresis, liquid-liquid chromatography. Mass spectrometry - basic principle and instrumentation, ESI, MALDI-TOF, SELDI-TOF, tandem MS. Peptide mass fingerprinting.

Unit 4 Structural Proteomics and Applications

Structural proteomics: X-ray and NMR for protein structure analysis. Comparative and homology modeling, secondary structure prediction, fold recognition and *ab initio* prediction. SCOP. Protein sequence analysis.

Unit 5 Functional Proteomics and Applications

Protein function determination: database search for homology. Protein-protein interactions: yeast 2-hybrid system, protein arrays and chips (concept and applications). Applications of proteomics-protein mining, pull down assay, drug diagnostics, and drug discovery.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Primrose J (2002) *Principles of Genome Analysis* 3rd Ed. Wiley, New Jersey.
2. Brown TA (2007) *Genomes* 4th Ed. Garland Science, New York.
3. Hartwell LH et al. (2014), *Genetics: From Genes to Genomes* 5thEd. McGraw-Hill, New York
4. Twyman RM (2013) *Principles of Proteomics* 2nd Ed. Garland Science, New York.
5. Lesk A (2017*) Introduction to genomics* 3rd Ed. Oxford University Press, Oxford.
6. Strachen T (2022) *Genetics and genomics in medicine* CRC Press, Boca Raton.

Supplementary Reading

1. Srivastava S (2023) *From proteins to proteomics basic concepts, techniques and applications* CRC Press, Boca Raton.
2. Turnpenny P et al. (2021) *Emery's elements of medical genetics and genomics* Elsevier, Amsterdam.
3. Ali A et al. (2023) *Proteomics: a promising approach for cancer research* Academic Press, Cambridge.

Reading List (Online)

1. https://www.researchgate.net/publication/283084372
2. https://www.mun.ca/biology/scarr/Bio4241_Chap_9_Genomics.pdf
3. https://bio.as.uky.edu/sites/default/files/overview%20of%20proteomics_0.pdf
4. https://www.gene-quantification.de/wishart-proteomics-bioinformatics-1.pdf
5. http://bioinformaticsinstitute.ru/sites/default/files/lapidus_1_0.pdf

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	2	3	2	3	3	2	3	2	3	3
CO2	3	3	3	3	3	3	3	3	2	3	3	3	3	2	3
CO3	3	3	3	3	3	2	3	2	2	3	2	3	2	3	3
CO4	3	3	3	3	3	3	3	2	2	3	3	3	3	2	3
CO5	3	3	3	3	3	2	3	2	2	3	2	3	2	3	3

ELECTIVE (GENERIC)
(FOR OTHER MAJOR STUDENTS)

Semester	23SBITN01: TISSUE ENGINEERING	L	T	P	C
II		3	0	0	3

Learning Objective (LO):

LO	To learn the about basics and applications of tissue engineering

Course Objectives

1	Contrast differences in tissue types and tissue components
2	To understand basics of tissue engineering
3	Distinguish the characteristics of biomaterials in tissue engineering
4	To understand about structural tissue engineering
5	To enrich knowledge on regulation of tissue-engineered products

Course Outcomes (CO)

At the end of the course, the student will be able to

CO1	Understand about scope of tissue engineering (K1-K3)
CO2	Comprehend the salient features of tissue types (K2 and K4)
CO3	Understand about mechanisms of biomaterials in tissue engineering (K1-K3, K5 and K6)
CO4	Detailed knowledge about applications of tissue engineering (K1-K4)
CO5	Understand about structural tissue engineering (K1, K2 and K5)

Unit 1 Introduction

Introduction to tissue engineering: Basic definition; current scope of development; use in therapeutics, cells as therapeutic agents, cell numbers and growth rates, measurement of cell characteristics morphology, number viability, motility and functions. Measurement of tissue characteristics, appearance, cellular component, ECM component, mechanical measurements and physical properties. Basic biology of tissue engineering: The basis of growth and differentiation-morphogenesis and tissue engineering

Unit 2 Tissue Types and Tissue components

In vitro control of tissue development-growth factors-tissue engineering bioreactors- *in vitro* synthesis of tissue and organs- organotypic and histotypic engineered tissues. 3D cell culture-tissue assembly in microgravity

Tissue types and tissue components, tissue repair, engineering wound healing and sequence of events. Basic wound healing, applications of growth factors: VEGF/angiogenesis, basic properties, cell-matrix and cell-cell interactions, telomeres and self-renewal, control of cell migration in tissue engineering.

Unit 3 Tissue Engineering I

Biomaterials in tissue engineering-Scaffolds, extracellular matrix, polymers and nanocomposites. Approaches to transplanting engineered cells.

Biomaterials: Properties of biomaterials, surface, bulk, mechanical and biological properties. Scaffolds and tissue engineering, types of biomaterials, biological and synthetic materials, biopolymers, applications of biomaterials, modifications of biomaterials, role of nanotechnology.

Unit 4 Tissue Engineering II

Bioartificial pancreas, Hepatassist liver support system, artificial womb, Heamatopoietic system: Red blood cell substitutes, renal replacement devices

Stem cells: Introduction, hematopoietic differentiation pathway potency and plasticity of stem sources, embryonic stem cells, hematopoietic and mesenchymal stem cells, stem cell markers, FACS analysis, differentiation, stem cell systems- liver, neuronal stem cells, types and sources of stem cell with characteristics: embryonic, adult, haematopoetic, fetal, cord blood, placenta, bone marrow, primordial germ cells, cancer stem cells induced pluripotent stem cells.

Unit 5 Applications of Tissue Engineering

Structural tissue engineering-bone regeneration through cellular engineering, skin tissue engineering, brain implants-neural stem cells, periodontal applications

Stem cell therapy, Molecular therapy, In vitro organogenesis, neurodegenerative diseases, spinal cord injury, heart disease, diabetes, burns and skin ulcers, muscular dystrophy, orthopaedic applications, stem cells and gene therapy, physiological models, issue engineered therapies, product characterization, components, safety, efficacy. Preservation –freezing and drying. Patent protection and regulation of of tissue-engineered products, ethical issues.

Current Streams of Thought

The faculty will impart knowledge on the current developments in the subject of study to the students and this component will not be covered in the examinations.

Text Books

1. Brown E (2022) *Tissue engineering* Elsevier, Amsterdam.
2. Lanza R et al. (2020) *Principles of tissue engineering* Elsevier, Amsterdam.
3. Redl H (2020) *Tissue engineering and regeneration* Elsevier, Amsterdam.
4. Sharma CP (2022) *Tissue engineering: current status and challenges* Elsevier, Amsterdam.
5. Palsson BO, Bhatia SN (2016) *Tissue engineering* Pearson Education India. New Delhi.

Reading List (Online)

1. https://application.wiley-vch.de/books/sample/3527338632_c01.pdf
2. https://www.lehigh.edu/~inbios21/PDF/Fall2015/Chow_10302015.pdf
3. chrome-extension:// engineerscanada.ca/sites/tissueengineering_eng.pdf
4. https://www.biolinscientific.com/blog/what-is-tissue-engineering?utm_term=&utm
5. https://www.udemy.com/course/introduction-to-tissue-engineering

Outcome Mapping (1-Low; 2-Medium; 3-Strong)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	2	3	3	2	3	3	3	2	3	2	2
CO2	3	3	2	3	3	2	3	3	3	3	3	3	2	3	3
CO3	3	2	2	3	2	2	3	2	3	3	3	2	2	3	2
CO4	3	3	3	2	3	3	3	3	3	3	3	3	3	2	3
CO5	3	2	3	2	2	3	3	2	3	3	3	2	3	2	2