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. BIOCHEMISTRY (2 YEAR)
(TANSCHE Syllabus)
Programme Code: SBIO21

Annamalai University

Faculty of Science

DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY

M. Sc. Biochemistry (TANSCHE syllabus)

Programme Code: SBIO21

These rules and regulations shall govern the Two year post graduate studies leading to the award of degree of **Master of Science in Biochemistry** in the Faculty of Science. These academic Regulations shall be called "**Annamalai University, Faculty of Science Two year M.Sc. Biochemistry 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 Biochemistry programme. A pass in B.Sc. Biochemistry / Biotechnology / 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 Enhancemen 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											

Annamalai University

Department of Biochemistry and Biotechnology

M. Sc. Biochemistry (Two Year) Programme

(TANSCHE Syllabus)

Programme Code: SBIO21

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								
23BIOC101	Core 1: Basics of Biochemistry	4	0		5	25	75	100
23BIOC102	Core 2: Biochemical and Molecular Biology Techniques	4	0		5	25	75	100
23BIOP103	Core 3: Practical I: Laboratory Course in Cell Biology, Biomolecules and Biochemical Techniques	0	0	16	4	25	75	100
23BIOE104	Elective 1: (Discipline Centric): Physiology and Cell Biology	3	0		3	25	75	100
23BIOE105	Elective 2: (Generic): Microbiology and Immunology	3	0		3	25	75	100
		30			20			
Semester-II								
23BIOC201	Core 4: Cellular Metabolism	4	0		5	25	75	100
23BIOC202	Core 5: Clinical Biochemistry	4	0		5	25	75	100
23BIOP203	Core 6: Practical II: Laboratory Course in Microbiology, Immunology and Enzymology			14	4	25	75	100
23BIOE204	Elective 3: (Discipline Centric): Enzymology	3	0		3	25	75	100
23BIOE205	Elective 4: (Generic): Energy and Drug Metabolism	3	0		3	25	75	100
23BIOS207	Skill Enhancement Course 1: SEC 1: Medical Laboratory Technology	2	0		2	25	75	100
		30			22			

Semester-III								
23BIOC301	Core 7: Industrial Microbiology	4	0		5	25	75	100
23BIOC302	Core 8: Molecular Biology	4	0		5	25	75	100
23BIOC303	Core 9: Gene Editing, Cell and Gene Therapy	4	0		5	25	75	100
23BIOP304	Core 10: Practical III – Laboratory Course in Clinical Biochemistry, Molecular Biology and Industrial Microbiology	0	0	13	4	25	75	100
23BIOE305	Elective 5: (Discipline Centric): Biostatistics and Data Science	3	0		3	25	75	100
23BIOS307	Skill Enhancement Course 2: SEC-2: Molecular Endocrinology and Cell Signaling	2	0		2	25	75	100
23BIOI308	Internship/Industrial Activity	0	0		2	25	75	100
		30			26			
Semester-IV								
23BIOC401	Core 11: Pharmaceutical Biochemistry	4	0		5	25	75	100
23BIOC402	Core 12: Biochemical Toxicology	4	0		5	25	75	100
23BIOD403	Project work with viva voce	0	0	17	7	25	75	100
23BIOE404	Elective 6: (Generic/Discipline Centric): Biosafety, Lab Safety and IPR	3	0		3	25	75	100
23BIOS406	Skill Enhancement Course 3: SEC-3/Professional Competency Skill: Developmental Biology	2	0		2	25	75	100
23BIOX407	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
(DISCIPLINE CENTRIC/GENERIC)

S. No.	Course Code	Course Title	Hours/ week			C	Marks		
			L	T	P		CIA	ESE	Total
1.	23BIOE104	Physiology and Cell Biology	3	0	0	3	25	75	100
2.	23BIOE105	Microbiology and Immunology	3	0	0	3	25	75	100
3.	23BIOE106	Basic Biotechnology	3	0	0	3	25	75	100
4.	23BIOE204	Enzymology	3	0	0	3	25	75	100
5.	23BIOE205	Energy and Drug Metabolism	3	0	0	3	25	75	100
6.	23BIOE206	Plant Biochemistry	3	0	0	3	25	75	100
7.	23BIOE305	Biostatistics and Data Science	3	0	0	3	25	75	100
8.	23BIOE306	Biofertilizers	3	0	0	3	25	75	100
9.	23BIOE404	Biosafety, Lab Safety and IPR	3	0	0	3	25	75	100
10.	23BIOE405	Genomics, Proteomics and Bioinformatics	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.	23SBION01	Nutritional Biochemistry	3	0	0	3	25	75	100
2.	23SBION02	Molecular Basis of Disease and Therapeutic Strategies	3	0	0	3	25	75	100

ANNAMALAI UNIVERSITY

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 Programme **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. Biochemistry (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 x 5	20		K3	**B**	2 x 5	10
	K4		4 x 5	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**	2 x 10	20
				100					**100**

PROGRAMME OUTCOMES (POs)

After the successful completion of the M. Sc. Biochemistry (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	Understand the functions of biomolecules in relation to their molecular structure.
PSO2	Acquire deep scientific knowledge in subjects like cell biology, enzymology, biotechnology, Metabolism, endocrinology, immunology, genetics, genetic engineering and clinical biochemistry.
PSO3	Describe the biochemical basis of diseases, regulation of metabolic pathways and gene expression regulation.
PSO4	Undertake biochemical experiments using classical and modern instruments of biochemistry & molecular biology, record and interpret the results, draw conclusions.
PSO5	Work collaboratively as a team in classroom and laboratory and communicate biochemical concepts through effective written and oral presentation.

SEMESTER - I

Semester	23BIOC101: BASICS OF BIOCHEMISTRY	L	T	P	C
I		4	0	0	5

Learning Objective (LO):

LO	To learn the basics of Biochemistry and Biomolecules

Course Objectives

1	Students will be introduced to the structure of biomolecules
2	The significance of carbohydrates in biological processes will be understood.
3	The structure, properties and biological significance of lipids in the biological system will be studied.
4	Students will learn about the concepts of protein structure and their significance in biological processes and comprehend the role of membrane components with their biological significance.
5	Students will gain knowledge about the structure and functional roles of nucleic acids in the biological system

Course Outcomes (CO)

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

CO1	Appreciate the hierarchical organisation of various biomolecules (K1 and K2)
CO2	Understand the various orders of protein structure, classification, properties and biological importance of proteins (K3 and K4)
CO3	Evaluate the structure and hierarchial organisation of nucleic acids with their biological functions (K4 and K5)
CO4	Analyse the realtionship between the structure and biological role of glycosaminoglycans and glycoconjugates (K3 and K4)
CO5	Acquire knowledge on the building blocks of lipids, classification and properties as well as lipoprotein and composition of membranes (K2, K3 and K4)

Unit 1 Carbohydrates

Carbohydrates- classification, structure (configurations, conformations and anomeric forms), function and properties of monosaccharides, mutarotation; disaccharides and oligosaccharides with suitable examples. Polysaccharides - homopolysaccharides (starch, glycogen, cellulose, inulin, dextrin, agar, pectin and dextran). Heteropolysaccharides - glycosaminoglycans– source, structure, functions of hyaluronic acid, chondroitin sulphate, heparin, keratan sulphate. Glycoproteins - proteoglycans. O- Linked and N-linked glycoproteins. Biological significance of glycan, blood group polysaccharides. Bacterial cell wall (peptidoglycans, teichoic acid) and plant cell wall carbohydrates.

Unit 2 Lipids

Lipids – classification of lipids, structure, properties and functions of fatty acids, triacylglycerols, phospholipids, glycolipids, sphingolipids and steroids – biological importance. Eicosanoids - classification, structure and functions of prostaglandins, thromboxanes and leukotrienes. Lipoproteins – classification, structure, transport (endogenous and exogenous pathways) and their biological significance.

Unit 3 Amino Acids and Proteins

Overview of amino acids - classification, structure and properties of amino acids and their biological role. Non-protein amino acids and their biological significance - proteins – classification based on composition, structure and functions. Primary, secondary, super secondary (motifs) (helix-turn–helix, helix-loop-helix, β-α-β motif - Rossmann fold, Greek key - tertiary and quaternary structure of proteins. Structural characteristics of collagen and hemoglobin. Determination of amino acid sequence. Chemical synthesis of a peptide, forces involved in stabilization of protein structure. Ramachandran plot. Folding of proteins. Molecular chaperons – Hsp 70 and Hsp 90 - biological role.

Unit 4 Membrane Proteins

Membrane proteins - types and their significance. Cytoskeleton proteins - actin, tubulin, intermediate filaments. Biological role of cytoskeletal proteins. Membrane structure-fluid mosaic model. The P-type ATPases (Na^+-K^+ ATPase), F-type ATPases (ATP synthase), ABC transporters, ionophores, aquaporins and ion-channels.

Unit 5 Nucleic Acids

Nucleic acids – types and forms (A, B, C and Z) of DNA. Watson-Crick model-primary, secondary and tertiary structures of DNA. Triple helix and quadruplex DNA. Mitochondrial and chloroplast DNA. DNA supercoiling (calculation of Writhe, linking and twist number). Determination of nucleic acid sequences by Maxam Gilbert and Sanger's methods. Forces stabilizing nucleic acid structure. Properties of DNA and RNA. C-value, C-value paradox, Cot curve. Structure and role of nucleotides in cellular communications. Major and minor classes of RNA, their structure and biological functions.

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. Voet D et al. (2016) *Fundamentals of Biochemistry: life at the molecular level* 5th Ed. Wiley Publishers, New Jersey.
3. Rodwell VW et al. (2018) *Harper's Illustrated Biochemistry* 31 Ed. McGraw-Hill Education, New York.
4. Berg JM et al. (2023) *Biochemistry* 10th Ed. Macmillan Education, London.

Supplementary Reading

1. Blackburn et al. (2006) *Nucleic acids in Chemistry and Biology* Royal Soc Chem, London.
2. Jeremy M et al. (2015) *Biochemistry* 8th Ed. Freeman Publishers, New York.
3. 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	2	3	3	2	3	3	3	2	3	3	3	2	1	3
CO2	3	3	2	3	3	2	3	3	3	3	3	3	3	2	3
CO3	3	2	3	3	2	3	3	3	2	3	3	3	2	3	3
CO4	3	3	2	3	3	2	3	3	1	3	3	3	3	2	3
CO5	3	2	1	3	2	3	3	3	2	3	3	3	2	3	3

Semester	23BIOC102: BIOCHEMICAL AND MOLECULAR BIOLOGY TECHNIQUES	L	T	P	C
I		4	0	0	5

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. https://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	23BIOP103: PRACTICAL I	L	T	P	C
I	LABORATORY COURSE IN CELL BIOLOGY, BIOMOLECULES AND BIOCHEMICAL TECHNIQUES	0	0	16	4

Learning Objective (LO):

LO	To analyse and estimate biomolecules, to develop knowledge on basic principles, instrumentation, cell culture and biochemical techniques

Course Objectives

1	To apprehend wider knowledge about principles and techniques to be employed for the estimation of biomolecules
2	To inculcate knowledge of various isolation and purification techniques of biomolecules
3	To perform spectrophotometric estimations to quantify important metabolites and minerals
4	To perform staining of cell cultures
5	To measure mitotic index

Course Outcomes (CO)

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

CO1	Independently undertake qualitative and quantitative analysis of biomolecules (K1, K2 and K4)
CO2	Acquire knowledge in the UV absorption studies of DNA and protein (K1 – K4)
CO3	Inculcate skills in the qualitative analysis of phytochemicals (K1, K2 and K4)
CO4	Identify cell types from tissues under microscope (K1-K4 and K6)
CO5	Undertake isolation of subcellular organelles (K1 – K4 and K6)

Cell Biology

1. Microscopic examination of epithelial cells and plant cells
2. Staining of cell cultures and observations under microscope
3. Tissue culture techniques: surface sterilization techniques, media preparation and storage, serum inactivation
4. Cell count and mitotic index

Biochemistry

I. Biochemical studies and estimation of macromolecules

1. Isolation and estimation of glycogen from liver
2. Isolation and estimation of DNA from animal tissue
3. Isolation and estimation of RNA from yeast
4. Purification of polysaccharides – starch and assessment of its purity

II. UV absorption studies

1. Denaturation of DNA and absorption studies at 260 nm
2. Denaturation of protein and absorption studies at 280 nm

III. Colorimetric estimations

1. Estimation of pyruvate
2. Estimation of tryptophan

IV. Estimation of minerals

1. Estimation of calcium
2. Estimation of iron

V. Plant biochemistry

1. Qualitative analysis – phytochemical screening
2. Quantitative analysis – estimation of flavonoids
3. Separation of plant pigments by adsorption chromatography

Biochemical Techniques

VI. Group experiments

1. Fractionation of sub-cellular organelles by differential centrifugation – mitochondria and nucleus
2. Identification of the separated sub-cellular fractions using marker enzymes (any one)
3. Separation of identification of lipids by thin layer chromatography
4. Separation of plant pigments from leaves by column chromatography
5. Identification of sugars by paper chromatography
6. Identification of amino acids by paper chromatography

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. Shankara SYM et al. (2013) *A laboratory manual for practical biochemistry* 2nd Ed. Jaypee brothers medical publishers (P) Ltd. New Delhi.
2. Davey J, Lord M (2005) *Essential cell biology: a practical approach* 4th Ed. Oxford University Press, London
3. Plummer DT (2017) *An introduction to Practical Biochemistry*, 3rd Ed, Tata McGraw Hill, New Delhi.
4. Sadasivam S, Manickam A (2018) *Biochemical methods*, New Age International Publishers, New Delhi.
5. Chavan SA et al. (2019) *A guide to chromatography techniques* 1st Ed. Notion press, Chennai.

Supplementary Reading

1. Agarwal S, Khan S (2019) *Advanced lab practices in biochemistry and molecular biology*, Wiley India, Bengaluru.
2. Haque MR (2023) *A practical book of biochemistry* ATBS 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	3	2	3	2	3	2	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	2	3	2	3	2	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	2	3	2	3	2	3	3

Semester	ELECTIVE 1: (DISCIPLINE CENTRIC)	L	T	P	C
I	23BIOE104: PHYSIOLOGY AND CELL BIOLOGY	3	0	0	3

Learning Objective (LO):

LO	To learn in detail about the organization of cells and tissues, membrane transport, cell division, differentiation, and cell death and to acquire knowledge on the physiology of mammalian system

Course Objectives

1	To understand the functions and activities of organs, tissues or cells and of physical and chemical phenomena involved in human body
2	To know about the physiological functions of the human system
3	To educate about the imbalances in acid-base, fluid and electrolytes
4	To impart knowledge on the process of cell division
5	To educate about salient features of digestive and respiratory systems

Course Outcomes (CO)

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

CO1	Understand the molecular organization of cells and tissues, cell-cell communication, cell junctions, cytoskeleton and extracellular matrix proteins (K1 and K5)
CO2	Appreciate membrane composition and transport mechanisms (K3 and K5)
CO3	Understand cell division, differentiation, cell cycle and cell death (K3 and K5)
CO4	Comprehend the steps in muscular contraction (K1, K2 and K6)
CO5	Understand the salient features of reproductive, digestive and respiratory systems (K1, K2 and K5)

Unit 1 Cell Junctions and Cell Cycle

Major classes of cell junctions- anchoring, tight and gap junctions. Major families of cell adhesion molecules (CAMs)- cadherins, integrins. Types of tissues. Epithelium- organisation and types. The basement membrane. Cell cycle- mitosis and meiosis, cell cycle-phases and regulation. Cell death mechanisms- an overview-apoptosis, necrosis.

Unit 2 Reproductive System

Reproductive system- sexual differentiation and development; sperm transport, sperm capacitation, semen analyses and acrosome reaction. Clinical relevance of female reproductive physiology- menstrual cycle, pregnancy and menopause. Fertilisation and infertility issues.

Unit 3 Digestive System

Digestive system- structure and functions of different components of digestive system, digestion and absorption of carbohydrates, lipids and proteins, role of bile salts in digestion and absorption, mechanism of HCl formation in stomach, role of various enzymes and hormones involved in digestive system. Composition of blood, lymph and CSF. Blood cells - WBC, RBC and energy metabolism of RBC, blood clotting mechanism and blood groups- ABO and Rhesus system.

Unit 4 Respiratory System

Respiratory system-gaseous transport and acid-base homeostasis. Mechanism of the movement of O_2 and CO_2 through lungs, arterial and venous circulation. Bohr effect, oxygen and carbon dioxide binding haemoglobin. Maintenance of pH by cellular and intracellular proteins. Phosphate and bicarbonate buffers, metabolic acidosis and alkalosis. Respiratory acidosis and alkalosis. Regulation of fluid and electrolyte balance.

Unit 5 Nervous System and Muscular Contraction

Sensory transduction, nerve impulse transmission- nerve cells, synapses, reflex arc structure, resting membrane potential, Nernst equation, action potential, voltage gated ion-channels, impulse transmission, neurotransmission, neurotransmitter receptors, synaptosomes, synaptotagmin, rod and cone cells in the retina, changes in the visual cycle, photochemical reaction and regulation of rhodopsin, odour receptors, learning and memory. Chemistry of muscle contraction – actin and myosin filaments, theories involved in muscle contraction, mechanism of muscle contraction, energy sources for muscle contraction.

Unit 6 A Succinct View of Hormones

Hormones – classification, biosynthesis, circulation in blood, modification and degradation. Mechanism of hormone action, target cell concept. Hormones of hypothalamus, pituitary, pancreatic, thyroid and parathyroid, adrenal and gonadal hormones. Synthesis, secretion, physiological actions and feedback regulation of synthesis of hormones.

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. Lodish H et al (2016) *Molecular Cell Biology*, 8th Ed. Freeman, New York.
3. Rodwell VW et al (2018) *Harper's Illustrated Biochemistry*, 31 Ed. McGraw-Hill Education, New York.
4. Brubaker AP (2018) *A textbook of human physiology* Palala Press, London.
5. Hall JE, Hall ME (2020) *Guyton and Hall Textbook of medical physiology*, Elsevier Health Science, Amsterdam.
6. Robertson RP (2023) *Degroots Endocrinology Volume I and Volume II* Elsevier, Amsterdam.

Supplementary Reading

1. Barrett KE et al. (2019) *Ganong's Review of Medical Physiology,* 26th Ed, McGraw Hill, New York.
2. Graaf and Rees (2010) *Schaum's Easy Outline of Human Anatomy and Physiology*. 2nd Ed. McGraw Hill, New York.

Reading List (Online)

1.https://www.genome.gov/genetics-glossary/Cell-Cycle

2.https://my.clevelandclinic.org/health/diseases/16083-infertility-causes

3.https://www.webmd.com/heartburn-gerd/reflux-disease

4.https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5760509/

5.https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3249628/

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	2	3	2	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	2	3	2	3	2	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	2	3	2	3	2	3	3

Semester	ELECTIVE 2: (GENERIC)	L	T	P	C
I	23BIOE105: MICROBIOLOGY AND IMMUNOLOGY	3	0	0	3

Learning Objective (LO):

LO	To gain comprehensive knowledge on salient features of microbiology, cells of the immune system, immunoprotection and immunochemical techniques

Course Objectives

1	Familiarize on basic concepts of microbiology and applications of microbes
2	Provide an insight into the immune cell types, antigens and antibodies
3	Inculcate knowledge on types of immunity, vaccines, antibody diversity and vaccination
4	Provide a platform to the understanding of hypersensitivity and tumor immunology
5	Educate on principles and applications of immunochemical techniques

Course Outcomes (CO)

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

CO1	Master the skills associated with growth, cultivation and screening of microorganisms (K1-K3)
CO2	Understand the components of immune system and the role of cells and organs in immune response (K2 and K3)
CO3	Comprehend the immunologic manifestation in transplantation and hypersensitivity and the genetic mechanisms in antibody diversity (K3-K6)
CO4	Apprehend the role of immunological mechanisms with a focus on management of diseases cancer, AIDS and autoimmune disorders (K1 and K5)
CO5	Know the advantages and disadvantages of the immunological techniques (K2 K4)

Unit 1 Microbiology and Spoilage of Foods by Microbes

Taxonomical classification – bacteria, algae and fungi and protozoa. Distribution and role of microorganisms in soil, water and air. Types of culture media, isolation of pure culture, growth curve and the measurement of microbial growth.

Contamination and spoilage of foods –fruits, vegetables, meat, fish, poultry, milk and milk products. General principles of traditional and modern methods of food preservation - steaming, curing, pasteurization, cold processing, freeze drying, irradiation, vacuum packing, control of oxygen and enzymes. Microbes involved in preparation of fermented foods - cheese, yoghurt, curd, ragi porridge (கேழ்வரகு கூழ்) and bread.

Unit 2 Food Poisoning and Antimicrobial Agents

Bacterial food poisoning, *Salmonella*, *Clostridium botulinum* (botulism), *Staphylococcus aureus*, fungal food poisoning – aflatoxin, food infection – *Clostridium, Staphylococcus* and *Salmonella*. Causes, control, prevention, cure and safety. Food microbiological screening- Real time PCR, ELISA, aerobic and anaerobic plate count. Hazard analysis critical control point (HACCP).

Antimicrobial chemotherapy. Mechanism of action – sulphonamides. Penicillin, streptomycin-spectra of activity, mode of administration, mode of action, adverse effects and sensitivity test. Antiviral and antiretroviral agents, antiviral RNA interference, natural intervention.

Unit 3 Immune Cell Types, Types of Immunity and Vaccines

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 -antigenicity, antigenic determinants, haptens and epitopes. Antibodies - structure, classification, functions, isotypes, allotypes and idiotypes. Complement system- components, nomenclature, biological functions, activation of complement, classical pathway and alternate pathway.

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. Vaccines-killed, attenuated organisms, toxoids, recombinant vaccines, subunit vaccines, DNA vaccines, antiidiotypic vaccines.

Unit 4 Antibody Diversity, Transplantation, Hypersensitivity and Immune Disorders

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. Hypersensitivity - definition and classification - type I to type V (brief account only). Autoimmunity and autoimmune disease - SLE. AIDS- pathogenesis, diagnosis and treatment.

Unit 5 Tumor Immunology and Immunotechniques

Tumor immunology - immune surveillance, tumor antigens, immune response to tumors, cancer immunotherapy. Immunochemical techniques - production of 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. Pelczar MJ (2001) *Microbiology* 5th Ed. McGraw Hill, New Delhi.
2. Willey JM et al. (2011) *Prescott's microbiology* 8th Ed. McGraw Hill, New Delhi.
3. Carrole K, Butel J (2023) *Jawetz, Melnick and Adelbergs medical microbiology* 28th Ed. McGraw Hill, New Delhi.
4. Punt J, Stranford S (2018) *Kuby Immunology* 8th Ed. WH Freeman & Co, New York.
5. Abbas AK et al. (2018) *Cellular and Molecular Immunology* 9th Ed. Elsevier, Berlin.
6. Murphy KM et al. (2017) Janeway's *Immunology: the immune system* 8th Ed. Garland Science, New York.
7. Coico R, Sunshine G (2015) *Immunology: A short Course* 7th Ed. Wiley, New Jersey.

Supplementary Reading

1. Seamus PJD et al. (2017) *Roitt's essential immunology* 13th Ed. Wiley, New Jersey.
2. Delves, PJ et al. (2017) *Roitt's Essential Immunology*, 13th Ed. Willey-Blackwell Sci. New Jersey.
3. Flajnik M (2022) *Paul's fundamental immunology* 8th Ed. LWW Publishers, Philadelphia.
4. Abbas A et al. (2021) *Cellular and molecular immunology* 10th Ed. Elsevier, Amsterdam.

Reading List (Online)

1. https://www.ijam.co.in/index.php/ijam/article/view/1326
2. Virtual Lectures in Microbiology and Immunology, University of Rochester
3. https://www.frontiersin.org/articles/10.3389/fphar.2020.578970/full#h9
4. https://www.frontiersin.org/articles/10.3389/fmicb.2018.02151/full
5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7559905/
6. https://apps.who.int/iris/bitstream/handle/10665/58891/WHO/
7. https://hmmcollege.ac.in/uploads/3._Immunology.pdf
8. http://www.helmberg.at/immunology.pdf
9. https://booksite.elsevier.com/samplechapters/9780443073267/9780443073267.pdf
10. 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	3	2	3	3	3	2	3	2	3	2	3	3
CO2	3	3	2	3	3	2	3	3	3	3	3	3	2	3	3
CO3	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3
CO4	3	3	2	3	3	2	3	3	3	3	2	3	2	3	3
CO5	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3

Semester	ELECTIVE: (DISCIPLINE CENTRIC/GENERIC)	L	T	P	C
I	23BIOE106: BASIC BIOTECHNOLOGY	3	0	0	3

Learning Objective (LO):

LO	To understand the classification, growth and cultivation of microorganisms and their industrial applications and to understand the aspects of genetic engineering.

Course Objectives

1	Familiarize on basic concepts of bioreactors and downstream processing
2	Provide an insight into the roles of biotechnology in environmental and agricultural management
3	Inculcate knowledge on vectors and gene transfer methods
4	Provide a platform to cloning strategies and transgenesis
5	Educate on techniques and safety aspects in genetic engineering

Course Outcomes (CO)

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

CO1	Master the skills associated with growth, cultivation and screening of industrial microorganisms (K1-K3)
CO2	Understand the bioprocess techniques for production of industrially important compounds, SCP, biofertilizers and biopesticides and their applications (K2 and K3)
CO3	Comprehend the methodology and applications of microbial mining and bioremediation (K3-K6)
CO4	Apprehend the role of rDNA technology in constructing vectors and cDNA and genomic libraries (K1 and K5)
CO5	Know the advantages and disadvantages of transgenic plants and foods (K2-K4)

Unit 1 Bioreactors and Downstream Processing

Bioprocess engineering: Isolation and screening of industrially important microbes. Maintenance and improvement of strains. Bioreactors - types, design, parts and their function. Media for industrial fermentation, air and media sterilization. Antifoaming devices. Types of fermentation processes: Analysis of batch, fed-batch and continuous bioreactions, analysis of mixed microbial population, specialized bioreactors (pulsed, fluidized, photobioreactors). Downstream processing: solid-liquid separation, release of intracellular compartments, concentration of biological products, purification, preservation, stabilization and product formulation.

Unit 2 Biotechnology for Industrial, Environmental and Agricultural Management

Industrial production of ethanol, lactic acid, penicillin and phenylalanine. Commercial production of fructose. Wastewater treatment - physical, chemical and biological treatment processes. Effluent treatment. Bioremediation, oil spill cleanup. Microbial mining. Biofertilizers-bacteria and blue green algae. Biopesticides in integrated pest management-*Bacillus* and *Pseudomonas* as biocontrol agents.

Single cell protein-microorganisms and steps in SCP production, biomass recovery, nutritional and safety evaluation, advantages. Soil microbiota. Bio-geochemical role of soil microorganisms. Microbial degradation of xenobiotics in the environment.

Unit 3 Vectors and Gene Transfer Methods

Basic steps in cloning. Restriction endonucleases, cloning vectors (pBR322, pUC), phages (λ and M13), cosmids, BACs, and YACs. Methods of ligating vector and insert DNA - cohesive end method, homopolymer tailing, blunt-end ligation, linkers and adapters.

Gene transfer methods-calcium phosphate coprecipitation, electroporation, lipofection, viral vectors, microinjection. Host organisms for cloning. Recombinant screening-marker inactivation (antibiotic resistance and blue-white selection), colony hybridization, immunological screening and *in vitro* translation.

Unit 4 Cloning Strategies and Transgenesis

Cloning strategies: Construction of genomic and cDNA libraries. Difference between genomic and cDNA libraries. Cloning of insulin gene. Expression vectors - baculovirus and mammalian expression systems (brief outline). Transgenic plant technology: Development of insect resistance, virus resistance, herbicide resistance and stress tolerant plants. Delayed fruit ripening. Terminator technology. Production of vaccines and antibodies in plants. Ethics of genetically engineered crops. Transgenic animal technology: Methods of producing transgenic animals (retroviral, microinjection, engineered stem cell). Applications of transgenic animals. Transgenic animals as models of human disease.

Unit 5 Techniques and Safety Aspects in Genetic Engineering

Preparation of probes. DNA sequencing. Chemical, enzymatic and automated methods. DNA fingerprinting - principle and applications. Brief outline of RFLP and FISH. PCR: basic reaction and applications. Modified PCR techniques-RT-PCR, real-time qPCR. Basic concepts of site-directed mutagenesis - directed evolution (basic concepts), protein engineering and uses. Basic principles of gene knock-in and knock-out technology. Precise genome editing - CRISPR/Cas 9 system. The human genome project - goals, results, benefits and hazards. 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. Gupta PK (2010) *Elements of Biotechnology*. 2nd Ed. Rastogi Publication, New Delhi.
2. Dale JW et al. (2011) *From Genes to Genomes: Concepts and applications of DNA technology*. 3rd Ed. Wiley-Blackwell, New Jersey.
3. Nicholls DTS (2008), *Genetic Engineering.* 3rd Ed. Cambridge University Press, Cambridge.
4. Glick BR et al. (2010), *Molecular Biotechnology: Principles and Applications of Recombinant DNA,* 4th Ed. ASM Press, Washington.
5. Singh BD (2010) *Biotechnology. Expanding horizon/.* 3rd Ed, Kalyani Publishers, New Delhi.

Supplementary Reading

1. Winnacker EL (2003) *From genes to clones*, 4th Ed. VCH Publishers, Weinheim.
2. Watson et al (2006) *Recombinant DNA*, 3rd Ed, Scientific American Publisher, US.
3. Sandy B et al (2002) *Principles of Gene Manipulation/* 6th Ed. Wiley, New Jersey.
4. Nicholl DST (2023) *An introduction to genetic engineering* Cambridge University Press, Cambridge.

Reading List (Online)

1. https://www.oecd.org/sti/emerging-tech/2097562.pdf
2. https://www.researchgate.net/publication/284169166/Biotechnology/
3. https://www.eib.org/attachments/pj/pjbio_en.pdf
4. https://nios.ac.in/media/documents/srsec314newe/lesson-30
5. http://pstu.ac.bd/old/uploads/resources/0._Introduction_to_Biotechnology/

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	3	2	3	3	3	2	3	2	3	2	3	3
CO2	3	3	2	3	3	2	3	3	3	3	3	3	2	3	3
CO3	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3
CO4	3	3	2	3	3	2	3	3	3	3	2	3	2	3	3
CO5	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3

SEMESTER - II

Semester	23BIOC201: CELLULAR METABOLISM	L	T	P	C
II		4	0	0	5

Learning Objective (LO):

LO	To understand the principles of energy production in cells, anabolic and catabolic reactions of biomolecules and the integral relationship of metabolic pathways

Course Objectives

1	Familiarize on blood glucose homeostasis
2	Provide an insight into the metabolic pathway of glycogen, glycoprotein, mucopolysaccharide and peptidoglycan with clinical correlation wherever required
3	Inculcate knowledge on nucleotide metabolism and disorders associated with it
4	Provide a platform to understand the versatile role of PLP in amino acid degradation, formation of specialised products and disorders associated with ammonia detoxification
5	Educate on heme and sulphur metabolism with associated clinical manifestation

Course Outcomes (CO)

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

CO1	Understand the basic principles of bioenergetics and mitochondrial mechanisms in energy production (K1, K2 and K5)
CO2	Appreciate the reaction pathways by which carbohydrates and lipids are synthesized and degraded (K1, K2 and K5)
CO3	Comprehend the metabolic fates of amino acids and the features of protein catabolism (K1, K2 and K4)
CO4	Know the biochemistry of porphyrins, purines and pyrimidines and comprehend the integral relationship of metabolic pathways (K1, K2 and K3)
CO5	Know the clinical conditions arising from metabolic dysregulation (K1, K2, K4 and K5)

Unit 1 Bioenergetics and Biological Oxidation

Free energy and entropy, endergonic and exergonic reactions. Phosphoryl group transfers and ATP. Enzymes involved in redox reactions. The electron transport chain - organization of respiratory chain complexes and electron flow.

Oxidative phosphorylation - electron transfer reactions in mitochondria. F_1F_0 ATPase - structure and mechanism of action. The chemiosmotic theory. Inhibitors of respiratory chain and oxidative phosphorylation - poisons, uncouplers and ionophores. Regulation of oxidative phosphorylation. Mitochondrial transport systems - ATP/ADP exchange, malate/glycerophosphate shuttle, creatine-phosphate shuttle.

Unit 2 Carbohydrate Metabolism

Overview of glycolysis and gluconeogenesis- regulation. The citric acid cycle and regulation. The pentose phosphate pathway and uronic acid pathway. Metabolism of glycogen and regulation. Glycogen storage diseases. Galactosemia. Fructose intolerance and fructosuria. The glyoxylate cycle. Cori cycle.

Photosynthesis- photosynthetic apparatus, light reaction, cyclic and noncyclic photophosphorylation. Dark reaction- Calvin cycle, Hatch-Slack pathway. Photorespiration. Starch biosynthesis and degradation.

Unit 3 Lipid Metabolism

Oxidation of fatty acids - role of carnitine in fatty acid transport, α, β and ω-oxidation. Metabolism of ketone bodies. Biosynthesis of fatty acids - fatty acid synthase complex - regulation of lipogenesis. Metabolism of triglycerides, phospholipids and sphingolipids. Cholesterol - biosynthesis, regulation, transport and excretion. Metabolism of lipoproteins and lipoproteinemia. Metabolism of prostaglandins - COX and LOX pathways. Lipid storage diseases and fatty liver.

Unit 4 Amino Acid and Porphyrin Metabolism

Biosynthesis of nonessential amino acids (overview only). Catabolism of amino acid nitrogen-transamination, deamination, ammonia formation and the urea cycle. Catabolism of carbon skeletons of amino acids. Conversion of amino acids to special products. Disorders of amino acid metabolism- phenylketonuria, alkaptonuria, albinism, and maple syrup urine disease.

Biosynthesis and degradation of porphyrins and heme. Porphyrias.

Unit 5 Metabolism of Purines and Pyrimidines and Metabolic Integration

Metabolism of purines- *de novo* and salvage pathways for biosynthesis. Purine catabolism. Biosynthesis and catabolism of pyrimidines. Regulation of purine and pyrimidine metabolism. Hyperuricemia and gout. Hypouricemia. Oroticaciduria.

Integration of metabolism - interconversion of major food stuffs. Metabolic profile of the liver, adipose tissue and brain. Altered metabolism in starvation. Brief account on metabolomics.

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. Plummer DT (2006) *An introduction to practical biochemistry* 3rd Ed. Tata McGraw Hill Pvt. Ltd. New Delhi.
2. Voet D et al. (2018) *Fundamentals of biochemistry* 5th Ed. Wiley, New York.
3. Rodwell VW et al. (2018) *Harper's illustrated biochemistry* 31st Ed. McGraw Hill, New York.
4. Kuchel PW et al. (2011) *Schaum's outline of biochemistry* 3rd Ed. McGraw Hill, New York.
5. Nelson DL, Cox MM (2017) *Lehninger Principles of Biochemistry*, 7th Ed. Freeman Publishers, New York.

Supplementary Reading

1. Frayn KN (2013) *Metabolic regulation. A human perspective* 3rd Ed. Wiley-Blackwell, New Jersey.
2. Berg JM et al. (2023) *Biochemistry* 10th Ed. Macmillan Education, London.
3. Ochs RS (2021) *Biochemistry* 2nd Ed. CRC Press, Boca Raton.

Reading List (Online)

1. https://www.embopress.org/doi/full/10.1038/msb.2013.19
2. https://people.wou.edu/~guralnl/450Glycogen%20metabolism.pdf
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3243375/
4. https://www.researchgate.net/publication/334458898_Urea_Cycle
5. https://www.researchgate.net/publication/51233381_Heme_biosynthesis
6. https://www.researchgate.net/publication/349746691

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	23BIOC202: CLINICAL BIOCHEMISTRY	L	T	P	C
II		4	0	0	5

Learning Objective (LO):

LO	To understand the biochemical and molecular basis of diseases, diagnosis and therapy

Course Objectives

1	To educate about the details of inherited disorders
2	To inculcate knowledge on the etiopathogenesis, symptoms and complications of metabolic and hormonal disorders and the relevant diagnostic markers
3	To emphasize the diagnostic significance of serum enzymes in different pathologies and other laboratory investigations of diagnostic importance
4	To conceive the role of inherited genes in inborn errors of metabolism and methodologies pertaining to *in utero* diagnosis and postnatal screening
5	To get updated about electrolyte and hormonal imbalances and the biochemical tests to diagnose them

Course Outcomes (CO)

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

CO1	Describe the molecular basis of genetic and acquired disorders (K1 and K2)
CO2	Understand the etiology, findings and management of diabetes, atherosclerosis and cancer (K3 and K5)
CO3	Describe and explain the diseases of the major organs and systems, organ functional tests for diagnosis and management (K2, K3, K5 and K6)
CO4	Comprehend the principles of recent advancements in diagnosis and therapy (K1, K3 and K4)
CO5	To appreciate the role of pre- and post-natal diagnosis leading to health progeny (K3 and K4)

Unit 1 Molecular Basis of Diseases I

Genetic diseases. Elementary details of chromosomal disorders (Down syndrome, Klinefelter's syndrome), monogenic disorders (autosomal dominant, autosomal recessive, sex-linked). Multifactorial diseases.

Role of tissues and hormones in blood glucose homeostasis. Diabetes mellitus: classification, metabolic abnormalities, diagnosis, acute (diabetic ketoacidosis, HONK coma) and long term (nephropathy, neuropathy, retinopathy, diabetic foot) complications, management. Hypoglycemia-classification, clinical manifestations, diagnosis and management.

Unit 2 Molecular Basis of Diseases II

Atherosclerosis: risk factors, biochemical findings and management. Cancer - differences between benign and malignant tumours. Growth characteristics of cancer cells. Morphological and biochemical changes in tumour cells. Tumor markers- oncofetal proteins, hormones, enzymes, tumor-associated antigens. Agents causing cancer (radiation, viruses and chemicals). Multistage carcinogenesis. Mechanisms of protooncogene activation. Functions of protooncogenes and tumor suppressor genes. Role of p53.

Unit 3 Liver Disorders

Structure and function of the liver. Metabolism of bilirubin. Excretory, synthetic, detoxification and metabolic liver function tests. Plasma enzymes in liver disease. Jaundice- retention, regurgitation, neonatal. Inherited hyperbilirubinemias. Causes, consequences, biochemical findings and management of hepatitis, cirrhosis and gallstones.

Unit 4 Gastrointestinal and Renal Disorders

Gastric function tests. Peptic ulcer: pathogenesis, biochemical findings and management. Pancreatic and intestinal function tests. Causes, biochemical findings and consequences of pancreatitis, cystic fibrosis and malabsorption.

Kidney function tests. Collection and preservation of urine. Normal and abnormal constituents of urine. Tests for abnormal constituents in urine. Pathogenesis, biochemical findings and management of glomerulonephritis, renal failure, nephrotic syndrome and nephrolithiasis.

Unit 5 Molecular Diagnosis and Therapeutics

Composition and analysis of CSF. Diagnostic kits. Prenatal and neonatal screening for genetic disorders. DNA diagnostic systems - probes. RFLP and PCR in disease diagnosis. Viral diagnostics: immunodiagnosis, molecular diagnosis. SNP-based diagnosis. Therapeutic agents from nonrecombinant and recombinant organisms. Antivirals and antiretrovirals. Drug delivery and targeting. Gene therapy: gene delivery systems, *ex vivo* and *in vivo* strategies, gene therapy for single-gene disorders, cancer and AIDS. Antisense and siRNA therapy. Nanotherapy. Stem cell therapy.

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. Varley H et al. (2006) *Practical clinical biochemistry* 6th Ed. CBS Publishers, New Delhi.
2. Mayne PD et al. (1994) *Clinical chemistry in diagnosis and treatment* 6th Ed. ELBS, Warsaw.
3. Marshall WJ et al. (2016) *Clinical chemistry* 8th Ed. Mosby Publishers, Missouri.
4. Rodwell VW et al. (2018) *Harper's illustrated biochemistry* 31st Ed. McGraw Hill, New York.
5. Glick BR et al. (2010) *Molecular biotechnology: principles and applications of recombinant DNA* 4th Ed. ASM Press, Washington.
6. Puri D (2023) *Text book of medical biochemistry* Elsevier, Amsterdam.

Supplementary Reading

1. Burtis CA (2018) *Tietz textbook of clinical chemistry and molecular diagnostics* 8th Ed. Saunders Publishers, Philadelphia.
2. Kasper EL (2015) *Harrison's principles of internal medicine* 19th Ed. McGraw Hill, New York.
3. Sood R (2019) *Textbook of clinical biochemistry*, CBS Publishers, New Delhi.

Reading List (Online)

1. https://www.aacc.org/science-and-research/clinical-chemistry
2. DOI: 10.7860/NJLM/2016/22587:2173
3. https://doi.org/10.2147/JMDH.S286679
4. https://diabetesjournals.org/clinical/article/40/1/10/139035/
5. http://www.ngsp.org/
6. https://www.researchgate.net/publication/335830829
7. https://labpedia.net/quality-control-of-the-clinical-laboratory/
8. https://journals.sagepub.com/doi/full/10.1016/j.jala.2008.12.001
9. https://doi.org/10.1016/B978-0-12-407821-5.00004-8
10. https://www.westgard.com/clia.htm
11. https://www.labroots.com/webinar/bio-rad-unity-solution-molecular-quality-control-data-

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	3	2	3	3	3	2	3	2	3	2	3	3
CO2	3	3	2	3	3	2	3	3	3	3	3	3	3	2	3
CO3	3	2	3	3	2	3	3	3	2	3	2	3	3	3	3
CO4	3	3	2	3	3	2	3	3	3	3	3	3	3	2	3
CO5	3	2	3	3	2	3	3	3	2	3	2	3	3	3	3

Semester	23BIOP203: PRACTICAL II	L	T	P	C
II	LABORATORY COURSE IN MICROBIOLOGY, IMMUNOLOGY AND ENZYMOLOGY	0	0	14	4

Learning Objective (LO):

LO	To develop practical skills to perform techniques in Microbiology, Immunology and Enzymology

Course Objectives

1	To apprehend wider knowledge about technique of microbiology
2	To inculcate knowledge of antigen-antibody interaction
3	To perform antigen/antibody reaction by ELISA
4	To isolate enzyme from biological sources
5	To measure activity and specific activity of enzyme

Course Outcomes (CO)

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

CO1	Classify and identify human blood groups and Rh factor (K1, K2 and K4)
CO2	Demonstrate Ag-Ab interaction in vitro by immunoprecipitation and electrophoresis (K1 – K4)
CO3	Analyse quantitatively antigen-antibody reaction by ELISA (K1, K2 and K4)
CO4	Isolate enzymes from biological sources (K1-K4 and K6)
CO5	Undertake the effect of inhibitors on enzyme activity (K1 – K4 and K6)

Microbiology

1. Liquid media preparation-nutrient broth
2. Steak plate method
3. Enumeration of total count of the bacteria
4. Isolation of microbes from soil (or) water (or) air
5. Isolation of pure culture of *E. coli*
6. Gram staining and morphological characteristics of microbes

Immunology

1. Blood grouping and Rh typing
2. Radial immunodiffusion
3. Double diffusion
4. Agglutination, rosette formation and complement fixation
5. Preparation of antisera
6. Immunoelectrophoresis (demonstration)
7. ELISA (demonstration)
8. Identification of various immune cells from human peripheral blood.
9. Lymphocyte separation and identification
10. Determination of lymphocyte viability by trypan blue method
11. WBC counting
12. Electrophoretic profile of human serum in native PAGE
13. Preparation of cellular antigen – human RBC
14. Preparation of antigen-adjuvant mixture for production of polyclonal antibody

Enzymology

Alkaline phosphatase

1. Isolation of alkaline phosphatase from goat kidney
2. Purification of alkaline phosphatase
3. Checking the purity of enzyme using SDS-PAGE
4. Determination of activity and specific activity and Km of alkaline phosphatase
5. Effect of activators and inhibitors on the activity of alkaline phosphatase

   Assay of enzymes

   1. Salivary amylase
   2. Urease
6. Enzyme immobilization using alginate beads

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. Shankara SYM et al. (2013) *A laboratory manual for practical biochemistry* 2nd Ed. Jaypee brothers medical publishers (P) Ltd. New Delhi.
2. Plummer DT (2017), *An introduction to Practical Biochemistry*, 3rd Ed, Tata McGraw Hill, New Delhi.
3. Sadasivam S, Manickam A(2018) *Biochemical methods*, New Age International Publishers,New Delhi.
4. Murphy A (2022) *Practical enzymology*, Murphy and Moore Publishing, New York.
5. Arora B, Arora DR (2023) *Practical microbiology* CBS Publishers, New Delhi.

Supplementary Reading

1. Feteih A et al. (2022) *The manual of allergy and clinical immunology* CRC Press, Boca Raton.
2. Mudili J (2020*) Introductory practical microbiology* Narosa Publishers, New Delhi.
3. Bisswanger H (2019) *Practical immunology* Wiley, New Jersey.

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	3	2	3	2	3	2	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	2	3	2	3	2	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	2	3	2	3	2	3	3

Semester	ELECTIVE 3: (DISCIPLINE CENTRIC)	L	T	P	C
II	23BIOE204: ENZYMOLOGY	3	0	0	3

Learning Objective (LO):

LO	To acquire knowledge of the 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 Education, 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)

Enzymes

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 4: (GENERIC)	L	T	P	C
II	23BIOE205: ENERGY AND DRUG METABOLISM	3	0	0	3

Learning Objective (LO):

LO	To gain comprehensive knowledge on metabolic processes of drugs

Course Objectives

1	To introduce about redox systems in biology
2	To comprehend electron transport chain and oxidative phosphorylation
3	To gain knowledge on light and dark reactions of photosynthesis
4	To elucidate the metabolism of xenobiotics
5	To introduce about green biofertilizers

Course Outcomes (CO)

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

CO1	Appreciate the relationship between free energy and redox potential (K1 – K4)
CO2	Know the salient features of overview of drug metabolism (K1, K2, K5 and K6)
CO3	Acquaint with the process of drug receptors (K1, K2 and K5)
CO4	Comprehend the diverse phase I reactions (K1, K2, K4 and K5)
CO5	Correlate the avenues available to metabolize the xenobiotics (K1, K2, K4 and K5)

Unit 1 Redox Systems in Biology, ETC and Photosynthesis

Thermodynamic principles in biology- concept of entropy, enthalpy and free energy change. Redox systems. Redox potential and calculation of free energy. Biological oxidation – oxidases, dehydrogenases, hydroperoxidases, oxygenases. Energy rich compounds – phosphorylated and non-phosphorylated. High energy linkages. Electron transport chain-various complexes of ETC, Q-cycle. Inhibitors of ETC. Mechanism of ATP synthesis.

Photosynthesis - light reaction-Hill reaction, absorption of light, photochemical event. Photo ETC-cyclic and non-cyclic electron flow. Photophosphorylation-role of CF0-CF1 ATPase. Dark reaction- Calvin cycle, control of C3 pathway, and Hatch-Slack pathway (C4 pathway), photorespiration. Synthesis and degradation of starch.

Unit 2 Introduction to Drug Metabolism

Introduction to drugs, routes of drug administration, absorption of drugs. Bioavailability: factors influencing absorption and bioavailability. Drug distribution – plasma protein binding, placental transfer, blood-brain barrier. Physicochemical properties of drugs – overview of metabolism of drug action.

Unit 3 Drug Receptors

Drug receptors: structure, types of receptors, second messengers, ligand gated ion channel, G-protein coupled receptor. Tyrosine kinase enzyme coupled receptors, steroid receptors. Drug-response relationship. Therapeutic index. Adverse drug reactions. Factors affecting drug action: drug-drug interaction, synergism, antagonism, additive effects. Drug tolerance and dependence.

Unit 4 Phase I Reactions

Principles of drug metabolism – first-order kinetics, zero-order kinetics, inducible biotransforming enzymes. Sites of drug metabolism - Phase I metabolism - endoplasmic reticulum and non-endoplasmic reticulum drug metabolism – Oxidative and hydrolysis reactions. Enzymes of phase I metabolism – the cytochrome P450 family, flavin containing monoxygenases, hydrolytic enzymes, mode of action and factors affecting the activities of enzymes.

Unit 5 Phase II Reactions and Induction of Drug Metabolism

Conjugation reactions (glucuronidation, sulphation, acetylation, methylation, glutathionylation), Enzymes involved in phase II reactions, mode of action and factors affecting the activities of enzymes. Role of xenobiotic metabolism in safe and effective use of drugs. Induction of drug metabolism – nuclear receptors that induce drug metabolism. Role of drug metabolism in drug development.

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. Ritter JM et al. (2008) *A textbook of clinical pharmacology and therapeutics* 5th Ed. Hodden Education, London.
2. Brunton LL, Knollmann B (2022) *Goodman and Gilman's the pharmacological basis of therapeutics* 14th Ed. McGraw Hill, New York.
3. Rodwell VW et al. (2018) *Harper's illustrated biochemistry* 31st Ed. McGraw Hill, New York.
4. Akash MSH, Rehman K (2022) *Biochemistry of drug metabolising enzymes* Elsevier, Amsterdam.

Supplementary Reading

1. Frayn KN (2013) *Metabolic regulation. A human perspective* 3rd Ed. Wiley-Blackwell, New Jersey.
2. Saravanan G, Alagarsamy V (2022) *Pharmaceutical biochemistry: a comprehensive approach* PharmaMed Press, New Delhi.
3. Song I-S (2021) *Drug metabolism, transport and pharmacokinetics*, MDPI, Basel.

Reading List (Online)

1. https://www.chuv.ch/fileadmin/sites/pha/documents/pha-cb_2010_burger7_metabolism.pdf
2. https://med.pdn.ac.lk/notices/studentnotices/2010-11%20Batch/PHARMACOKINETICS2.pdf
3. https://m.pothys.com/download/11f63_drug-metabolism-kau
4. https://www.philadelphia.edu.jo/s_telfa/Chapter-5-Phase-IDrug%20Metabolism-03-2020.pdf
5. https://www.uomustansiriyah.edu.iq/media/lectures/2/2_2016_10_19!10_15_43_AM.pdf
6. https:://www.slideshare.net/abushaikh07/drug-metabolismpdf

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	3	3	3	2	3	3	3	2	3	3
CO3	3	2	3	2	2	3	3	2	3	3	3	2	3	3	2
CO4	3	3	3	2	3	3	3	3	3	3	3	3	3	2	3
CO5	3	2	2	3	2	2	3	2	2	3	3	2	2	3	2

Semester	ELECTIVE: (GENERIC/DISCIPLINE CENTRIC)	L	T	P	C
II	23BIOE206: PLANT BIOCHEMISTRY	3	0	0	3

Learning Objective (LO):

LO	To gain comprehensive knowledge on plant cell structure, respiration, nitrogen metabolism, plant hormones and secondary metabolites

Course Objectives

1	To introduce about plant cell structure and carbon assimilation
2	To comprehend about glycolysis and TCA cycle
3	To gain knowledge on nitrogen metabolism
4	To elucidate about plant hormones and plant growth
5	To introduce about secondary metabolites

Course Outcomes (CO)

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

CO1	Understand plant cell structure and photosynthesis
CO2	Apprehend the concepts of respiration in plants
CO3	Understand about nitrogen metabolism
CO4	Understand the basic concepts of plant hormones and regulation of plant growth
CO5	Describe the functions of secondary metabolites

Unit 1 - Plant Cell Structure, Photosynthesis and Carbon Assimilation

Plasma membrane, vacuole and tonoplast membrane, cell wall, plastids and peroxisomes. Structure of PSI and PSII complexes, light reaction, Cyclic and non-cyclic photophosphorylation, Calvin cycle and regulation; C4 cycle and Crassulacean acid metabolism (CAM), Photorespiration.

Unit 2 - Respiration

Overview of glycolysis, Alternative reactions of glycolysis, Regulation of plant glycolysis, translocation of metabolites across mitochondrial membrane, TCA cycle, Alternative NAD(P)H oxidative pathways; cyanide resistant respiration. Respiration rate

Unit 3 - Nitrogen Metabolism

Biological nitrogen fixation by free living and in symbiotic association, structure and function of enzyme nitrogenase. Nitrate assimilation: Nitrate and nitrite reductase. Primary and secondary ammonia assimilation in plants; ammonia assimilation by glutamine synthetase-glutamine oxoglutarate amino transferase (GS-GOGAT) pathway. Seed storage proteins in legumes and cereals.

Unit 4 - Plant Hormones and Regulation of Plant Growth

Plant hormones: Biosynthesis, physiological effects and mechanism of action of auxins, gibberellic acid, cytokinin, abscisic acid, Ethylene, brassinosteroids and polyamines. Influence of plant hormones on plant growth and development, regulation of plant morphogenetic processes by light.

Unit 5 - Secondary Metabolites

Representatives of alkaloid group products and their amino acid precursors, function of alkaloids, examples of major phenolic groups; simple phenylpropanoids, coumarins, benzoic acid derivatives, flavonoids, tannins and lignin, biological role of plant phenolics, classification of terpenoids and representative examples from each class, biological functions of terpenoids.

Text Books

1. Bowsher C et al. (2008) *Plant biochemistry*, Garland science, London.
2. Buchanan BB et al.(2005) *Biochemistry and molecular biology of plants* 6th ed. Wiley, New York.
3. Dey PM, and Harborne JB (Ed) (2014) *Plant biochemistry* Academic Press, New York.
4. Heldt H-W, Piechulla B (2021) *Plant biochemistry* Academic Press, New York.
5. Bej S et al. (2019) *Plant biochemistry* Scitus Academics, Wilmington.

Supplementary Reading

1. Bowsher C, Tobin A (2021) *Plant biochemistry* 2nd Ed. CRC Press, Boca Raton.
2. Cormier J (2023) *Plant physiology, biochemistry and molecular biology* White Press Academics, New Orleans.

Reading List (Online)

1. http://site.iugaza.edu.ps/wp-content/Heldt%20-%20Plant%20Biochemistry%203e.pdf
2. https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SBC3201.pdf
3. https://uou.ac.in/sites/default/files/slm/BSCBO-303.pdf
4. https://k8449r.weebly.com/uploads/3/0/7/3/plant_biochemistrybiotechnology.pdf
5. https://www.omicsonline.org/concepts-of-plant-biochemistry-2168-9652-100234.pdf

Outcome Mapping

	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	3
CO2	3	3	2	2	3	2	3	3	2	3	3	3	2	3	2
CO3	3	2	3	3	2	3	3	2	3	3	3	2	2	2	3
CO4	3	3	2	3	3	2	3	3	2	3	3	3	2	3	2
CO5	3	2	3	2	2	3	3	2	3	3	3	2	3	3	3

Semester	SKILL ENHANCEMENT COURSE 1: SEC 1:	L	T	P	C
II	23BIOS207: MEDICAL LABORATORY TECHNOLOGY	2	0	0	2

Learning Objective (LO):

LO	To understand the basic concepts and to learn the techniques essential for clinical laboratory

Course Objectives

1	Familiarize on basic haematology and biochemistry
2	Provide an insight into microbiological examinations
3	Inculcate knowledge on histopathological interpretations
4	Teach the concepts of immunological techniques
5	Educate on recent advances in laboratory automation and quality control

Course Outcomes (CO)

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

CO1	Perform the basic haematology techniques and undertake biochemical analysis of clinical samples (K1 and K3)
CO2	Understand the tests performed in clinical microbiology lab (K1, K2 and K4)
CO3	Undertake histological analysis of samples (K1, K2 and K6)
CO4	Comprehend the basic techniques performed in clinical immunology laboratory (K3)
CO5	Know about quality control, lab accreditation and automation (K1-K4)

Unit 1 Basic Haematology and Biochemistry

Methods of estimation of haemoglobin, PCV, total and differential count of WBC, platelet count, clotting, bleeding and prothrombin time. Blood group - methods of grouping and Rh factor. Determination of proteins in serum and plasma. Determination of glucose, glycated hemoglobin, triglycerides, cholesterol, lipoproteins. Examination of body fluids - ascitic fluid, pleural fluid, synovial fluid, pericardial fluid, CSF and amniotic fluid. Urine analysis, abnormal constituents. Faecal specimen - macroscopic and microscopic examinations - detection of occult blood.

Unit 2 Microbiology

Microscopic examination, Gram staining, acid-fast staining, laboratory culture - culture media, preparation of culture media, pH adjustment of culture media, making of culture plates, techniques of aseptic transfer, blood and urine culture. Antibiotic sensitivity tests. Laboratory analysis of throat swab, sputum specimens, purulent exudates - tuberculosis, *Vibrio* infections and cholera, gonorrhoea and leprosy

Unit 3 Histopathology

Tissue reception, labelling, fixation and section cutting, preparation of paraffin blocks (dehydration, clearing, embedding, blocking). Handling and care of microtome, types of microtomes, and section cutting. Frozen section techniques - CO_2 freezing, cryostat. Preparation of common stains. H and E, Congo red, methyl violet, Leishman stain, Giesma and staining techniques. Mounting of specimens. Molecular analysis of chromosomal aberrations in leukaemia and lymphomas. Molecular diagnosis of genetic diseases.

Unit 4 Laboratory Immunology

Agglutination tests, haemagglutination tests, precipitation tests and flocculation tests, tests for RA factor, CRP, ASO, VDRL, Widal, TORCH, auto-antibodies, hepatitis, HIV testing and EBV. Aldehyde test ELISA test, serum electrophoresis. Immunohistochemical staining methods for auto-antibodies and tumour markers. Cutaneous sensitivity test.

Unit 5 Laboratory Automation and Quality Control

Functional components of clinical laboratories. Basic requirements of clinical laboratory technician. Maintenance of glassware and equipment. Quality assurance in clinical laboratory. External QC and internal QC – assessment - corrective and preventive actions. Clinical validation and accreditation. Equipment calibration. Automation - advantages over manual methods. Automated analyzers.

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. Godkar PB, Godkar DP (2014) *Text book of Medical Laboratory Technology* Bhalani Publishing House, New Delhi.
2. Baker FJ et al.. (2014) *Introduction to Medical Laboratory Technology* Butterworth-Heinemann, Oxford, UK.
3. Mayne PD et al., (1994) *Clinical Chemistry in Diagnosis and Treatment* 6th ed. ELBS, Warsaw.
4. Varley H et al. (2006) *Practical Clinical Biochemistry* 6th ed. CBS Publishers, New Delhi.
5. Todd CJ (2016) *Clinical Diagnosis and Management by Laboratory Methods* 16th ed. Saunders Publications, Philadelphia.
6. Sant M (2023) *Textbook of medical laboratory technology* CBS publishers, New Delhi.

Supplementary Reading

1. Bain B et al. (2016) *Dacie and Lewis practical haematology* Elsevier, Amsterdam.
2. Garg K, Garg S (2023) *Practical histology* CBS Publishers, New Delhi.

Reading List (Online)

1. https://www.cartercenter.org/resources/pdfs/health/ephti/library/lecture_notes
2. https://www.shoklo-unit.com/sites/default/files/resources/laboratory_technician
3. https://jssaherstorage.blob.core.windows.net/ /Medical%20Laboratory.pdf
4. https://main.mohfw.gov.in/sites/ %20Handbook-Medical%20lab%20sciences.pdf
5. https://www.nsdcindia.org/scmp/assets/image/759275563-Preview_MLT_BOOK.pdf

Outcome Mapping

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

SEMESTER - III

Semester	23BIOC301: INDUSTRIAL MICROBIOLOGY	L	T	P	C
III		4	0	0	5

Learning Objective (LO):

LO	To gain knowledge of the principles of bioprocessing, downstream processing and concepts of food and agricultural microbiology

Course Objectives

1	To apprehend wider knowledge on use of microorganisms in industries
2	To know various fermenter designs, culture systems and fermentation process
3	To understand the production and purification of fermented products
4	To comprehend the basic concepts of food and agriculture microbiology
5	To emphasize on entrepreneurship in industrial microbiology

Course Outcomes (CO)

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

CO1	Obtain necessary knowledge on structure and classification of microorganisms (K2 and K4)
CO2	Gain knowledge on the use of microorganisms in various industrial applications (K3 and K4)
CO3	Exhibit knowledge on fermentation process, harvest and recovery (K1 and K5)
CO4	To differentiate the types of fermentation processes and applications in pharmaceutical industry (K2 and K3)
CO5	Apply practically the use of microorganisms in beverages, dairy and food industries (K3 and K6)

Unit 1 Introduction

Structure of bacteria, fungi and viruses and their classification. Characteristics used for the classification of bacteria. Reproduction in bacterial and fungi. Types and characteristics of microorganisms used in industries – food industry, chemical industry and pharmaceutical industry.

Unit 2 Microbial Fermentation I

Fundamentals and principles of microbial fermentation techniques – application in pharmaceutical industry. Fermentation – types, techniques, design and operation of fermenters including addition of medium. Types and characteristics of microorganisms, environmental conditions required for the growth and metabolism of industrially and pharmaceutically important microbes. Sterilization methods in fermentation techniques, air, gas, culture medium sterilization. Steam-filtration and chemicals. Types and constituents of fermentative culture medium and conditions of fermentations, antifoaming devices.

Unit 3 Microbial Fermentation II

Recovery and estimation of products of fermentation- production of ethanol, acetic acid, glycerol, acetone, butanol and citric acid by fermentation. Production of enzymes- amylase, protease and lipase. Production of pharmaceuticals by fermentation– penicillin, streptomycin, tetracycline, riboflavin, vitamin B12. Beverages-wine, beer and malt beverages.

Unit 4 Food Microbiology

Production of dairy products-bread, cheese and yoghurt (preparation and their types). Food borne diseases- bacterial and non-bacterial. Food preservation - principles–physical methods: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, Chemical methods - salt, sugar, organic acids, SO_2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins.

Unit 5 Agricultural Microbiology

General Properties of soil, microorganisms in soil – decomposition of organic matter in soil. Biogeochemical cycles, nitrogen fixation, production of bio fertilizers and its field applications – *Rhizobium*, *Azotobacter*, blue green algae, mycorrhizae and *Azospirilium*. Production of biofuels (biogas- methane), soil inoculants.

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. Ratledge A, Kristiansen V (2006) *Basic biotechnology* 3rd Ed. Cambridge University Press, Cambridge, UK.
2. Gupta PK (2010) *Elements of biotechnology* 2nd Ed. Rastogi Publication, New Delhi.
3. Ahmed N (2014) *Industrial and environmental biotechnology* Horizon Scientific Press, London.
4. Matthews KR et al. (2017) *Food microbiology: an introduction* 4th Ed. Wiley, New Jersey.
5. Charles WB, Cook DJ (2019) Food, fermentation and microorganisms 2nd Ed. Blackwell Science Ltd. New Jersey.

Supplementary Reading

1. Flickinger E, Drew C (1999) *Encyclopedia of biotechnology 5 volumes* John Wiley, New Jersey.
2. Casida LEJR (2019) *Industrial microbiology* New Age International, New Delhi.
3. Patel AH (2022) *Industrial microbiology*, Laxmi Publications, Chennai.

Reading List (Online)

1. https://nptel.ac.in/courses/102/105/102105058/
2. https://nptel.ac.in/courses/102/106/102106053/
3. https://nptel.ac.in/courses/126/103/126103017/
4. https://www.youtube.com/watch?v=f7UXyVImZ_c
5. http://site.iugaza.edu.ps/mwhindi/files/Modern-Industrial-MicrobiologyBiotechnology.pdf

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	3	3	3	3	2	3	2	3	3	3	2	3	3	3
CO2	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3
CO3	3	3	3	3	3	2	3	2	3	3	3	2	3	3	3
CO4	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3
CO5	3	3	3	3	3	2	3	2	3	3	3	2	3	3	3

Semester	23BIOC302: MOLECULAR BIOLOGY	L	T	P	C
III		4	0	0	5

Learning Objective (LO):

LO	To understand genome complexity, central dogma of molecular biology and regulation of gene expression

Course Objectives

1	To impart the concepts of genome, chromatin and chromosomes
2	To impart knowledge on DNA replication, transcription and translation
3	To provide understanding of posttranscriptional and posttranslational modifications
4	To comprehend the concepts of gene expression and regulatory RNAs
5	To enlighten about posttranslational modifications and their significance

Course Outcomes (CO)

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

CO1	Compare the genome structure of prokaryotes and eukaryotes and appreciate the complexity of eukaryotic genome (K1, K2, K3 and K5)
CO2	Inculcate the mechanisms of DNA replication, repair and recombination (K1-K5)
CO3	Explain the enzymes and processes involved in RNA biosynthesis, protein biosynthesis and degradation (K1, K2, K4 and K5)
CO4	Comprehend protein targeting and the role of ubiquitin in protein degradation and chaperones in folding (K1 – K6)
CO5	Gain an understanding on the regulation of gene expression at transcriptional, translational and epigenetic levels (K2-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. Split genes- exons and introns. DNA sequence elements: unique sequence DNA, repetitive DNA (SINEs, LINEs, satellite, minisatellites and microsatellites).

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. The end-replication problem and telomerase. Inhibitors of replication.

DNA damage by physical and chemical agents. DNA repair - photoreactivation, excision repair, mismatch repair, SOS response, double strand break repair. Molecular biology of homologous recombination. Transposons: mechanism of transposition and applications.

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. Brief account of ribozymes, RNA editing and reverse transcription.

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. Protein targeting to nucleus and subcellular organelles (mitochondria and lysosomes), secretory proteins (the signal sequence hypothesis). Protein degradation: the ubiquitin pathway. Protein folding-models, molecular chaperones.

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 and *trp* operon. Regulation of r-protein operons. Regulation of gene expression in eukaryotes: Transcriptional regulation by steroid hormone receptors, phosphorylation (STAT proteins), alternative splicing. Translational regulation. Antisense RNA and RNA interference. 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.
3. Allison LA (2021) *Fundamental molecular biology* Wiley Blackwell, New Jersey.

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	3	2	2	3	2	3	2	3	3	3	3	3	2	3
CO2	3	3	2	3	2	3	3	3	2	3	3	3	3	3	3
CO3	3	2	3	2	3	2	3	2	3	3	3	3	3	2	3
CO4	3	3	2	3	2	3	3	3	2	3	3	3	3	3	3
CO5	3	3	2	3	2	3	3	3	2	3	3	3	3	3	3

Semester	23BIOC303: GENE EDITING, CELL AND GENE THERAPY	L	T	P	C
III		4	0	0	5

Learning Objective (LO):

LO	To acquire knowledge on molecular basis of gene therapy and gene therapy applications in hereditary and acquired diseases

Course Objectives

1	To inculcate knowledge on comparing the animal models used to model genetic diseases
2	To understand the molecular basis of genetic diseases
3	To educate the therapeutic strategies in gene therapy and stem cell therapy
4	To enlighten the importance of gene and cell therapy
5	To emphasize the ethical considerations of gene and cell therapry

Course Outcomes (CO)

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

CO1	Understand the fundamental concepts of immune therapy, gene therapy and cell therapy (K1 and K2)
CO2	State the strategies of gene cloning and the applications of gene delivery vectors (K3)
CO3	Understand the nature of diseases wherein gene therapy and stem cell therapy can be applied (K1 – K4)
CO4	To identify knowledge gaps of immune therapy, gene therapy and stem cell therapy (K5 and K6)
CO5	To evaluate the ethical and social aspects of the novel therapeutic strategies (K1,K2 and K5)

Unit 1 Basics of Gene Editing

Gene editing: basis of gene editing, DNA repair mechanisms, double strand DNA breaks, non-homologous end-joining (NHEJ), homology directed repair, programmable nucleases for gene editing, meganucleases, zinc-finger nucleases, transcription activator-like effector nucleases (TALEN), CRISPR-Cas systems, gene editing using CRISPR-Cas, drawbacks and major challenges to present gene editing techniques, gene editing for human disease therapy.

Unit 2 Gene Therapy I

Basics of gene and cell therapy, types of gene therapy, gene therapy strategies, therapeutic targets for gene therapy, choice of the therapeutic target, administration routes, delivery systems, expression of transgene, persistence of the gene therapy, cell targeting, immunological response to the therapy, ethical and legal issues, concerns about gene and cell therapy

Unit 3 Gene Therapy II

Vectors for gene therapy: non-viral and viral vectors for gene therapy, physical methods of gene delivery, polymer, lipid and inorganic material based chemical systems for gene delivery, viral vectors, lentiviral, adenoviral, adeno-associated virus, herpes simplex virus, vaccinia, baculoviral vectors for gene delivery, choice of viral vector and oncolytic virus. gene therapy applications, gene therapy for cancer and oncolytic gene therapy.

Unit 4 Stem Cell

Stem cells and tissue regeneration: adult and fetal stem cells, embryonic stem cells, cell reprogramming, induced pluripotent stem cells (iPSC), chemically induced pluripotent stem cells (CiPSC), reprogramming factors, iPSC derived progenitor cells, organoids, three dimensional (3D) bioprinting.

Unit 5 Ethical Issues of Gene and Cell Therapy

Regulatory and ethical considerations of stem cell and gene therapy, pluripotent stem cell-based cell replacement therapies. Assessing human stem cell safety, use of genetically modified stem cells in experimental gene therapies. Technological challenges towards development of pluripotent stem cell-based cell replacement therapies.

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. Pastrnek JJ (2005) *An introduction to human molecular genetics: mechanisms of inherited diseases* 2nd Ed. Wiley, New Jersey.
2. Kresina TF (2002) *An introduction to molecular medicine and gene therapy* 1st Ed. Wiley, New Jersey.
3. Strachan T, Read A (2019) *Human molecular genetics* 5th Ed. CRC Press, Boca Raton.
4. Sell S (2013) *Stem cells handbook* 2nd Ed. Humana Press, Totowa.
5. Mungekar PR (2022) *Stem cell science* Adhhyan Books, New Delhi.

Supplementary Reading

1. Marshak DR et al. (2001) *Stem cell biology* Cold Spring Harbor Laboratory Press, New York
2. Battler A (2006) *Stem cell and gene-based therapy* Springer, Berlin.
3. Aranha H, Vega-Mercado H (2023) *Handbook of cell and gene therapy: from proof-of-concept through manufacturing to commercialization* CRC Press, Boca Raton.
4. Nobrega C et al. (2020) *A handbook of gene and cell therapy* Springer, Berlin.

Reading List (Online)

1. https://medlineplus.gov/download/genetics/understanding/therapy.pdf
2. https://www.mlsu.ac.in/econtents/47_00%20gene%20therapy.pdf
3. https://www.researchgate.net/publication/329250849_Gene_therapy
4. https://dbtindia.gov.in/sites/default/files/National_Guidelines_StemCellResearch-2017.pdf
5. https://www.researchgate.net/publication/338524087_Stem_Cell_Therapy-_An_Overview

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	2	3	3	2	2	3	2	3
CO2	3	3	2	3	2	3	3	2	2	3	2	2	3	3	3
CO3	3	2	1	2	2	2	1	2	3	3	3	3	3	2	3
CO4	3	1	2	3	2	3	3	3	2	3	3	3	3	3	3
CO5	3	2	2	3	3	2	3	2	3	3	3	1	3	2	3

Semester	23BIOP304: PRACTICAL III	L	T	P	C
III	LABORATORY COURSE IN CLINICAL BIOCHEMISTRY, MOLECULAR BIOLOGY AND INDUSTRIAL MICROBIOLOGY	0	0	13	4

Learning Objective (LO):

LO	To know the assay methods for blood parameters of diagnostic importance and techniques of molecular biology

Course Objectives

1	To instil skill on clinical approach, normal values and clinical interpretations
2	To evaluate lipid profile and assess their relationship with cardiac function
3	To assess liver function and markers of liver
4	To perform urea clearance test to assess renal function
5	To understand the principle, instrumentation and advantages of autoanalyzer

Course Outcomes (CO)

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

CO1	Describe the principles associated with the biochemical measurements performed in clinical laboratory
CO2	Quantitatively analyze blood constituents and assay enzymes of diagnostic importance
CO3	Interpret the clinical result patterns in relation to normal level.
CO4	Acquire knowledge to interpret electrolyte concentration in serum
CO5	Group experiments will help to acquire practical skills to work in health sector

Clinical Biochemistry

I Hematology

1. RBC count, WBC count, total and differential count, ESR, PCV, MCV, bleeding time and clotting time
2. Estimation of hemoglobin
3. Determination of electrolytes – sodium, potassium and calcium

II Liver function test

1. Estimation of bilirubin – direct and indirect
2. Estimation of plasma protein, A/G ratio
3. Thymol turbidity test, prothrombin time
4. Assay of alanine transaminase, aspartate transaminase and γ-glutamyl transferase
5. Separation of LDH isoenzyme by electrophoresis

III Renal function test

1. Qualitative tests for normal and pathological components of urine
2. BUN – estimation of blood urea, creatinine and uric acid
3. Urea clearance test

IV Estimation of blood constituents

1. Blood glucose
2. Serum uric acid
3. Serum creatinine
4. Serum cholesterol
5. Serum phospholipid
6. Serum triglycerides
7. Serum free fatty acids
8. Serum iron
9. Serum inorganic phosphorus
10. Serum alkaline phosphatase

V Group experiments

1. Antigen-antibody reaction – HCG kit method, RA kit method
2. Phlebotomy – venipuncture, different techniques of venipuncture
3. Automation in clinical biochemistry – autoanalyzer and semi-autoanalyser

Molecular Biology

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

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

Industrial Microbiology

1. Production of citric acid using *Aspergillus niger*
2. Production of amylase by *Bacillus subtilis* and estimation of amylase activity

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. Plummer DT (2006) *An introduction to Practical Biochemistry* 3rd Ed. Tata McGraw Hill, New Delhi.
2. Varley H et al. (2022) *Practical Clinical Biochemistry* 6th Ed. CBS Publishers, New Delhi.
3. Goyal S (2023) *Practical biochemistry with clinical correlation* Jaypee Publishers, New Delhi.
4. Sharma PVGK (2021) *Molecular biology a practical manual* MJP Publishers, Chennai.
5. Kulandaivelu S, Janarthanan S (2018) *Practical manual on fermentation technology* IK International Publishers, New Delhi.

Supplementary Reading

1. Gupta RC, Bhargava S (2022) *Practical biochemistry* CBS Publishers, New Delhi.
2. Goyal S (2022) Practical biochemistry with clinical correlations Jaypee Publishers, Chennai.
3. Sharma DC, Riyat M (2018) *Practical medical biochemistry* Woter Kluwer India, New Delhi.

Reading List (Online)

1. https://www.researchgate.net/publication/260182512
2. https://main.icmr.nic.in/sites/default/files/upload_documents/GCLP_Guidelines_2020_Final.pdfhttps://www.westgard.com/clia.html
3. https://www.researchgate.net/publication/263929434_Biochemistry
4. https://ucms.ac.in/Lectures-C-2020/Renal%20function%20Tests%20-%20PPT.pdf
5. https://youtu.be/i2PfjEks4GQ
6. https://www.euro.who.int/__data/assets/pdf_file/0005/268790/WHO-guidelines-on-drawing-blood-best-practices-in-phlebotomy-Eng.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	2	3	3	3	2	3	3
CO3	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3
CO4	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3
CO5	1	3	3	3	3	3	3	2	2	3	3	3	2	3	2

Semester	ELECTIVE 5: (DISCIPLINE CENTRIC)	L	T	P	C
III	23BIOE305: BIOSTATISTICS AND DATA SCIENCE	3	0	0	3

Learning Objective (LO):

LO	To learn in detail about classification of data, statistical analysis and fundamentals of data science

Course Objectives

1	To inculcate knowledge about collection and classification of data
2	To comprehend about correlation and regression analysis
3	To inculcate knowledge about the distribution of data
4	To elucidate about the tests of significance
5	To gain fundamental knowledge about data science

Course Outcomes (CO)

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

CO1	Understand the salient features of classification of data (K1 and K2)
CO2	Learn the correlation and regression analysis of data(K2 – K5)
CO3	Gain an understanding of distribution of data (K1, K3 and K5)
CO4	Know the different types of statistical tests (K4 and K6)
CO5	Comprehend the fundamentals of data science (K3 – K5)

Unit 1 Collection and Classification of Data

Statistics – Scope –collection, classification, tabulation of statistical data. Nature of biological and clinical experiments-primary and secondary data. Methods of data collection. Different forms of diagrams and graphs related to biological studies. Measures of averages-mean, median and mode. Use of these measures in biological studies.

Unit 2 Correlation and Regression Analysis

Measures of dispersion for biological characters. Quartile deviation, mean deviation, standard deviation and coefficient of variation. Measures of skewness and kurtosis. Correlation and regression, rank correlation, regression equation. Simple problems based on biochemical data.

Unit 3 Sampling and Distribution of Data

Basic concepts of sampling. Simple, random sample, stratified sample and systemic sampling. Sampling distribution and standard error. Tests of significance based on large samples. Tests for mean, difference of means, proportions and equality of proportions.

Unit 4 Tests of Significance

Small sample tests. Student's t test for mean, difference of two way means, tests for correlation and regression coefficients. Chi-square test for goodness of a non-independence of attributes. F test for equality of variances. ANOVA – one way and two way-basic concepts related to biological studies

Unit 5 Introduction to Data Science

Definition of data science. Importance and basic applications. Machine learning algorithms, deep learning, artificial neural networks and their applications. Reinforcement learning, natural language processing, artificial intelligence (AI), data visualization, data analysis, optimization techniques, big data predictive analysis, application of AI in medical, health and pharma industries.

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.
5. Anand G, Sharma R (2020) *Data science fundamentals and practical approaches* Kalyani Publishers, 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.
3. Jones H (2020) *Data science* Bravex Publications, New Delhi.

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	2	2	3	2	3	2	3	3	3	3	3	2	3
CO2	3	3	2	3	2	3	3	3	2	3	3	3	3	3	3
CO3	3	2	3	2	3	2	3	2	3	3	3	3	3	2	3
CO4	3	3	2	3	2	3	3	3	2	3	3	3	3	3	3
CO5	3	1	2	3	2	3	1	3	2	3	3	3	1	3	3

Semester	ELECTIVE: (DISCIPLINE CENTRIC/GENERIC)	L	T	P	C
III	23BIOE306: BIOFERTILIZERS	3	0	0	3

Learning Objective (LO):

LO	To gain comprehensive knowledge on types and importance of biofertilizers, cyanobacteria and organic agriculture

Course Objectives

1	To introduce about various types of biofertilizers
2	To comprehend about *Azotobacter* as a biofertilizer
3	To gain knowledge about *Anabaena* and *Azolla* association
4	To elucidate about the advantages of Mycorrhiza
5	To introduce about green biofertilizers

Course Outcomes (CO)

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

CO1	Discuss the types and importance of biofertilizers (K1 and K3)
CO2	Know the isolation and mass multiplication of *Azospirillum* (K1 – K3)
CO3	Describe the types and characteristics of cyanobacteria (K3 – K5)
CO4	Understand the types and importance of mycorrhizal association (K1, K2 and K6)
CO5	Understand the risk factors and significance of organic agriculture (K3 and K5)

Unit 1 Introduction

Biofertilizers: Introduction and types and importance of biofertilizers. Classification of biofertilizers microorganisms used in biofertilizers production. General account about the microbes used as biofertilizer – *Rhizobium* – isolation, identification, mass multiplication, carrier-based inoculants, Actinorrhizal symbiosis.

Unit 2 *Azotobacter* as a Biofertilizer

Isolation and mass multiplication – carrier-based inoculant, associative, effect of different microorganisms. *Azotobacter*: classification, characteristics – crop response to *Azotobacte*r inoculum, maintenance and mass multiplication, cultivation and inoculation

Unit 3 *Anabaena* and *Azolla*

Azolla and *Anabaena Azollae* association, mechanism and enzymes involved in nitrogen fixation, factors affecting growth, blue green algae as bioferilizer and *Azolla* in rice cultivation.

Unit 4 Mycorrhiza

Types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

Unit 5 Organic Fertilizers

Green manuring and organic fertilizers, recycling of biodegradable, municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – applications.

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. Dubey RC (2007) *A Text book of Biotechnology* S. Chand and Co, New Delhi
2. Kumaresan V (2012) *Biotechnology* Saras Publications, Nagercoil.
3. Prakash JJE (2009) *Outlines of Plant Biotechnology* Emkay Publication, New Delhi.
4. Sathe TV (2010) *Vermiculture and Organic Farming* Daya publishers, New Delhi.
5. Panda H (2022) *Biofertilizer and organic farming* NIIR Services, New Delhi.

Supplementary Reading

1. Rao NS (2012) *Soil Microbiology* 4th ed. Oxford and IBH Publishers, New Delhi.
2. Vayas SC et al. (2008) *Bio-fertilizers and organic Farming* Ekta Prakashan, Rajkot.
3. Acharya K et al. (2019) *Biofertilizers and biopesticides* Techno World Press, Kolkata.

Reading List (Online)

1. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/biofertilizer
2. https://byjus.com/biology/biofertilizers/
3. https://www.google.com/search?q=biofertilizers/
4. https://www.vedantu.com/biology/biofertilizers
5. https://www.peptechbio.com/blog-biofertilizers/

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	3	3	3	2	3	3	3	2	3	3
CO3	3	2	3	2	2	3	3	2	3	3	3	2	3	3	2
CO4	3	3	3	2	3	3	3	3	3	3	3	3	3	2	3
CO5	3	2	2	3	2	2	3	2	2	3	3	2	2	3	2

Semester	SKILL ENHANCEMENT COURSE 2: SEC 2:	L	T	P	C
III	23BIOS307: MOLECULAR ENDOCRINOLOGY AND CELL SIGNALING	2	0	0	2

Learning Objective (LO):

LO	To learn in detail the physiological and biochemical effects of hormones as well as disorders related to hormone action

Course Objectives

1	To inculcate knowledge about hypothalamic and pituitary hormones
2	To comprehend the functions of thyroid and parathyroid hormones
3	To inculcate knowledge about the mechanisms of actions of adrenal hormones
4	To elucidate about the molecular mechanisms of gonadal and pancreatic hormones
5	To inculcate knowledge about signal transduction

Course Outcomes (CO)

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

CO1	Understand the role of hypothalamo-pituitary axis in the coordination of nervous and endocrine system (K1 and K2)
CO2	Learn the functions pituitary, thyroid and parathyroid secretions and associated disorders (K2 – K5)
CO3	Gain an understanding of the actions of adrenal and gonadal, gastrointestinal tract and pancreatic hormones and disorders associated with their hypo and hyper secretion (K1, K3 and K5)
CO4	Know the different types of signaling, ligand –receptor interaction, cellular messengers of hormones and response pathways triggered by hormonal stimuli (K4 and K6)
CO5	Comprehend the interrelationships and regulation of signal transduction mechanism (K3 – K5)

Unit 1 Hypothalamic and Pituitary Hormones

Classification of hormones. Hypothalamic and pituitary hormones. Hypothalamic releasing factors. Anterior pituitary hormones: biological actions and regulation of growth hormone, ACTH, gonadotropins and prolactin. Leptin. Posterior pituitary hormones - biological actions of vasopressin. Diabetes insipidus, Oxytocin. Hypopituitarism.

Unit 2 Thyroid and Parathyroid Hormones

Thyroid hormones - synthesis, secretion, regulation, transport and biological actions. Hyper and hypothyroidism. Hormonal regulation of calcium and phosphate metabolism. Secretion and biological actions of PTH, calcitonin and calcitriol.

Unit 3 Adrenal Hormones

Adrenal cortical hormones. Synthesis, regulation, transport and biological effects of glucocorticoids and mineralocorticoids. Hypo and hyper function - Cushing's syndrome, aldosteronism, CAH, aderenal cortical insufficiency, Addison's disease. Adrenal medullary hormones - synthesis, secretion, regulation and biological effects of catecholamines.

Unit 4 Gonadal, Gastrointestinal and Pancreatic Hormones

Gonadal hormones: Biosynthesis, regulation, transport and biological actions of androgens. Biosynthesis, regulation, transport and biological effects of oestrogen and progesterone. The menstrual cycle. Pancreatic hormones - synthesis, regulation, biological effects of glucagon, somatostatin and insulin. Insulin receptor. Brief account of gastrointestinal hormones.

Unit 5 Signal Transduction

Fundamental concepts and general features of cell signalling. Endocrine, paracrine, autocrine and juxtacrine signaling. Types of receptors. Transmembrane, nuclear and cytosolic receptors. G-protein-coupled receptors. Second messengers: c-AMP, cGMP, inositol triphosphate and Ca^{2+}. Receptor tyrosine kinases - insulin signalling, ras-raf-MAP kinase and JAK-STAT pathways (brief account only).

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. Melmed S et al. (2015) *Williams Text Book of Endocrinology* 13th Ed, Elsevier, Berlin, Germany
2. Robertson P (2023) *DeGroot's Endocrinology* Volume I and II Elsevier, Amsterdam.
3. Rodwell VW et al. (2018) *Harper's Illustrated Biochemistry* 31st Ed, McGraw Hill, New York
4. Nelson DL, Cox MM, (2017) *Lehninger Principles of Biochemistry* 7th Ed. Freeman Publishers, US
5. Mayne PD et al, (1994) *Clinical Chemistry in Diagnosis and Treatment* 6th ed. ELBS, Warsaw, Poland
6. Marshall D et al. (2016) *Clinical Chemistry* 8th Ed. Mosby Publishers, Maryland, USA

Supplementary Reading

1. Kleine B, Rossmanith WG (2016) *Hormones and the Endocrine System: Textbook of Endocrinology,* Springer, New York.
2. Lim W (2014) *Cell signalling* GS Publications, New Delhi.

Reading List (Online)

1. https://www.uc.edu/content/dam/uc/ce/docs/The%20Endocrine%20System.pdf
2. https://pubs.niaaa.nih.gov/publications/arh22-3/153.pdf
3. http://www.uop.edu.pk/ocontents/Lec%20no%203(3).pdf
4. https://wp-content/uploads/2020/09/introduction_to_endocrinology.pdf
5. https://mcb.berkeley.edu/courses/mcb110spring/nogales/mcb14signaling.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	3	2	3	2	3	3	3	3	3	2	3
CO2	3	3	2	3	2	3	3	3	2	3	3	3	3	3	3
CO3	3	2	3	2	3	2	3	2	3	3	3	3	3	2	3
CO4	3	3	2	3	2	3	3	3	2	3	3	3	3	3	3
CO5	3	1	2	3	2	3	1	3	2	3	3	3	1	3	3

SEMESTER - IV

Semester	23BIOC401: PHARMACEUTICAL BIOCHEMISTRY	L	T	P	C
IV		4	0	0	5

Learning Objective (LO):

LO	To impart knowledge on drug metabolism, mechanism of action and underpinnings of regulatory processes

Course Objectives

1	To understand the different types of bioinformatic tools for drug discovery
2	To comprehend the drug-target identification, drug screening and structure-activity relationship
3	To assimilate knowledge on different drug metabolic pathways and drug elimination
4	To inculcate mode of action of drugs
5	To elucidate the guidelines and regulations of phase I, II and III trials

Course Outcomes (CO)

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

CO1	Understand the basic concepts of pharmacokinetics (K1-K3)
CO2	Know about mechanism of drug action (K2-K4)
CO3	Comprehend the drug metabolic pathways and their interactions (K1-K3)
CO4	Apprehend the role mode of action of various drugs (K4 and K5)
CO5	To understand the phase of clinical trial and method of conduct of clinical trials (K2, K3 and K6)

Unit 1 Basics of Drug Development

Drug discovery and development, drug target identification and validation, hit identification, general principles of screening, correlations between various animal models and human situations, correlation between *in vitro* and *in vivo* screens; special emphasis on cell-based assay, biochemical assay, radiological binding assay, pharmacological assay, *in vitro*, *in vivo* and *ex vivo* experiments, lead optimization, preclinical studies.

Unit 2 Bioinformatics and Drug Development

Bioinformatics approaches for drug development - identification of potential molecules, chemical compound library preparation, identification of target in pathogen, ligand and protein preparation, molecular docking, binding free energy estimation, high throughput virtual screening, docking protocol validation and enrichment analysis, single point energy calculation, pharmacokinetics and pharmacodynamics, ADME and toxicity prediction, molecular dynamic simulation, rule of three and five, Lipinsky rule, pharmacophore development, quantitative structure activity relationship, 3D-QSAR, techniques of developing a pharmacophore map covering both ligand based and receptor based approaches.

Unit 3 Metabolism of Drugs

Drug metabolism and interactions - drug-receptor interactions, receptor theories and drug action, xenobiotics, xenobiotics phases (phase-I, phase-II and phase-III), role of cytochrome P450 oxidases and glutathione S-transferases in drug metabolism, factors affecting drug metabolism, enzymes as a drug target, kinase inhibitors, ATPase inhibitors, drug protein interaction, drug-DNA interaction. basic ligand concepts-agonist, antagonist, partial agonist, inverse agonist, efficiency and potency. Forces involved in drug-receptor complexes. Receptor classification – the four super families. Receptor binding assays- measurement of Kd, Bmax and IC_{50}.

Unit 4 Mode of Action of Drugs

Biochemical mode of action of antibiotics- penicillin and chloramphenicol, actions of alkaloids, antiviral and antimalarial substances. Biochemical mechanism of drug resistance- sulphonamides. Drug potency and drug efficacy. General principles of chemotherapy: chemotherapy of parasitic infections, fungal infections, viral diseases. Introduction to immunomodulators and chemotherapy of cancer.

Unit 5 Clinical Trials

Clinical trials (phase-I, phase-II, phase-III and phase-IV). Main features of clinical trials, including methodological and organizational considerations and the principles of trial conduct and reporting. Key designs surrounding design, sample size, delivery and assessment of clinical trials.

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. Patrick G (2013) *Introduction to medical chemistry* 5th Ed. Oxford University Press, London.
2. Knollmann B, Brunton L (2022) *Goodman and Gilman's the pharmacological basis of therapeutics* 14th Ed. McGraw-Hill, New Jersey.
3. Smith HS, Williams H (2005) *Introduction to the principles of drug design and drug action* 4th Ed. CRC Press, Boca Raton.
4. Thomas G (2003) *Fundamentals of medical chemistry* John Wiley, New Jersey.

Supplementary Reading

1. Grant C (2022) *Pharmaceutical biochemistry* ED Tech Press, London.
2. Kenakin T (2012) *Pharmacology in drug discovery* 1st Ed. Elsevier, Amsterdam.
3. Saravanan G, Alagarsamy V (2022) *Pharmaceutical biochemistry – a comprehensive approach* Pharma Med Press, Hyderabad.

Reading List (Online)

1. https://www.researchgate.net/publication/352836248_Pharmaceutical_Biochemistry
2. https://www.academia.edu/26924019/Laboratory_Manual_in_Pharmaceutical_Biochemistry
3. https://pharmareview.files.wordpress.com/2015/03/biopharmaceuticals
4. https://www.scribd.com/document/352974635/
5. http://www.actabp.pl/pdf/Supl4_10/S4.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	3	2	3	3	3	2	3	2	3	2	3	3
CO2	3	3	2	3	3	2	3	3	3	3	3	3	2	3	3
CO3	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3
CO4	3	3	2	3	3	2	3	3	3	3	2	3	2	3	3
CO5	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3

Semester	23BIOC402: BIOCHEMICAL TOXICOLOGY	L	T	P	C
IV		4	0	0	5

Learning Objective (LO):

LO	To impart knowledge on metabolism of toxins, mechanism of action and underpinnings of regulatory processes

Course Objectives

1	To understand the different types of toxins and their actions
2	To comprehend the fundamentals of toxicology and dose-response relationships
3	To assimilate knowledge on toxin testing protocols based on *in vivo* and animal systems
4	To emphasize the underlying mechanisms of cellular toxicity
5	To inculcate knowledge about the toxicity to various organs of the body

Course Outcomes (CO)

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

CO1	Appreciate the role of toxicological biomarkers (K1-K3)
CO2	Conceive the role of disposition of toxins in human system (K2-K4)
CO3	Evaluate the drug disposition mechanisms and associated drug toxicities (K1-K3)
CO4	Apprehend the toxicological response in various systems of body (K4 and K5)
CO5	Link the mechanism of toxicity and clinical systems (K2, K3 and K6)

Unit 1 Introduction

Fundamentals of toxicology and dose-response relationships - introduction, biomarkers criteria of toxicity, new technologies for evaluation of toxicity interactions; dose response; measurement of dose-response relationships, linear dose response, hormesis; hazard and risk assessment, duration and frequency of exposure and effect

Unit 2 Toxic Responses

Acute and chronic toxicity. Toxicokinetics. Acute and chronic toxicity. Factors affecting toxic responses: disposition: absorption, sites of absorption, distribution, excretion; metabolism, types of metabolic change, phase I and phase 2 reactions; control of metabolism, toxication vs. detoxication.

Unit 3 Toxicity I

Toxicity testing; test protocol, genetic toxicity testing and mutagenesis assay: *in vitro* test systems: bacterial mutation tests-reversion test, Ames test, fluctuation test, and eukaryotic mutation test. *In vivo* test system, mammalian mutation test-host mediated assay and dominant lethal test. Molecular mechanisms of carcinogenesis. Biochemical basis of toxicity: mechanism of toxicity: disturbance of excitable membrane function, altered calcium homeostasis, covalent binding to cellular macromolecules and genotoxicity, tissue specific toxicity

Unit 4 Toxicity II

Toxic responses to foreign compounds - direct toxic action, tissue lesions; mechanism and response in cellular toxicity, pharmacological, physiological and biochemical effects; developmental toxicology- teratogenesis; immunotoxicity, genetic toxicity; chemical carcinogenesis. Toxicogenomics and toxicology of genetically modified organisms with example to the GM food.

Unit 5 Organ Toxicity

Biochemical mechanisms of toxicity: tissue lesions: liver necrosis; kidney damage; lung damage, liver damage, cardiac damage; neurotoxicity; exaggerated and unwanted pharmacological effects; physiological effects; biochemical effects: lethal synthesis and incorporation, interaction with specific protein receptors; teratogenesis; immunotoxicity; multi-organ toxicity

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. Stine KE, Brown TM (2015) *Principles of toxicology* 3rd Ed. CRC Press, Boca Raton.
2. Timbrell JA (2009) *Principles of biochemical toxicology* 4th Ed. CRC Press, Boca Raton.
3. Zakrzewski SF (2002) *Environmental toxicology* 3rd Ed. Oxford University Press, Oxford.
4. Smart RC (2017) *Molecular and biochemical toxicology* 5th Ed. Wiley, New Jersey.
5. James RC (2022) *Principles of toxicology* Wiley, New Jersey.

Supplementary Reading

1. Faqi AS (2017) *A comprehensive guide to toxicology in nonclinical drug development* 2nd Ed. Academic Press, London.
2. Hodgson E (2010) *A textbook of modern toxicology* 4th Ed. Wiley, New Jersey.
3. Srivastava AK et al. (2022) *Xenobiotics in chemical carcinogenesis* Academic Press, Cambridge.

Reading List (Online)

1. https://www.atsdr.cdc.gov/training/toxmanual/pdf/module-1.pdf
2. https://ec.europa.eu/health/ph_projects/2003/action3/docs/2003_3_09_a21
3. https://www.cartercenter.org/resources/pdfs/health/ephti/library/
4. https://www.drdo.gov.in/sites/default/files/publcations-document/Toxicology
5. https://www.toxicology.org/education/k12/k12MaterialsActivities/Files/

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	3	2	3	3	3	2	3	2	3	2	3	3
CO2	3	3	2	3	3	2	3	3	3	3	3	3	2	3	3
CO3	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3
CO4	3	3	2	3	3	2	3	3	3	3	2	3	2	3	3
CO5	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3

Semester	ELECTIVE 6: (GENERIC/DISCIPLINE CENTRIC)	L	T	P	C
IV	23BIOE404: BIOSAFETY, LAB SAFETY AND IPR	3	0	0	3

Learning Objective (LO):

LO	To understand the characteristics and types of biosafety, lab safety, IPR and bioethics

Course Objectives

1	To master the skills associated with methods of biosafety (K1, K2 and K3)
2	To comprehend the features of laboratory safety procedures (K2 and K4)
3	To gain knowledge on intellectual property rights (K1-K3, K5 and K6)
4	To elucidate about various types of patenting and procedures of patenting (K1-K4)
5	To introduce bioethics in a succinct manner (K1, K2 and K5)

Course Outcomes (CO)

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

CO1	Classify different types of laboratory safety procedures (K1, K2 and K5)
CO2	Understand the salient features of intellectual property rights (K1, K2 and K4)
CO3	Comprehend the various types of applications of patenting(K2, K5 and K6)
CO4	Apprehend the valuable potentials of IPR and trade mark (K1, K5 and K6)
CO5	Apprehend the basics of bioethics (K2, K4 and K5)

Unit 1 Biosafety

Historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; recommended biosafety levels for infectious agents and infected animals; biosafety guidelines - government of India, roles of IBSC, RCGM, GEAC etc. for GMO applications in food and agriculture; environmental release of GMOs; risk assessment; risk management and communication; national regulations and international agreements.

Unit 2 Laboratory Safety

Chemical, electrical and fire hazards; handling and manipulating human or animal cells and tissues, toxic, corrosive or mutagenic solvents and reagents; mouth pipetting, and inhalation exposures to infectious aerosols, safe handling of syringe needles or other contaminated sharps, spills and splashes onto skin and mucous membranes. Health aspects; toxicology, allergenicity, antibiotic resistance.

History of biosafety, risk assessment, personal protective equipment, laboratory facilities and safety equipment, disinfection, decontamination, and sterilization, regulatory compliance, laboratory security and emergency response and administrative controls.

Unit 3 Intellectual Property Rights (IPR)

Intellectual Property Rights (IPR): Introduction to patents, types of patents, process involved in patenting in India, trademarks, copyright, industrial design, trade secrets, traditional knowledge, geographical indications, history of national and international treaties and conventions on patents, WTO, GATT, WIPO, Budapest Treaty, Patent Cooperation Treaty (PCT) and TRIPS. Patent databases: searching international databases; analysis and report formation. Indian Patent Act 1970; recent amendments; filing of a patent application; precautions before patenting disclosure/non-disclosure; procedure for filing a PCT application. The patentability of microorganisms-claims, characterization and repeatability, disposition in the culture collections, legal protection for plants and other higher organisms, new plant varieties by rights, tissue culture protocols

Unit 4 Patent

Patent filing and infringement: patent application- forms and guidelines, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and convention patent applications, international patenting-requirement, financial assistance for patenting-introduction to existing schemes; publication of patents-gazette of India, status in Europe and USA. Research patenting: patenting by researchers and scientists-University/organizational rules in India and abroad. Detailed information on patenting biological products, case studies on patents (basmati rice, turmeric, neem etc.), and patent infringement.

Unit 5 Bioethics

Introduction to bioethics, human genome project and its ethical issues, genetic manipulations and their ethical issues, ethical issues in GMOs, foods and crops in developed and developing countries, environmental release of GMOs, ethical issues involved in stem cell research and use, use of animals in research experiments, animal cloning, human cloning and their ethical aspects, testing of drugs on human volunteers.

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. *Laboratory Biosafety Manual*. 4th Ed. (2020) World Health Organization, Geneva.
2. Sateesh MK (2020) *Bioethics and Biosafety* Dreamtech Press, New Delhi.
3. Vijayasekar RD (2020) *Intellectual Property Rights* Deccan Law House, Vijayawada.
4. Attorney RS (2022) *Copyright, patent and trade mark* NOLO Press, Berkeley.
5. Act B (2023) *Intellectual property rights* Commercial Law Publishers, New Delhi.

Supplementary Reading

1. Sveinbjornsson BR, Gizurarson S (2022) *Handbook for laboratory safety*/ Elsevier, Amsterdam.
2. Talbot M (2012) *Bioethics, an introduction* Cambridge University Press, Cambridge.

Reading List (Online)

1. https://www.cdc.gov/labs/pdf/CDC-BiosafetymicrobiologicalBiomedicalLaboratories-2009-P.pdf
2. https://www.icsi.edu/media/website/IntellectualPropertyRightLaws&Practice.pdf
3. https://www.wipo.int/edocs/pubdocs/en/wipo_pub_450_2020.pdf
4. https://www.researchgate.net/publication/24008480_Patents_and_Patent_Policy
5. https://vulms.vu.edu.pk/Courses/BIF402/Downloads/The-cambridge-textbook-of-bioethics.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	3	2	3	3	3	2	3	2	3	2	3	3
CO2	3	3	2	3	3	2	3	3	3	3	3	3	2	3	3
CO3	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3
CO4	3	3	2	3	3	2	3	3	3	3	2	3	2	3	3
CO5	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3

Semester	ELECTIVE: (GENERIC/DISCIPLINE CENTRIC)	L	T	P	C
IV	23BIOE405: GENOMICS, PROTEOMICS AND BIOINFORMATICS	3	0	0	3

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 and Functional 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.

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.

Unit 5 Bioinformatics

Useful search engines. File formats. PubMed. Bioinformatics workstation, Unix. Biological databases (primary, secondary, organism - specific, miscellaneous). Sequence alignment: substitution scores and gap penalties. Database similarity searching: BLAST, FASTA. Multiple sequence alignments: CLUSTAL. Gene discovery and prediction. Molecular phylogenetics: phylogenetic tree construction and analysis. Identification of orthologs and paralogs. Protein motifs and domain prediction. NGS data analysis.

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. Primrose J (2002) *Principles of Genome Analysis* 3rd Ed. Wiley, New Jersey.
3. Brown TA (2007) *Genomes* 4th Ed. Garland Science, New York.
4. Hartwell LH et al. (2014), *Genetics: From Genes to Genomes* 5thEd. McGraw-Hill, New York
5. Srivastava S (2023) *From proteins to proteomics basic concepts, techniques and applications* CRC Press, Boca Raton.

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.
4. Twyman RM (2013) *Principles of Proteomics* 2nd Ed. Garland Science, New York.

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

Semester	SKILL ENHANCEMENT COURSE 3: SEC 3/PROFESSIONAL COMPETENCY SKILL 23BIOS406: DEVELOPMENTAL BIOLOGY	L	T	P	C
IV		2	0	0	2

Learning Objective (LO):

LO	To learn the different phases of embryo development and associated medical implications

Course Objectives

1	Familiarize on basic concepts of development
2	Provide an insight into early embryonic development
3	Inculcate knowledge on organogenesis
4	Provide a platform to understand about post embryonic development
5	Educate on medical implications of developmental biology

Course Outcomes (CO)

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

CO1	Understand the basics of embryo development in vertebrates and invertebrates (K1 and K3)
CO2	Learn the events in the early embryonic development (K1, K2 and K4)
CO3	Understand the development of organs and developmental pattern (K1, K2 and K6)
CO4	Understand the events taking place during post – embryonic development (K3-K5)
CO5	Understand the medical implications of developmental biology (K1-K4)

Unit 1 Basic Concepts of Development

History and the origin of developmental biology – cell theory, mosaic and regulative 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 Early Embryonic Development

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*; origin of anterior posterior and dorsal – ventral patterning – role of maternal genes, patterning of early embryo by zygotic genes (brief account only)

Unit 3 Organogenesis

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, insect imaginal disc – determination of wing and leg imaginal discs, organizing center in patterning of the wing, butterfly wing development, the homeotic selector genes for segmental identity. Insect compound eye – morphogenetic furrow, ommatidia, signaling, eyeless gene (brief account only)

Unit 4 Postembryonic 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 Medical Implications of Developmental Biology

Medical implications of developmental biology: genetic errors of human development – the nature of human syndromes – pleiotropy, genetic heterogeneity, phenotypic variability, gene expression and human disease – inborn errors of nuclear RNA processing, inborn errors of translation; teratogenesis – environmental assaults on human development – teratogenic agents like alcohol, retinoic acid (brief account only)

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. Slack J (2012) *Essential Developmental Biology* 3rd Ed. Wiley-Blackwell, New Jersey
2. Wolpert L (2012) *Principles of Development* 4th Ed. Oxford University Press, Oxford, UK
3. Muller WA (2012) *Developmental Biology* Springer, Berlin, Germany
4. Gilbert SF (2013) *Developmental Biology* 10th Ed. Sinauer Associates Inc., Sundarland, USA
5. Kalthoff K (2000) *Analysis of Biological Development* 2nd Ed. McGraw-Hill, New York
6. Weber M (2022) *Philosophy of developmental biology* Cambridge University Press, Cambridge

Reading List (Online)

1. http://people.ucalgary.ca/~browder/virtualembryo/dev_biol.html
2. http://bgc.ac.in/pdf/study-material/developmental-biology-7th-ed-sf-gilbert.pdf
3. https://www.uou.ac.in/lecturenotes/17/MZO%20(509)Developmental%20Biology.pdf
4. https://www.researchgate.net/publication/309032743_Developmental_biology
5. https://www.ncbi.nlm.nih.gov/books/NBK9983/

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

ELECTIVE (GENERIC)
(FOR OTHER MAJOR STUDENTS)

Semester	23SBION01: NUTRITIONAL BIOCHEMISTRY	L	T	P	C
II		3	0	0	3

Learning Objective (LO):

LO	To gain comprehensive knowledge on nutrition, health and nutritional requirements

Course Objectives

1	To understand basic concepts involved in growth, health, nutrition, physiology and metabolism
2	To discuss the concepts and applications of nutrition in correlation with biochemistry
3	To define nutritional needs in healthy individuals and modification of diet during illness
4	To gain knowledge on malnutrition
5	To understand the mechanisms involved in nutrition deficiency diseases

Course Outcomes (CO)

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

CO1	Plan a balanced diet based on an individual's energy requirement, assess nutritional status of an individual (K3, K4 and K5)
CO2	Describe the biochemical, physiological and nutritional functions of macronutrients and their integrated role; understand the role played by antinutritional factors (K1-K6)
CO3	Evaluate the functions of vitamins and minerals, fluids and electrolyte balance in different physiological states and in sports persons (K1 to K6)
CO4	Identify nutritional deficiency conditions, its prevention and dietary management (K3 and K4)
CO5	Acquire knowledge about the importance of balanced diet and diet therapy (K5K6)

Unit 1 Basic Concepts

Nutrition - food groups and balanced diet. Novel foods. Calorific value of foods: Direct and indirect calorimetry. Empty calories. Basal metabolic rate: Factors affecting BMR. SDA and physical activity. Calculation of day's energy requirement. Assessment of nutritional status. Lactose intolerance. Nutritional requirement and biochemical changes in different physiological states -infancy, childhood, pregnancy, lactation, and ageing. Sports nutrition.

Unit 2 Elements of Nutrition

Plant and animal sources of simple and complex carbohydrates, fats and proteins and their requirement. Biological significance, deficiency and toxicity of macronutrients and micronutrients. Role of dietary fibre. Protein sparing action of carbohydrates and fats. Essential amino acids. Essential fatty acids. Effects of naturally occurring food toxins, preservatives, additives, alcohol and tobacco on health.

Unit 3 Vitamins and Minerals

Vitamins and minerals- dietary sources, classification, biochemical functions, requirements, absorption, metabolism and excretion. Vitamin B complex as coenzyme. Nutritional significance of dietary calcium, phosphorus, magnesium, iron, iodine, zinc and copper.

Unit 4 Malnutrition

Diseases arising due to protein - calorie malnutrition and undernutrition (kwashiorkor and marasmus), prevention of malnutrition. Deficiency diseases associated with vitamin B complex, vitamin C and A, D, E and K vitamins - mineral deficiency diseases - aetiology, sign and symptoms and dietary supplementation. Enrichment and fortification (vitamins and minerals)

Unit 5 Nutrition in Diseases

Nutrition in diseases - aetiology, signs and symptoms, treatment and dietary management during fever (typhoid and malaria) and infectious diseases (COVID-19), jaundice, hyperacidity (ulcer), atherosclerosis, hypertension, kidney diseases and diabetes in adults. Starvation and obesity. Interrelationship of nutrition, infection, immunity and poverty

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. McWilliams M (2012) *Food fundamentals* 10th Ed. Pearson, London.
2. Bender DA (2003) *Nutritional biochemistry of the vitamins* 2nd Ed. Cambridge University Press, Cambridge.
3. Malik D et al. (2023) *Textbook of nutritional biochemistry* Springer Nature, Singapore.
4. Manjeshwar PR (2014) *Textbook of nutrition and biochemistry* 5th Ed. PR Publishers, New Delhi.
5. Malik D (2023) *Textbook of nutritional biochemistry* Springer, Berlin.

Supplementary Reading

1. Yadav M (2007) *Nutritional biochemistry and metabolism* Arise Publishers, New Delhi.
2. Roada S (2018) *Food science and nutrition* Oxford University Press, Oxford.

Reading List (Online)

1. https://www.jmedscindmc.com/article.asp?issn=1011/
2. https://www.researchgate.net/figure/Relationship-between-malnutrition/
3. https://en.wikipedia.org/wiki/Novel_food
4. https://www.chemicalsafetyfacts.org/preservatives/
5. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/

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

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

Semester	23SBION02: MOLECULAR BASIS OF DISEASE AND THERAPEUTIC STRATEGIES	L	T	P	C
III		3	0	0	3

Learning Objective (LO):

LO	To inculcate in-depth knowledge on molecular mechanisms and molecular regulatory processes of diseases and understanding of various strategies of therapeutics

Course Objectives

1	To understand the concepts of the mechanisms involved in regulation of blood sugar and management of diabetes mellitus
2	To gain in-depth knowledge of the mechanisms of cancer and of tumor metastasis
3	The basic organization of the central and peripheral nervous system and understanding of impaired features underlying the major neuropathological complications
4	To gain knowledge in renal diseases
5	To understand the mechanisms involved in cardiac disorders

Course Outcomes (CO)

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

CO1	Attain overall view about the complications of diabetes mellitus and its management (K2 and K3)
CO2	Understand comprehensively about the concepts of cancer biology and implicating the theoretical concepts for further research (K2, K4 and K5)
CO3	Understand and appreciate the pathophysiology of conditions affecting the nervous system (K3 and K5)
CO4	Possess a thorough knowledge of renal and cardiac diseases with emphasis related to mechanistic aspects and therapeutic interventions (K1-K4 and K6)
CO5	Inculcate knowledge on the experimental models of non-communicable diseases that will be applied for future research (K4 and K5)

Unit 1 Diabetes

Mechanism of blood sugar regulation in human body. Pathophysiology of Type I and II diabetes. Diabetes – investigation methods for the diagnosis of diabetes. Nutritional care. Complications related to diabetes – diabetic cardiovascular disease, retinopathy, neuropathy and nephropathy. Cellular and molecular mechanism of development of diabetes- management of type I and type II diabetes, drugs for the treatment of diabetes.

Unit 2 Cancer

Biology of cancer: Overview of hallmarks of cancer. Tumorigenesis, tumor progression and mechanism of metastasis. Proto-oncogene to oncogene. Oncogene- myc and src family. Tumor suppressor gene-Rb and p53 pathway in cancer. Diagnosis- non-invasive imaging techniques, tumor diagnosis, interventional radiology, new imaging technique, molecular techniques in cancer diagnosis - treatment of cancer- surgery, radiotherapy, chemotherapy, hormonal treatment, and biological therapy. Introduction to personalized medicine.

Unit 3 Neurodegenerative Diseases

Brain- neuronal network- memory- Neurogenerative diseases- Parkinson and Alzheimer disease- molecular understanding of the neurodegenerative diseases- treatment modalities.

Unit 4 Renal Diseases

Acute and chronic renal failure, glomerular diseases–glomerulonephritis, nephritic syndrome, diabetes insipidus, diagnosis of kidney disease.

Unit 5 Cardiovascular Diseases

Introduction to cardiovascular diseases. Lipids and lipoproteins in coronary heart disease-cardiac enzymes, molecular changes during cardiac remodeling – hypertrophy of hearts – heart failure-treatment modalities.

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. Das UN (2011) *Molecular basis of health and disease* Springer, Dordrecht.
2. Feuer G, Iglesia FA (2020) *Molecular biochemistry of diseases* CRC Press, Boca Raton.
3. Rosenthal MD, Glew RH (2009) *Medical biochemistry human metabolism in health and disease* John Wiley, New Jersey.
4. Coleman WB, Tsongalis GJ (2017) *Molecular pathology: the molecular basis of human disease,* Academic Press, Cambridge.
5. Alentzi FQB (2023) Molecular targets and cancer therapeutics, Bentham Publications, Sharjah.

Reading List (Online)

1. https://medicalsciences.med.unsw.edu.au/sites/default/files/soms/page/
2. http:// http://www.actabp.pl/pdf/Supl4_10/S7.pdf
3. https://units.imamu.edu.sa/colleges/Medicine/AcademicDepts/Pathology/
4. http:// https://ncert.nic.in/ncerts/l/lebo106.pdf
5. https://pdf.sciencedirectassets.com/272028/1-s2.0-S0958166900X00596/

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

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