Annamalai University

(Accredited with 'A' Grade by NAAC)

M.Sc. Biochemistry (Two-Year) Programme

Regulations & Curriculum-2019

UGC-SAP and DST-FIST Assisted

Department of Biochemistry and Biotechnology

ANNAMALAI UNIVERSITY

REGULATIONS FOR THE TWO-YEAR POST GRADUATE PROGRAMMES UNDER CHOICE BASED CREDIT SYSTEM (CBCS)

These Regulations are common to all the students admitted to the Two-Year Master's Programmes in the Faculties of Arts, Science, Indian Languages, Education, Marine Sciences, and Fine Arts from the academic year 2019-2020 onwards.

1. Definitions and Nomenclature

1.1 University refers to Annamalai University.

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

1.3 Discipline refers to the specialization or branch of knowledge taught and researched in higher education. For example, Botany 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/Tutorials/Laboratory work/Seminar/Project work/Experiential learning/ Report writing/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. Each academic year is divided into two semesters.

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

1.12 Elective Course is a course that a student can choose from a range of alternatives.

1.13 Value-added Courses are optional courses that complement the students' knowledge and skills and enhance their employability.

1.14 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.

1.15 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.

1.16 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.

1.17 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.

1.18 Learning Objectives also known as 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 as a result of instruction.

1.19 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. The relationship between PO and CO is mentioned as- 3-substantial/high, 2- medium and 1-low.

1.20 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

1.21 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.

1.22 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. Programmes Offered and Eligibility Criteria

The PG Programmes offered by the Department of Biochemistry and Biotechnology and the eligibility criteria for each of these programmes are as follows:

S.No.	Programme	Eligibility Criteria
1.	M.Sc. Biochemistry	A pass in B.Sc. Biochemistry / Biotechnology / Microbiology / Chemistry / Botany / Zoology with not less than 50% of marks in Part–III.
2.	M.Sc. Biotechnology	A pass in B.Sc. Biotechnology / Biochemistry / Microbiology / Botany / Zoology with not less than 50% of marks in Part–III.

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 Programmes 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 (Departmental & Interdepartmental), and Project.

5.2 Core courses

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

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

5.3 Elective courses

5.3.1 **Departmental Electives (DEs)** are the Electives that students can choose from a range of Electives offered within the Department.

5.3.2 **Interdepartmental Electives (IDEs)** are Electives that students can choose from amongst the courses offered by other departments of the same faculty as well as by the departments of other faculties.

5.3.3 Students shall take a combination of both DEs and IDEs.

5.4 Experiential Learning

5.4.1 Experiential learning provides opportunities to students to connect principles of the discipline with real-life situations.

5.4.2 In-plant training/field trips/internships/industrial visits (as applicable) fall under this category.

5.4.3 Experiential learning is categorised as Core.

5.5 Project

5.5.1 Each student shall undertake a Project in the final semester.

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

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

5.5.4 Students who wish to undertake project work in recognised institutions/industry shall obtain prior permission from the University. The Research Supervisor will be from the host institute, while the Co-Supervisor shall be a faculty in the parent department.

5.6 Value added Courses (VACs)

5.6.1 Students may also opt to take Value added Courses beyond the minimum credits required for award of the Degree. VACs are outside the normal credit paradigm.

5.6.2 These courses impart employable and life skills. VACs are listed in the University website and in the Handbook on Interdepartmental Electives and VACs.

5.6.3 Each VAC carries 2 credits with 30 hours of instruction, of which 60% (18 hours) shall be Theory and 40% (12 hours) Practical.

5.6.4 Classes for a VAC are conducted beyond the regular class hours and preferably in the II and III Semesters.

5.7 Online Courses

5.7.1 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.

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

5.8 Credit Distribution

The credit distribution is organised as follows:

	Credits
Core Courses	65-75
Elective Courses	15
Project	6-8
Total (Minimum requirement for award of Degree)	90-95

5.9 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 per week over a semester

1 Tutorial period of one hour per week over a semester

1 Practical/Project period of two or three hours (depending on the discipline) 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 organisation of lesson plan of the Course Instructor.

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

6.4 At the end of the semester, the record shall be duly signed by the Course Instructor and the Head of the Department and placed in safe custody for any future verification.

6.5 The Course Instructor 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, seminars, and viva-voce that would be suitable to the course. 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 Test-I will cover the syllabus of the first two units while CIA Test-II will cover the last three units.

8.4.5 CIA Tests will be for two to three hours duration depending on the quantum of syllabus.

8.4.6 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.

8.5 End Semester Examinations (ESE)

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

8.5.2 A candidate who does not pass the examination in any course(s) of the first, second and third semesters will be permitted to reappear in such course(s) that will be held in April and November in the subsequent semester/year.

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

9 Evaluation

9.1 Marks Distribution

9.1.1. Each course, both Theory and Practical as well as Project/Internship/Field work/In-plant training 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 constitute 40% and the ESE 60% 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 & Test-II	15
Seminar	05
Assignment	05
Total	25

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

	Marks
Test-I	15
Test-II	15
Viva-voce and Record	10
Total	40

9.3 Assessment of End-Semester Examinations

9.3.1 Evaluation for the ESE is done by both External and Internal examiners (Double Evaluation).

9.3.2 In case of a discrepancy of more than 10% between the two examiners in awarding marks, third evaluation will be resorted to.

9.4 Assessment of Project/Dissertation

9.4.1 The Project Report/Dissertation shall be submitted as per the guidelines laid down by the University.

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:

<table>
<tr><td colspan="2">Continuous Internal Assessment (25 Marks)</td><td colspan="2">End Semester Examination (75 Marks)</td></tr>
<tr><td rowspan="2">Review-I 10</td><td rowspan="2">Review-II: 15</td><td>Project / Dissertation Evaluation</td><td>Viva-voce</td></tr>
<tr><td>50</td><td>25</td></tr>
</table>

9.5 Assessment of Value-added Courses

9.5.1 Assessment of VACs shall be internal.

9.5.2 Two CIA Tests shall be conducted during the semester by the Department(s) offering VAC.

9.5.3 A committee consisting of the Head of the Department, faculty handling the course and a senior faculty member shall monitor the evaluation process.

9.5.4 The grades obtained in VACs will not be included for calculating the GPA.

9.6 Passing Minimum

9.6.1 A student is declared to have passed in each course if he/she secures not less than 40% marks in the ESE and not less than 50% marks in aggregate taking CIA and ESE marks together.

9.6.4 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 from the first semester to the current semester.

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 passed in 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 passed in that semester.

m is the number of semesters

11.5 Evaluation of the performance of the student will be rated as shown in the Table.

Letter Grade	Grade Points	Marks %
S	10	90 and above
A	9	80-89
B	8	70-79
C	7	60-69
D	6	55-59

E	5	50-54
RA	0	Less than 50
W	0	Withdrawn from the examination

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 8.25 or 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 6.5 or 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 highest marks in all examinations at the first appearance alone will be considered for University Rank.

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 card 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 is **not** 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 sensitised on issues of academic integrity and ethics.

14. Transitory Regulations

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

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

Annamalai University

Department of Biochemistry & Biotechnology

M.Sc. Biochemistry (Two Year) Programme
Programme Code: SBIO21

Programme Structure
(For students admitted from the academic year 2019-2020)

Course Code	Course Title	Hours/Week		C	Marks		
		L	P		CIA	ESE	Total
Semester-I							
19BIOC101	Core 1: Biomolecules	4	-	4	25	75	100
19BIOC102	Core 2: Cell Biology and Genetics	4	-	4	25	75	100
19BIOC103	Core 3: Enzymes	4	-	4	25	75	100
19BIOP104	Core 4: Practical I – Biomolecules, Cell Biology, Genetics and Enzymes	-	12	6	40	60	100
	Elective 1: Interdepartmental Elective	3	-	3	25	75	100
				21			
Semester-II							
19BIOC201	Core 5: Metabolism and Regulation	4	-	4	25	75	100
19BIOC202	Core 6: Immunology	4	-	4	25	75	100
19BIOC203	Core 7: Molecular Biology	4	-	4	25	75	100
19BIOP204	Core 8: Practical II – Immunology and Molecular Biology	-	12	6	40	60	100
	Elective 2: Interdepartmental Elective	3	-	3	75	25	100
	Elective 3: Department Elective	3	-	3	25	75	100
				24			
Semester-III							
19BIOC301	Core 9: Analytical Techniques	4	-	4	25	75	100
19BIOC302	Core 10: Molecular Endocrinology and Signaling	4	-	4	25	75	100
19BIOC303	Core 11: Physiology and Nutrition	4	-	4	25	75	100
19BIOC304	Core 12: Basic Biotechnology	4	-	4	25	75	100
19BIOP305	Core 13: Practical III – Analytical Techniques, Molecular Endocrinology, Physiology and Biotechnology.	-	12	6	40	60	100
	Elective 4: Interdepartmental Elective	3	-	3	25	75	100
	Elective 5: Department Elective	3	-	3	25	75	100
				28			
Semester-IV							
19BIOC401	Core 14: Clinical Biochemistry	4	-	4	25	75	100
19BIOC402	Core 15: Genomics, Proteomics and Bioinformatics	4	-	4	25	75	100
19BIOP403	Core 16: Practical IV – Clinical Biochemistry and Bioinformatics.	-	12	6	25	75	100
19BIOPJ404	Project Work / Inplant training	-	10	6	25	75	100
				20			
	Total Credits			**93**			
	Value Added Courses						

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

Note:

1. **Students shall take both Department Electives (DEs) and Interdepartmental Electives (IDEs) from a range of choices available.**
2. **Students may opt for any Value-added Courses listed in the University website.**

Elective Courses

Department Elective (DE)

S.No.	Course Code	Course Title	Hours/Week		C	Marks		
			L	P		CIA	ESE	Total
1.	19BIOE205.1	Developmental Biology	3	-	3	25	75	100
2.	19BIOE205.2	Environmental and Medical Biotechnology	3	-	3	25	75	100
3.	19BIOE306.1	Genetic Engineering and Nanobiotechnology	3	-	3	25	75	100
4.	19BIOE306.2	Medical Laboratory Technology	3	-	3	25	75	100
5.	19BIOE306.3	Drug Design and Drug Development	3	-	3	25	75	100

Interdepartment Elective (IDE)

S.No.	Course Code	Course Title	Department	Hours/Week		C	Marks		
				L	P		CIA	ESE	Total
1.	19 SOSX 115.1	Soft Skills	English	3	-	3	25	75	100
2.	19 ATX 215.1	Discrete Mathematics	Mathematics	3	-	3	25	75	100
3.	19MATX 215.2	Numerical Methods		3	-	3	25	75	100
4.	19MATX 315.1	Differential Equations		3	-	3	25	75	100
5.	19 STSX 215.1	Statistical Methods	Statistics	3	-	3	25	75	100
6.	19 STSX 215.2	Mathematical Statistics		3	-	3	25	75	100
7.	19 STSX 315.1	Bio-Statistics		3	-	3	25	75	100
8.	19 PHYX 215.1	Classical Mechanics and Special Theory of Relativity	Physics	3	-	3	25	75	100
9.	19 PHYX 215.2	Physics of the Earth		3	-	3	25	75	100
10.	19 PHYX 315.1	Bio-Medical Instrumentation		3	-	3	25	75	100
11.	19 PHYX 315.2	Energy Physics		3	-	3	25	75	100
12	19 CHEX 215.1	Applied Chemistry	Chemistry	3	-	3	25	75	100
13	19 CHEX 315.1	Basic Chemistry		3	-	3	25	75	100
14	19 CHEE 315.2	Instrumental Methods of Analysis		3	-	3	25	75	100
15	19 BOTX 215.1	Plant Tissue Culture	Botany	3	-	3	25	75	100
16	19 BOTX 215.2	Plant Science – I		3	-	3	25	75	100
17	19 BOTX 315.1	Gardening and Horticulture		3	-	3	25	75	100

18	19 BOTX 315.2	Plant Science – II		3	-	3	25	75	100
19	19 ZOOX 215.1	Animal Culture Techniques	Zoology	3	-	3	25	75	100
20	19 ZOOX 315.1	Environmental Science		3	-	3	25	75	100
21	19 GEOX 215.1	Environmental Geosciences	Earth Sciences	3	-	3	25	75	100
22	19 GEOX 315.1	Applied Geophysics		3	-	3	25	75	100
23	19 MIBX 315.1	Microbiology	Microbiology	3	-	3	25	75	100
24.	19 CISX 215.1	R Programming	Computer & Information Science	3	-	3	25	75	100

Interdepartment Elective Offered to Other Departments

Course Code	Course Title	Hours/Week		C	Marks		
		L	P		CIA	ESE	Total
19BIOX215.1	Basic Biochemistry	3	-	3	25	75	100
19BIOX215.2	Basic Biotechnology	3	-	3	25	75	100
19BIOX315.1	Biochemical Techniques	3	-	3	25	75	100
19BIOX315.2	Immunology	3	-	3	25	75	100

Value Added Course

Course code	Course title	Hours/Week		C	Marks		
		L	P		CIA	ESE	Total
CHEA415	Phytochemistry and Biological Activities of Medicinal Plants	3	-	-	25	75	100

Programme Outcomes

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 organizational 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 Outcome

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.

PSO6 Communicate biochemical concepts through effective written and oral presentation.

Semester-I **19BIOC 101: Biomolecules** **Credits: 4**
Hours: 4

Learning Objective (LO): To understand the structure and functions of biomolecules.

Unit-1 Proteins I

Amino acids - structure and properties. Orders of protein structure. Primary structure - Determination of amino acid sequence of proteins. The peptide bond: The Ramachandran plot.

Secondary structures - α-helix, β-sheet and β-turns. Pauling and Corey model for fibrous proteins.

Super secondary structure- helix-loop-helix, hairpin β motif, Greek key motif and β-α-β motif. Structural & classification of proteins.

Unit-2 Proteins II

Tertiary structure - All α, all β, α/β, $\alpha+\beta$ domains. Structural motifs - protein family and superfamily. Quaternary structure - protomers, multimers - rotational and helical symmetry. Collagen triple helix. The structure of haemoglobin. Binding of oxygen to haemoglobin, Hill equation, Bohr effect, changes in conformation on O_2 binding. Role of 2,3-BPG. Models for haemoglobin allostery. Methods for characterization and purification of proteins. Criteria for purity of proteins.

Unit–3 Nucleic Acids

DNA double helical structure - Watson and Crick model. A, B and Z forms of DNA. Unusual structures - palindrome, inverted repeats, cruciform and hairpins. Triple and quadruple structures. DNA supercoiling and linking number. Properties of DNA: buoyant density, viscosity, UV absorption, denaturation, the cot curve. Differences between DNA and RNA. Major classes of RNA- mRNA, rRNA, tRNA: structure and biological functions. Minor classes of RNA.

Nucleic acid-binding proteins- HTH, HLH, zinc finger motif, leucine zipper motif.

Unit–4 Glycosaminoglycans and Glycoconjugates

Glycosaminoglycans - structure, location and biological role of hyaluronic acid, chondroitin sulphate, keratin sulfate, heparin sulfate, dermatan sulfate and heparin. Sialic acid - structure and significance. Proteoglycans.

Glycoproteins and their biological importance. Principal sugars in human glycoproteins. Lectins - structure, function, applications. Major classes of glycoproteins - O-linked, N-linked, GPI linked oligosaccharides. Carbohydrates as information molecules- the sugar code. Blood group antigens and bacterial cell wall polysaccharides.

Unit–5 Lipids

Fatty acids - saturated, unsaturated and hydroxy fatty acids. Phospholipids and glycosphingolipids - structure and biological functions. Steroids - plant and animal sterols. Structure, properties and functions of cholesterol. Eicosanoids - structure and biological actions of prostaglandins, prostacyclins, thromboxanes, leukotrienes and lipoxins. Novel role of lipids as signals, cofactors and pigments (an overview).

Lipoproteins - classification and composition. Amphipathic lipids (membranes, micelles, emulsions and liposomes).

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 and Cox. Lehninger Principles of Biochemistry. Freeman. 7th ed. 2017.
2. Voet and Voet. Fundamentals of Biochemistry. Wiley. 5th ed. 2018.
3. Rodwell et al. Harper's Illustrated Biochemistry. McGraw Hill. 31th ed. 2018.

Supplementary Reading

1. Blackburn et al. Nucleic acids in Chemistry and Biology. Royal Soc Chem. 2006.
2. Berg, Tymoczko, Stryer. Biochemistry. Freeman. 8th ed. 2015.

Course Outcomes

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

CO1: Appreciate the hierarchical organisation of various biomolecules.

CO2: Understand the various orders of protein structure, classification, properties and biological importance of proteins.
CO3: Evaluate the structure and hierarchial organisation of nucleic acids with their biological functions.
CO4: Analyse the realtionship between the structure and biological role of glycosaminoglycans and glycoconjugates.
CO5: Acquire knowledge on the building blocks of lipids, classification and properties as well as lipoprotein and composition of membranes.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	3	3	2	3	3	3	2	3	3	3	2	1	3	3
CO2	3	3	2	3	3	2	3	3	3	3	3	3	3	2	3	3
CO3	3	2	3	3	2	3	3	3	2	3	3	3	2	3	3	3
CO4	3	3	2	3	3	2	3	3	1	3	3	3	3	2	3	3
CO5	3	2	1	3	2	3	3	3	2	3	3	3	2	3	3	3

Semester-I **19BIOC 102: Cell Biology and Genetics** **Credits: 4**
Hours: 4

Learning Objective (LO)*:* To learn in detail about the organization of cells and tissues, membrane transport, cell division, differentiation, and cell death, tissue culture techniques and principles of genetics.

Unit - 1 Cell and Tissue organization

Molecular organization of prokaryotic and eukaryotic cells. Structure and functions of subcellular organelles. The cytoskeleton - microtubules, microfilaments and intermediate filaments. Types of tissues. Epithelium - organization and types. The basement membrane. Connective tissue.
Major classes of cell junctions - anchoring, tight and gap junctions. Major families of cell adhesion molecules (CAMs) - cadherins, integrins. Brief account of the extracellular matrix.

Unit - 2 Membrane composition and transport

Composition of membranes - the lipid bilayer, peripheral and integral proteins. The fluid mosaic model. Brief account of membrane rafts. Endocytosis and exocytosis.
Membrane transport: types. Diffusion - passive and facilitated. General classes of transport systems - uniport, symport, antiport. Active transport - primary and secondary. The P-type ATPases (Na^+K^+-ATPase), F-type ATPases (ATP synthases), ABC transporters, ionophores, aquaporins, ion channels (ligand-gated and voltage-gated).

Unit - 3 Cell division, cell differentiation, cell cycle, and cell death

Molecular events in mitosis and meiosis. Brief account of cell differentiation. Stem cells: types (embryonic, adult), isolation, identification, expansion, differentiation and uses, stem cell engineering, ethical issues.
The cell cycle: phases, regulation by cyclins and cyclin - dependent kinases. Checkpoints.
Cell death - types. Necrosis - causes and mechanism. Apoptosis: morphology, mitochondrial and death receptor pathways. Differences between apoptosis and necrosis. Basic elements in autophagy.

Unit - 4 Cell Culture Techniques

Cell and tissue culture - merits and demerits, aseptic techniques, substrates, culture media, freeze storing, transport, contamination. Growth and development of plant cells and tissues *in vitro*. Callus, suspension, and protoplast culture. Somatic hybridization. Applications of plant cell and tissue culture in breeding and industry.
Animal cell culture: Primary cell culture: disaggregation, separation of viable cells. Secondary culture - maintenance of cell lines. Cancer cell lines. 3D culture. Scaffold preparation and organogenesis (brief account only). Large - scale cell cultures. Commercial applications of animal tissue culture.

Unit - 5 Genetics

Definitions of some common terms in genetics - phenotype, genotype, heterozygous, homozygous, allele (dominant, recessive, wild-type, mutant), character, gene, gene locus, pure line, hybrid. Mendel's laws. Monohybrid cross, multiple alleles, dihybrid cross, test cross, backcross, epistasis.
Chromosome structure. Polytene and lampbrush chromosomes. Types of chromosomes on the basis of centromere position. Karyotyping. Variation in chromosome number (euploidy, aneuploidy), arrangement (translocation, inversion), number of segments (deletion, duplication). Population genetics- The Hardy-Weinberg law (basic concept).

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.

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Text Books

1. Pierce B A Genetics: a conceptual approach. W H Freeman Publishers. 2012
2. Fletcher et al. Instant Notes in Genetics. Garland Science. 4th ed. 2012.
3. Karp. Cell & Molecular Biology. Wiley. 8th ed. 2016.
4. Lodish et al Molecular Cell Biology. Freeman. 8th ed. 2016.
5. Martin BM. Tissue Culture Techniques-An Introduction. Springer Science and Business Media. 2013.

Supplementary Reading

1. De Robertis and De Robertis. Cell and Molecular Biology. Lippincott Williams and Williams. (Paperback). 8th ed. 2017.
2. Alberts et al. Molecular Biology of the cell. Garland Sci. 6th ed. 2014.
3. Freshney RI. Culture of animal cells: A manual of Basic Technique. Wile –Liss. 6th ed. 2010.
4. Smith RH. Plant Tissue Culture. Elsevier. 3rd ed. 2013.

Course Outcomes

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.
CO2: Appreciate membrane composition and transport mechanisms.
CO3: Understand cell division, differentiation, cell cycle and cell death
CO4: Comprehend the steps in cell and tissue culture
CO5: Understand Mendelian principles of genetics, chromosome variation, and population genetics.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1		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
CO3		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
CO5		3	3	3	3	3		3	3	3	3	3	3	3	3	3

Semester-I **19BIOC 103: Enzymes** **Credits: 4**
Hours: 4

Learning Objective (LO): To acquire knowledge of the classification, kinetics, mechanism of action, regulation and applications of enzymes.

Unit–1 Enzymes - Classification and General Characteristics
Enzymes - general characteristics, classification and IUB nomenclature, methods of enzyme isolation and purification. Methods of enzyme assay. Enzyme units: IU, Katal, specific activity. Active site - investigation of active site structure. Brief account of extremozymes and non-protein enzymes (abzymes, ribozymes, DNA enzymes).

Unit-2 Enzyme Kinetics
Enzyme kinetics. Steady state kinetics. Effect of pH, temperature, enzyme and substrate concentration on enzyme activity. Michaelis-Menten plot, Lineweaver-Burk plot. Significance of K_m and V_{max}. Turnover number. Presteady state kinetics - elucidation of intermediates and rate limiting steps (flow and relaxation methods).
Kinetics of allosteric enzymes, positive and negative cooperativity, MWC and KNF models. Hill's equation and co-efficient. K and V series enzymes. Sequential and nonsequential bisubstrate reactions.

Unit–3 Inhibition and Mechanism of Action of Enzymes
Enzyme inhibition - irrerversible and reversible, competitive, non competitive, uncompetitive, mixed inhibition (derivation not required). Clinical uses of competitive inhibition using methotrexate, methanol and insecticide poisoning.
Mechanism of enzyme action - acid base catalysis, covalent catalysis, strain, proximity and orientation effects. Mechanism of action of chymotrypsin.

Unit–4 Functional forms of Enzymes and Enzyme Regulation
Coenzymes - coenzymic role of thiamine pyrophosphate FAD, NAD, pyridoxal phosphate, Coenzyme A, biotin, folic acid and cobalamine. Multienzyme complexes. Metal-dependent and metalloenzymes.
Enzyme regulation: feedback inhibition and feedforward stimulation. Enzyme repression, induction and degradation, control of enzymic activity by products and substrates. Zymogen activation. Covalent modification of enzymes- phosphorylation. Compartmentation.

Unit–5 Industrial and Clinical Enzymology
Immobilized enzymes- methods of immobilization, applications. Enzyme Engineering with reference to T4 lysozyme. Enzyme electrode.
Industrial and Clinical Enzymology: Enzymes of industrial and clinical significance, sources and applications of amylases, protease and lipases. Therapeutic use of asparginase. Streptokinase. Enzymes and isoenzymes of diagnostic importance. LD, CK, transaminases, phosphatases and amylase. Enzyme patterns in diseases - liver disease and myocardial infarction.

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 and Bonner. Enzymes. Horwood Publishing Limited. 2nd ed. 2008.
2. Buchholz et al. Biocatalysts and Enzyme Technology. Wiley-Blackwell. 2nd ed. 2012.
3. Pandey et al. Enzyme Technology. Springer. 2010.
4. Nelson, Cox. Lehninger Biochemistry. Freeman. 7th ed. 2017.
5. Balasubramanian et al. Concepts in Biotechnology. Univ Press 2004.

Supplementary Reading

1. Dixon and Webb. Enzymes. Elsevier.2nd ed. 2014.
2. John E. Smith. Biotechnology. Cambridge university press, 5th ed. 2009.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the characteristics, classification, isolation and assay of enzymes.
CO2: Analyse the factors that influence enzyme kinetics.
CO3: Evaluate the mechanisms and regulation by enzyme modulation
CO4: Translate the basic concepts of enzymology to industrial and medical applications.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	1	3	2	3	3	3	2	3	2	3	3	2	3	3
CO2	3	3	2	3	3	2	3	3	3	3	3	3	3	3	3	3
CO3	3	2	3	3	2	3	3	3	2	3	2	3	3	2	3	3
CO4	3	3	2	3	1	2	3	3	3	3	3	3	3	3	3	3

Semester-I **19BIOP 104: Core Practical - 1** **Credits: 6**

Practicals in Biomolecules, Cell Biology, Genetics and Enzymes **Hours: 12**

Learning Objective (LO): To analyse and estimate biomolecules, to examine plant and animal cell types, to assay enzyme activity and acquire practical skills in cell biology studies and genetics.

1. Estimation of glucose by anthrone method.
2. Qualitative analysis of amino acids
3. Estimation of protein by Lowry *et al* method.
4. Thermal denaturation of DNA.
5. Microscopic examination of epithelial cells, plant cells.
6. Tissue culture techniques: Surface sterilisation techniques, media preparation and storage, serum inactivation.
7. Staining of cell cultures and observations under microscope.
8. Cell count and mitotic index.
9. Wild type and mutants (*vestigial*, *ebony* and *cry^b*) of *Drosophilla melanogaster*
10. Effect of pH and temperature on enzyme activity.
11. Activity and specific activity of any one enzyme (urease/alkaline phosphatase)
12. K_m value of any one enzyme (urease/alkaline phosphatase).
13. Enzyme immobilization using alginate beads.

Text Books

1. Shivaraja. S, anesh. M.K., Hemavathi. A Laboratory manual for biochemistry. Jaypee Brothers Medical Publishers (P) Ltd. 2nd ed. 2013
2. Davey J, Lord M. Essential Cell Biology: A Practical Approach. Oxford University Press. London. 2005
3. Jones RN, Richards GK. Practical Genetics. Wiley, New York. 2007
4. Copeland RA. Enzymes: a practical introduction to structure, mechanism and data analysis Wiley India, New Delhi. 2008
5. Plummer DT. An introduction to Practical Biochemistry 3rd edition. Tata McGraw Hill Pvt. Ltd. 2006

Course Outcomes

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

CO1: Independently undertake qualitative and quantitative analysis of biomolecules
CO2: Distinguish different cell types
CO3: Culture cells in vitro and perform cell-based assays
CO4: Assess various factors influencing enzyme kinetics and undertake enzyme immobilization.
CO5: Differentiate wild type and mutants of *Drosophila melanogaster*

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	3	3	3	3	3	2	3	2	3	3	-	2	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3
CO3	3	3	3	3	3	3	2	3	2	3	3	3	2	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3
CO5	3	3	3	3	3	3	2	3	2	3	3	3	2	3	3	3

Semester-II **19BIOC 201: Metabolism and Regulation** **Credits: 4**
Hours: 4

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

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 lipoproteinemias. 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. Nelson and Cox. Lehninger Principles of Biochemistry. Freeman, 7th ed. 2017.
2. Voet and Voet. Fundamentals of Biochemistry. Wiley. 5th ed. 2018.
3. Rodwell et al. Harper's Illustrated Biochemistry McGraw Hill. 31th ed. 2018.
4. Kuchel et al. Schaum's Outline of Biochemistry. McGraw Hill. 3rd ed. 2011.

Supplementary Reading

1. Keith N. Frayn. Metabolic Regulation. A human perspective. Wiley-Blackwell. 3rd ed. 2013.
2. Berg, Tymoczko. Stryer Biochemistry. Freeman. 8th ed. 2015

Course Outcomes

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.
CO2: Appreciate the reaction pathways by which carbohydrates and lipids are synthesised and degraded and know the biochemistry of photosynthesis.
CO3: Comprehend the metabolic fates of amino acids and the features of protein catabolism
CO4: Know the biochemistry of porphyrins, purines and pyrimidines and comprehend the integral relationship of metabolic pathways.
CO5: Know the clinical conditions arising from metabolic dysregulation.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	3	3	2	3	2	3	3	2	**3**	**3**	3	3	2	3	3
CO2	3	2	2	3	2	3	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	3
CO4	3	3	2	3	2	3	3	3	3	3	3	3	3	3	3	3
CO5	3	2	3	2	3	2	3	3	2	3	3	3	3	2	3	3

Semester-II **19BIOC 202: Immunology** **Credits: 4**
Hours: 4

Learning Objective (LO)*:* To acquire a comprehensive knowledge on cells of the immune system, immunoprotection and immunochemical techniques.

Unit–1 Immune Cell Types, Antigens and Antibodies
Central and peripheral lymphoid organs. Bone marrow, thymus. Lymph node, spleen and mucosal associated lymphoid tissue. Cells of the lymphoreticular system. T-Cells, B-Cells, mononuclear phagocytes, dendritic cells, granulocytes, NK cells, mast cells. Antigens definition antigenicity, antigenic determinants, haptens and epitopes. Antibodies - structure, classification, functions, Isotypes, allotypes and idiotypes. Complement system- components, nomenclature, activation of complement, classical pathway and alternate pathway. Biological functions of complement.

Unit–2 Types of Immunity and Vaccines
Types of immunity - innate and acquired immunity, Antigen recognition - T-cell and B-cell receptor complexes, antigen processing and presentation. Interaction of T and B-cells. Immunological memory, Effector mechanisms: phagocytosis, cell mediated cytotoxicity, antibody dependent cell mediated cytotoxicity.
Vaccines-killed, attenuated organisms, toxoids, recombinant vaccines, subunit vaccines, DNA vaccines, synthetic peptide vaccines, antiidiotypic vaccines.

Unit–3 Antibody Diversity and Transplantation
Antibody diversity - mechanisms contributing to diversity- somatic recombination, rearrangement and generation of antibody diversity. Class switching. MHC complex- gene organisation - HLA genes class I and II antigens. Histocompatibility testing, cross matching. MHC & disease association. Transplantation-types - Graft versus host reactions. Immunosuppressive agents.

Unit–4 Hypersensitivity, Immune Disorders and Tumor Immunology
Hypersensitivity - definition and classification - type I to type V (brief account only). Autoimmunity and autoimmune disease - SLE. AIDS- pathogenesis, diagnosis and treatment. Tumor immunology - immune surveillance, tumor antigens, immune response to tumors, cancer immunotherapy.

Unit–5 Immunotechniques
Immunochemical techniques - production of antibodies - polyclonal and monoclonal antibodies. Applications of Mab. Immunodiffusion techniques, Immunoprecipitation, RIA, ELISA, fluorescence immune-assay, avidin-biotin mediated assay, immunohistochemistry, immunoelectrophoresis, immunoblotting. Complement fixation test. Flow cytometry.

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

Text Books

1. Jenni Punt, Sharon Stranford et al. Kuby Immunology. WH Freeman & Co. 8th ed. 2018.
2. Abbas et al. Cellular and Molecular Immunology. Elsevier. 9th ed. 2018.
3. Janeway, C. (Ed), Travers. Immunobiology. Garland Publ. 8th ed.. 2016.
4. Coico and Sunshine. Immunology: A short Course. Wiley-Liss. 7th ed. 2015.

Supplementary Reading

Roitt et al. Roitt's Essential Immunology. Wiley-Blackwell Sci. 13th ed. 2017.

Course Outcomes

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

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

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	3	2	3	2	3	3	2	3	2	3	2	2	3	3
CO2	3	3	2	3	2	3	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	3
CO4	3	3	2	1	2	3	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	3

Semester-II **19BIOC 203: Molecular Biology** **Credits: 4**
Hours: 4

Learning Objective (LO): To understand genome complexity, central dogma of molecular biology and regulation of gene expression.

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, rho-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 and Cox. Lehninger Principles of Biochemistry. Freeman. 7th ed. 2017.
2. Krebs JE et al. Lewin's. Genes XII. Jones & Bartlett Publ. 2017.
3. Alberts et al. Molecular Biology of the Cell. Garland Sci. 6th ed. 2014.
4. Watson. Molecular Biology of the Gene. Pearson Edu. 7th ed. 2013.
5. Lodish-Cell and Molecular Biology. Macmillan Learning. 8th ed. 2016

Supplementary Reading

1. Watson et al. Recombinant DNA: Genes and Genomes - A short course. Freeman. 3rd ed. 2006.
2. Twyman. Advanced Molecular Biology. Garland Science. 2018.

Course Outcomes

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.
CO2: Discuss the mechanisms of DNA replication, repair and recombination.
CO3: Explain the enzymes and processes involved in RNA biosynthesis, protein biosynthesis and degradation.
CO4 Comprehend protein targeting and the role of ubiquitin in protein degradation and chaperones in folding
CO5 Gain an understanding on the regulation of gene expression at transcriptional, translational and epigenetic levels.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3	3
CO2	3	3	2	3	3	2	3	3	3	3	3	3	3	2	3	3
CO3	3	2	3	3	2	3	3	3	2	3	2	3	3	3	3	3
CO4	3	3	2	3	3	2	3	3	3	3	3	3	3	2	3	3
CO5	3	2	3	3	2	3	3	3	2	3	2	3	3	3	3	3

Semester-II **19BIOP 204: Core Practical -2** **Credits: 4**

Practicals in Immunology and Molecular Biology **Hours: 4**

transformation.

1. Blood grouping and Rh typing
2. Radial Immunodiffusion
3. Double diffusion
4. Agglutination, rosette formation, complement fixation
5. Preparation of antisera
6. Immunoelectrophoresis (demonstration)
7. ELISA (demonstration)
8. Extraction of genomic DNA, electrophoresis in agarose gel, determination of molecular mass.
9. Isolation of RNA from yeast.
10. Estimation of DNA by diphenylamine method.
11. Estimation of RNA by orcinol method
12. Plasmid preparation, characterization by electrophoresis.
13. Bacterial conjugation
14. Transformation.

Text Books

1. Hay FC, Westwood OMR Practical Immunology, Wiley, New Jersey, USA, 4th ed., 2008
2. Schleif RF, Pieter WP. Practical methods in Molecular Biology Springer, Berlin, Germany, 2011
3. Plummer DT An introduction to Practical Biochemistry, Tata McGraw Hill, New Delhi, 3rd ed., 2006.

Course Outcomes

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

CO1: Classify and identify human blood groups and Rh factor.
CO2; Demonstrate Ag-Ab interaction *in vitro* by immunoprecipitation and electrophoresis.
CO3: Analyze quantitatively antigen/antibody reaction by ELISA
CO4: Extract nucleic acids from biological sources
CO5: Analyze DNA and RNA by chemical and electrophoretic methods
CO6: Analyze DNA transfer mechanism in bacteria

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	3	3	3	3	3	3	3	2	3	2	3	2	3	3	3
CO2	3	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	3
CO4	3	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	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Semester-III **19BIOC 301: Analytical Techniques** **Credits: 4**
Hours: 4

Learning Objectives (LO): To learn the basic principle, instrumentation and applications of the analytical tools of biochemistry.

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 techniques.

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. Andreas Hofmann and Samuel Clokie. Wilson and Walker's Principles and techniques of Biochemistry and Molecular Biology. Cambridge University Press. 8th ed. 2018.
2. Upadhyay, Upadhyay and Nath. Biophysical Chemistry principles and Techniques. Himalaya Publ. 2010.
3. Rodney Boyer, Modern Experimental Biochemistry. Pearson Education, Inc. 3rd ed. 2009.

Supplementary Reading

1. Friefelder and Friefelder. Physical Biochemistry - Applications to Biochemistry and Molecular Biology.WH Freeman & Co. 1983.
2. Pavia, Lampman, Kriz and Vyvyan. Introduction to Spectroscopy. Cengage Learning. 5th ed. 2015.

Course Outcomes

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

CO1: Obtain necessary knowledge to perform techniques essential to biochemistry
CO2: Explain the instrument components, principles of operation and applications of spectroscopy, radioisotope technique and microscopy.
CO3: Exhibit a knowledge base in handling different chromatographic techniques and to make an appropriate choice based on nature of the sample.
CO4: To differentiate the principles of paper, ion exchange, gel and affinity chromatography.
CO5: Apply practically the knowledge acquired on centrifugation for separation of biological samples and isolation of cell organelles.
CO6: Gain knowledge on principles of electrophoresis and learn the procedure for 2D Gel electrophoresis, blotting and hybridisation techniques.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PS O3	PSO 4	PSO 5	PSO 6
CO1	3	3	3	3	3	2	3	2	3	3	3	2	3	3	3	3
CO2	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3	3
CO3	3	3	3	3	3	2	3	2	3	3	3	2	3	3	3	3
CO4	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3	3
CO5	3	3	3	3	3	2	3	2	3	3	3	2	3	3	3	3
CO6	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3	3

Semester-III **19BIOC 302: Molecular Endocrinology and Signalling** **Credits: 4**
Hours: 4

Learning Objective (LO): To learn in detail the physiological and biochemical effects of hormones as well as disorders related to hormone action.

Unit - 1 Hypothalamic and Pituitary Hormones
Classification of hormones and mechanism of action. Hypothalamic and pituitary hormones. Hypothalamic releasing factors. Anterior pituitary hormones: biological actions, regulation and disorders of growth hormone, ACTH, gonadotropins and prolactin. Leptin.
Posterior pituitary hormones - biological actions of vasopressin. Diabetes insipidus and syndrome of inappropriate ADH secretion (SIADH) Oxytocin. Hypopituitarism.

Unit - 2 Thyroid and Parathyroid Hormones
Thyroid hormones - synthesis, secretion, regulation, transport, metabolic fate and biological actions. Antithyroid agents. Thyroid function tests. Hyper and hypothyroidism. Hormonal regulation of calcium and phosphate metabolism. Secretion and biological actions of PTH, calcitonin and calcitriol. Hypercalcemia and hypocalcemia. Rickets and osteomalacia.

Unit - 3 Adrenal Hormones
Adrenal cortical hormones. Synthesis, regulation, transport, metabolism 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, metabolism, regulation and biological effects of catecholamines. Phaeochromocytoma.

Unit - 4 Gonadal, Gastrointestinal and Pancreatic Hormones
Gonadal hormones: Biosynthesis, regulation, transport, metabolism and biological actions of androgens. Hypogonadism and gynecomastia. Biosynthesis, regulation, transport, metabolism and biological effects of oestrogen and progesterone. The menstrual cycle. Pancreatic hormones - synthesis, regulation, biological effects and mechanism of action 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, diacylglycerol, inositol triphosphate and Ca^{2+}. Receptor tyrosine kinases - insulin signalling, ras-raf-MAP kinase and JAK-STAT pathways. ATM signalling pathway.

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. Williams Text Book of Endocrinology, S. Melmed et al. Saunders. 13th ed. 2015
2. Rodwell et al. Harper's Illustrated Biochemistry. McGraw Hill. 31th ed. 2018.
3. Nelson and Cox. Lehninger Principles of Biochemistry. Freeman, 7th ed. 2017.
4. Mayne. Clinical Chemistry in Diagnosis and Treatment. ELBS. 6th ed. 1994
5. W. J. Marshall, M. Lapsley, S. K. Bangert. Clinical Chemistry. Mosby. 8th ed. 2016.

Supplementary Reading

Kleine and Rossmanith. Hormones and the Endocrine System: Textbook of Endocrinology. Springer. 2016.

Course Outcomes

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.

CO2: Learn the functions pituitary, thyroid and parathyroid secretions and associated disorders

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

CO4: Know the different types of signaling, ligand –receptor interaction, cellular messengers of hormones and response pathways triggered by hormonal stimuli.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	3	2	2	3	2	3	2	3	3	3	3	3	2	3	3
CO2	3	3	2	3	2	3	3	3	2	3	3	3	3	3	3	3
CO3	3	2	3	2	3	2	3	2	3	3	3	3	3	2	3	3
CO4	3	3	2	3	2	3	3	3	2	3	3	3	3	3	3	3

Semester-III **19BIOC 303: Physiology and Nutrition** **Credits: 4**
Hours: 4

Learning Objective (LO): To acquire knowledge on the physiology of mammalian system and basic elements of nutrition.

Unit – 1 Neuromuscular system

Structure of neuron. Propagation of action potential. Neurotransmitters - examples, release and cycling of neurotransmitters. The neuromuscular junction. The acetylcholine receptor.
Structure of skeletal muscle. Muscle proteins- myosin, actin, troponin and tropomyosin and other proteins. Sequence of events in contraction and relaxation of skeletal muscle. Cardiac and smooth muscle (Brief account only).

Unit – 2 Digestive and Excretory System

Composition, functions and regulation of saliva, gastric, pancreatic, intestinal and bile secretions. Digestion and absorption of carbohydrates, lipids, proteins and nucleic acids.
Structure of nephron. Formation of urine- glomerular filtration, tubular reabsorption of glucose, water and electrolytes. Tubular secretion. Normal and abnormal constituents of urine.

Unit – 3 Blood, Lymph and CSF

Composition and functions of blood. Plasma proteins in health and disease. Red blood cells- formation and destruction. Composition and functions of WBCs. Blood coagulation-mechanism. Fibrinolysis. Anticoagulants. Transport of blood gases: oxygen and carbon dioxide.
Lymph- composition and functions. CSF- composition and clinical significance.

Unit – 4 Hydrogen Ion and Fluid Electrolyte Homeostasis

Hydrogen ion homeostasis: Factors regulating blood pH- buffers, respiratory and renal regulation. Causes, biochemical findings and management of metabolic and respiratory acidosis and alkalosis.
Distribution of water and electrolytes in the ECF and ICF. Water balance - role of ADH. Sodium balance - the renin-angiotensin-aldosterone system. Potassium balance. Hypo - and hypernatremia. Hypo and hyperkalemia.

Unit – 5 Nutrition

Elements of nutrition: BMR, Nitrogen balance, Essential amino acids and fatty acids, protein quality. Protein energy malnutrition - Marasmus and Kwashiorkor. Sources, requirements, biological functions and clinical significance of fat-soluble vitamins and water soluble vitamins. Sources, requirements, biological functions and clinical significance of calcium, phosphorous and trace elements.

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 and Cox. Lehninger Principles of Biochemistry. Freeman. 7th ed. 2017.
2. Lodish et al. Molecular Cell Biology. Freeman. 8th ed. 2016.
3. Rodwell et al. Harper's Illustrated Biochemistry. McGraw Hill. 31th ed. 2018.
4. Maurice E. Shils et al. Modern Nutrition in Health and Disease. Lippincott Williams & Wilkins. 10th ed. 2006.
5. Martha H. Stipanuk and Marie A. Caudill. Biochemical, Physiological, and Molecular Aspects of Human Nutrition. Elsevier. 3rd ed. 2013.

Supplementary Reading

1. Barrett et al. Ganong's Review of Medical Physiology. Lange. 25th ed. 2015.
2. Graaf & Rees. Schaum's Easy Outline of Human Anatomy & Physiology. 2nd ed. 2010.

Course Outcomes

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

CO1: Understand the fundamental components and functions of nervous, digestive, urinary and muscular system.

CO2: State the normal and abnormal composition, functions and clinical significance of investigating body fluids.

CO3: Understand the basic concepts of acid-base and water-electrolyte homeostasis and pathophysiological mechanisms of diseases arising due to imbalance.

CO4: Be aware of energy requirements for humans, malnutrition disorders in children and role of vitamins and minerals in maintaining health.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	3	3	2	3	2	3	2	3	3	2	2	3	2	3	3
CO2	3	3	2	3	2	3	3	2	2	3	2	2	3	3	3	3
CO3	3	2	3	2	2	2	3	2	3	3	3	3	3	2	3	3
CO4	3	1	2	3	2	3	3	3	2	3	3	3	3	3	3	3

Semester-III **19BIOC 304: Basic Biotechnology** **Credits: 4**
Hours: 4

microorganisms and their industrial applications and to understand the aspects of genetic engineering.

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 and stabilization, product formulation. Monitoring.

Unit–2 Biotechnology for Industrial, Environmental and Agricultural Management

Industrial production of ethanol, lactic acid, butanol, 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. Elements of Biotechnology. Rastogi Publication. 2nd ed. 2010.
2. Dale and von Schantz. From Genes to Genomes: Concepts and Applications of DNA Technology. Wiley-Interscience. 3rd ed. 2011.
3. Nicholls DTS. An Introduction to Genetic Engineering. Cambridge Univ Press. 3rd ed. 2008.
4. Glick and Pasternak. Molecular Biotechnology: Principles and Applications of Recombinant DNA.ASM Pres. 4th ed. 2010.
5. Singh B.D. Biotechnology. Expanding horizons. Kalyani Publ. 3rd ed. 2010

Supplementary Reading

1. Winnacker EL. From Genes to Clones. VCH Publ. 4th ed. 2003.
2. Watson et al. Recombinant DNA. Sci Am Publ. 3rd ed. 2006.
3. Sandy B. Primrose, Richard Twyman and Bob Old. Principles of Gene Manipulation. Wiley-Blackwell. 6th ed. 2002.

Course Outcomes

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.
CO2: Understand the bioprocess techniques for production of industrially important compounds, SCP, biofertilizers and biopesticides and their applications.
CO3: Comprehend the methodology and applications of microbial mining and bioremediation
CO4: Apprehend the role of rDNA technology in constructing vectors and cDNA and genomic libraries.
CO5: Know the advantages and disadvantages of transgenic plants and foods.
CO6: Know the methods of DNA sequencing, protein engineering, SDM, gene knock in, knockout experiments and learn in detail about human genome project.
CO7: Learn the recent technological advances like precise genome editing, directed evolution and synthetic biology.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3	3
CO2	3	3	2	3	3	2	3	3	3	3	3	3	2	3	3	3
CO3	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3	3
CO4	3	3	2	3	3	2	3	3	3	3	2	3	2	3	3	3
CO5	3	2	3	3	2	3	3	3	2	3	2	3	2	3	3	3
CO6	3	3	2	3	3	2	3	3	3	3	3	3	3	3	3	3
CO7	3	2	3	3	2	1	3	3	3	3	2	3	2	3	3	3

Semester-III **19BIOP 305: Core Practical - 3** **Credits: 6**

Practicals in Analytical Techniques, Molecular Endocrinology, Physiology and Biotechnology **Hours: 12**

Learning Objective (LO): To gain training in analysis/ assay of proteins, nucleic acids, lipids, vitamins and hormones through molecular and biochemical methods and to learn experiments for assessing water quality.

1. UV-Absorption spectrum of proteins and nucleic acids.
2. Separation of lipids by TLC.
3. Separation of plant pigments by adsorption chromatography.
4. Separation of proteins by SDS-PAGE and Western blotting.
5. HPLC - Demonstration.
6. Subcellular fractionation - isolation and analysis of nuclear and mitochondrial fractions.
7. Enumeration of RBCs, WBCs (Total & differential).
8. Estimation of bleeding time and clotting time.
9. Blood haemoglobin.
10. Estimation of vitamin C
11. Hormone assay.
12. Restriction enzyme digestion of DNA.
13. PCR and analysis of PCR products.
14. Real-time qPCR - Demonstration.
15. Determination of D.O. concentration of water sample.
16. Determination B.O.D. and C.O.D. of sewage sample.

Text Books

1. S.Sadasivam, A.Manickam (2018) Biochemical methods New Age International Publishers, New Delhi
2. Plummer DT (2006) An introduction to Practical Biochemistry 3rd edition, Tata McGraw Hill, New Delhi
3. Cathcart EP (2018) Practical Physiology, Forgotton books (publishers), London
4. Dutta S(2011) Experimental biotechnology: practical manual. New India Publications, New Delhi

Course Outcomes

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

CO1: Show expertise in a variety of separation techniques for lipids, DNA and proteins.
CO2: Gain skill in handling PCR machine, SDS-PAGE, TLC, and HPLC.
CO3: Undertake isolation of subcellular organelles.
CO4: Perform hematology studies
CO5: Quantitate the levels of vitamin C and hormones in blood
CO6: Quantitatively analyze water sample and sewage for microbial contamination and growth respectively.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	3	3	3	3	3	3	2	3	3	3	3	2	3	3	3
CO2	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	2	3	3	3	3	2	3	3	3
CO4	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	2	3	3	3	3	2	3	3	3
CO6	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3

Semester-IV **19BIOC 401: Clinical Biochemistry** **Credits: 4**
Hours: 4

Learning Objective (LO): To understand the biochemical and molecular basis of diseases, diagnosis and therapy

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 &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 & 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. Practical Clinical Biochemistry. CBS Publishers. 4th and 6th ed. 2006
2. Mayne. Clinical Chemistry in Diagnosis and Treatment. ELBS. 6th ed. 1994
3. W.J. Marshall, S. K. Bengert, M. Lapsley. Clinical Chemistry. Mosby. 8th ed. 2016
4. Rodwell et al. Harper's. Biochemistry. McGraw-Hill. 31th ed. 2018.
5. Glick and Pasternak. Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press. 4th ed. 2010.

Supplementary Reading

1. Tietz. Textbook of Clinical Chemistry and Molecular Diagnostics. Saunders. 8th ed. 2018.

2. Principles of Internal Medicine. Harrison's Vol 1 & 2. McGraw Hill. 19th ed. 2015.

Course Outcomes

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

CO1: To describe the molecular basis of genetic and acquired disorders.
CO2: Understand the etiology, findings and management of diabetes, atherosclerosis, and Cancer.
CO3: Describe and explain the diseases of the major organs and systems, organ functional tests for diagnosis and management.
CO4: Compherend the principles of recent advancements in diagnosis and therapy**.**

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	3	2	3	2	3	3	3	3	3	3	3	3	2	3	3
CO2	3	3	3	2	3	2	3	3	3	3	2	3	3	3	3	3
CO3	3	3	2	3	2	3	3	3	3	3	3	3	3	2	3	3
CO4	3	3	3	2	3	2	3	3	3	3	2	3	3	3	3	3

Semester-IV **19BIOC 402: Genomics, Proteomics and Bioinformatics** **Credits: 4**
Hours: 4

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

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 - *in situ* hybridization, STG mapping. Chromosome walking and jumping. Genome sequencing approaches: whole-genome shotgun, hierarchical shotgun.

Unit – 2 NGS, Genome Projects, Post-Genome Analysis
Next-Generation Sequencing. Exome sequencing. Genome annotation - ORF scanning, Tilign array, Similarity searchers. Genome projects –Sequence data of *E.coli* and *D.melanogaster*. The Human Genome Project: goals, sequencing technologies, results, potential benefits, ethical, legal and social issues (ELSI).Post-genome analysis- microarrays, transcriptome, ChIPs, knock-out analysis, genome editing – CRISPR/Cas9

Unit – 3 Protein Separation, Identification and Quantitation
Proteomics - introduction. Protein separation - general principles. 2D-gel electrophoresis, liquid-liquid chromatography. Protein identification by antibodies, Edman degradation, mass spectrometry-basic principle and instrumentation, ESI, MALDI-TOF, SELDI-TOF, tandem MS. Peptide mass fingerprinting (elementary details).

Unit – 4 Structural & Functional Proteomics & 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: substitution score matrices, pairwise similarity search, pattern recognition.
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, protein expression profiling and mapping protein-network, co-immunoprecipitation, 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). Data submission and retrieval. 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 structure database-protein structure visualization, comparison* and classification. 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. Introduction to Bioinformatics. OUP. 4th ed. 2014.
2. Primrose. Principles of Genome Analysis. Wiley. 3rd ed. 2002.
3. T.A. Brown. Genomes. Garland Science. 4th ed. 2007.
4. Hartwell etal. Genetics: From Genes to Genomes. 5th ed. 2014.
5. Twyman. Principles of Proteomics. 2nd ed. 2013

Supplementary Reading

1. Gibas and Per Jambeck. Developing Bioinformatics Computer Skills. O'Reilly Associates. 2nd ed. 2013.
2. Baxevanis, Ouellette. Bioinformatics. A Practical Guide to the Analysis of Genes and Proteins. Wiley Interscience. 3rd ed. 2004.

Course Outcome

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.

CO2: Comprehend genome projects, post-genome analysis and ELSI

CO3: Apply the modern methods for separation, identification ,quantitation and structural analysis of proteins

CO4: Apply structural bioinformatics tools to predict and elucidate protein structures and map protein- protein interactions.

CO5: Retrieve, align, analyze and interpret sequence and structural data from databases.

CO6: Construct the phylogenetic tree of different sequences and apply database information for molecular modelling.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	3	3	3	3	2	3	2	3	3	2	3	2	3	3	3
CO2	3	3	3	3	3	3	3	3	2	3	3	3	3	2	3	3
CO3	3	3	3	3	3	2	3	2	2	3	2	3	2	3	3	3
CO4	3	3	3	3	3	3	3	2	2	3	3	3	3	2	3	3
CO5	3	3	3	3	3	2	3	2	2	3	2	3	2	3	3	3
CO6	3	3	3	3	3	3	3	3	2	3	3	2	3	2	3	3

Semester-IV **19BIOP 403: Core Practical - 4** **Credits: 6**

Practicals in Clinical Biochemistry and Bioinformatics **Hours: 12**

Learning Objective (LO): To know the assay methods for blood parameters of diagnostic importance and to perform alignment and searching of protein and gene sequences using bioinformatics tools.

A. Blood analysis - preparation of plasma and serum.

Estimation of blood constituents

1. Blood glucose
2. Blood urea.
3. Serum uric acid.
4. Serum creatinine.
5. Serum cholesterol.
6. Serum calcium.
7. Serum iron.
8. Serum inorganic phosphorus.
9. Serum bilirubin
10. Serum protein- Biuret method – A/G ratio.
11. Serum ALT
12. Serum alkaline phosphatase

B. Visit to Clinical Laboratory

C. 1. Sequence alignment and searching
2. Phylogenetic analysis
3. Protein sequence analysis
4. Finding of SNPs
5. Browsing of 1000 genome sequencing database

Text Books

1. Plummer DT, An introduction to Practical Biochemistry, Tata McGraw Hill, New Delhi, 3rd ed, 2006
2. Varley H, Practical clinical biochemistry. S Chand Publishers, New Delhi, 4th ed., 2006
3. Bujinicki JM, Practical Bioinformatics, Springer, Berlin, Germany, 2006.

Course Outcomes

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 result patterns in relation to normal level.
CO4: Apply the knowledge in bioinformatics for phylogenetic analysis of sequences, SNP detection and protein sequence analysis

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	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	3
CO3	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3

Department Electives (DE)

19BIOE 205.1: Developmental Biology

Credits: 3
Hours: 3

Learning Objective (LO): To learn the different phases of embryo development and associated medical implications.

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, zebrafish; invertebrate model organism- *Drosophila melanogaster*, *Caenorhabditis elegans.*

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 anteriorposterior and dorsal - ventral patterning - role of maternal genes, patterning of early embryo by zygotic genes; segmentation genes - the gap genes, the pair - rule genes, the segment polarity genes, the homeotic selector genes - bithorax and antennapedia complex.

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; kidney development - development of ureteric bud and mesenchymal tubules.

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, mechanism of dominance; 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 etc.

Text Books

1. Jonathan Slack. Essential Developmental Biology. Wiley-Blackwell. 3rd ed. 2012
2. Lewis Wolpert. Principles of Development. Oxford University Press.4th ed. 2012
3. Werner A Muller. Developmental Biology. Springer. 2012
4. Scott F. Gilbert. Developmental Biology. Sinauer Associates Inc., 10th ed. 2013
5. Klaus Kalthoff. Analysis of Biological Development. McGraw-Hill. 2nd ed. 2000.

Online Resource
1. Website: virtual embryo - http://people.ucalgary.ca/~browder/virtualembryo/dev_biol.html

Course Outcomes

On Successful completion of the course, the students will be able to

CO1: Understand the basics of embryo development in vertebrates and invertebrates
CO2: Learn the events in the early embryonic development.
CO3: Understand the development of organs and developmental pattern
CO4: Understand the events taking place during post - embryonic development.
CO5: Understand the medical implications of developmental biology.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	3	2	3	2	3	3	2	3	3	2	3	2	3	3	3
CO2	3	3	3	2	3	2	3	3	3	3	3	2	2	2	3	3
CO3	3	3	2	3	3	3	3	2	3	3	2	3	3	3	3	3
CO4	3	3	3	2	3	2	3	3	3	3	3	2	3	2	3	3
CO5	3	3	2	3	2	3	3	2	3	3	2	3	2	3	3	3

19BIOE 205.2: Environmental and Medical Biotechnology

Credits: 3
Hours: 3

Learning Objective (LO): To learn the biotechnological approaches to environmental management as well as the molecular aspects of diseases diagnosis and therapy.

Unit–1 Pollution and Control

Environmental pollution - types, methods for measurement, biosensors to detect environmental pollutants, hazards from wastes and pollutants. Air pollution and its control through biotechnology. Water pollution and control. Wastewater treatment - physical, chemical and biological. Activated sludge - oxidation ditches and ponds, trickling filter, towers, rotating discs and drums. Anaerobic processes: anaerobic digestion and filters. Effluent treatment, B.O.D and C.O.D

Unit–2 Soil and Agricultural Biotechnology

Soil microbiota. Growth, ecological adaptations, interactions among soil microorganisms, biogeochemical role of soil microorganisms. Microorganisms and soil fertility. Microbial degradation of xenobiotics in the environment. Oil spill clean up. Bioremediation of contaminated soil and waste land. Biofertilisers - Definition - types and application methods. Biopesticides in integrated pest management- *Bacillus* and baculoviruses as biocontrol agents.

Unit–3 Alternative Energy Sources and Green Technology

Renewable sources of energy (solar, wind, biogas); Biogas production-hydrogen production using hydrogenase and nitrogenase. Bioleaching- use of microorganisms in mining of gold and uranium. Global environmental problems; Ozone depletion, greenhouse effect, impact and management. Mass production of blue green algae. Reforestation through micropropagation - use of *Casuarina,* and mycorrhizae. Biodiversity - Alpha and beta diversity. Extinction and endangered species. Conservation of biodiversity. *In situ* and *ex situ* - gene banks.

Unit–4 Molecular Diagnostics

Diagnostic kits- AIDS. Tumor markers - oncofetal proteins, hormones, enzymes, tumor-associated antigens. Prenatal & neonatal screening for genetic disorders. DNA diagnostic systems - probes. RFLP & PCR in disease diagnosis. Histocompatibility testing: cross matching. Viral diagnostics: immunodiagnosis, molecular diagnosis. SNP-based diagnosis.

Unit–5 Molecular Therapeutics

Mabs, growth factors and interferons as therapeutic agents. 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. Ethical issues in human gene therapy.

Text books

1. Scragg A. Environmental Microbiology 1st ed. Am Society for Microbiology 2005.
2. Ahmed N. Industrial and environmental Biotechnology. Horizon Scientific Press 2001.
3. Glick and Pasternak. Molecular Biotechnology. 4th ed. ASM Press 2009.
4. Singh BD. Biotechnology. Kalyani Publ.
5. Maulik and Patel Molecular Biotechnology Wiley-Liss.

Course Outcomes

On Successful completion of the course, the students will be able to

CO1: Apprehend the harmful effects of pollution and biotechnological measures for pollution control.
CO2: Apply biotechnological process in waste management, cleanup of environment and agricultural improvement
CO3: Comprehend the fundamentals of biodegradation, biotransformation and bioremediation and apply biotechnological innovation in conservation.
CO4: Recognize the importance of renewable energy sources and green technology.
CO4: Use diagnostic kits for screening diseases and understand recent molecular diagnostic methods
CO5: Know the various new therapeutic approaches like nanotherapy, gene therapy and stem cell therapy.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	2	3	3	2	3	3	3	3	2	2	2	2	3	3
CO2	3	1	2	3	2	3	3	3	3	3	3	2	3	2	3	3
CO3	3	2	3	3	2	2	3	3	3	3	2	2	2	3	3	3
CO4	3	3	2	3	3	3	3	3	3	3	3	3	2	2	3	3
CO5	3	2	1	3	2	2	3	3	3	3	2	2	2	3	3	3

19BIOE 306.1 Genetic Engineering and Nanobiotechnology

Credits: 3
Hours: 3

Learning Objective (LO): To master the basic principles and applications of genetic engineering.

Unit–1 Restriction enzymes and cloning vectors

Basic principles of rDNA technology. Type II Restriction endonucleases - nomenclature and types of cleavage types. Cloning vectors - essential features. Mechanism of cloning in plasmid (pBR322) and phage (λ phage) vectors. Cosmids. Brief introduction to high-capacity cloning vectors.

Unit–2 Ligation and rDNA Transfer

Ligation of rDNA molecules: cohesive end method, homopolymeric tailing, blunt-end ligation. Linkers and adaptors. Gene transfer methods: calcium phosphate coprecipitation, electroporation, lipofection, viruses, microinjection. Host organisms for cloning- bacteria, plant, yeast and mammalian cells.

Unit–3 rDNA Screening and Cloning Strategies

Screening of recombinants: marker inactivation (antibiotic resistance, blue-white selection). Cloning strategies: Construction of genomic and cDNA libraries. Differences between genomic and cDNA libraries. Cloning of insulin gene in *E. Coli*

Unit–4 Techniques in Genetic Engineering and Transgenesis.

Methods of gene transfer in plants-*Agrobacterium*-mediated transformation and particle gun method. Transgenic plant technology - development and applications. Methods for producing transgenic animals-retroviral, microinjection, engineered stem cell. Uses of transgenic animals. DNA sequencing - Sanger method. Southern, Western hybridization.

DNA fingerprinting- principle and applications. PCR: basic reaction, and applications. Gene therapy - basic principles. The human genome project (elementary details). Hazards and safety aspects of genetic engineering

Unit–5 Nanobiotechnology

Nanobiology-concepts, definitions. Bionanoparticles-Production of nanoparticles: collision/ coalescence mechanism. Nanoparticle agglomerates and aerogels. DNA based artificial nanostructures. Nanorobots. Applications of nanotechnology in life sciences and medicine. Nanomolecular diagnostics-use of nanoparticles as molecular imaging probes. Nanoparticles for drug delivery, gene delivery.

Text Books

1. Nicholls DTS. An Introduction to Genetic Engineering. Cambridge Univ Press. 3rd ed. 2008.
2. Glick and Pasternak. Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press. 4th ed. 2010.

Supplementary Reading

1. Winnacker EL. From Genes to Clones. VCH Publ. 4th ed. 2003
2. Sandy B. Primrose and Richard Twyman. Principles of Gene Manipulation and Genomics. Wiley-Blackwell. 7th ed. 2006.

Course Outcomes

On Successful completion of the course, the students will be able to

CO1: Understand the basic principles of recombinant technology,
CO2: Appreciate the mechanisms of cloning,
CO3; Comprehend the methods of gene transfer
CO4: Understand the principle and applications of DNA sequencing, DNA fingerprinting and PCR.
CO5: Understand the concept and applications of nanobiotechnology.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	3	3	2	3	3	2	3	3	2	3	2	3	3	3
CO2	3	3	2	2	3	2	3	3	3	3	3	3	3	3	3	3
CO3	3	2	3	2	2	3	3	2	3	3	2	3	2	3	3	3
CO4	3	3	2	3	3	2	3	3	3	3	3	3	3	3	3	3
CO5	3	2	3	2	2	3	3	2	3	3	2	3	2	3	3	3

19BIOE 306.2 Medical Laboratory Technology

Credits: 3
Hours: 3

Learning Objective (LO): To understand the basic concepts and to learn the techniques essential for clinical laboratory

Unit-1 Basic Haematology and Biochemistry

Specimen collection and handling, transportation of specimens, disposal of specimen after laboratory use.

Composition of blood. 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, Semen analysis.

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, Gonorrhea, Leprosy.

Unit-3 Histopathology

Tissue reception, labeling, fixation and section cutting, Preparation of paraffin blocks (Dehydration, clearing, embedding, blocking). Handling and care of microtome, types of microtome, sharpening of knives, and section cutting. Frozen section techniques - CO_2 freezing, cryostat. Preparation of common stains. H & E, Congo red, methyl violet, Leishman stain, Giesma and staining techniques. Mounting of specimens, record keeping, indexing of slides. Molecular analysis of chromosomal aberrations in leukemias 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. Complement titration, hemolysin titration, Aldehyde test ELISA test, serum electrophoresis. Preparation of slides of LE cell phenomenon and identification. Immuno -histochemical 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 equipments. 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. Lab informatics and scientific data management system - record keeping, coding and indexing.

Text Books

1. Praful. B. Godkar, Darshan. P. Godkar, Text book of Medical Laboratory Technology. Bhalani Publishing House. 2014
2. F.J.Baker, R.E.Silverton, Butterworth-Heinemann. Introduction to Medical Laboratory Technology. Butterworth- Heinemann. 2014.
3. Mayne. Clinical Chemistry in Diagnosis and Treatment. ELBS. 6th ed. 1994
4. Harold Varley. Practical clinical biochemistry. CBS Publisher. 6th ed. 2002,
5. Todd & Stanford. Clinical Diagnosis and Management by Laboratory Methods. 16th ed. 2016

Course Outcomes

On Successful completion of the course, the students will be able to

CO1: Perform the basic haematology techniques and undertake biochemical analysis of clinical samples
CO2: Understand the tests performed in clinical microbiology lab.
CO3: Undertake histological analysis of samples
CO4: Comprehend the basic techniques performed in clinical immunology laboratory.
CO5: Know about quality control, lab accredition and automation.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	3	2	3	2	3	2	3	3	2	3	3	3	3	3
CO2	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3
CO3	3	2	3	2	3	2	3	2	3	3	2	3	2	3	3	3
CO4	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3
CO5	3	2	3	2	3	2	3	2	3	3	2	3	2	3	3	3

19BIOE 306.3 Drug Design and Drug Action

Credits: 3
Hours: 3

Learning Objective (LO): To impart knowledge on drug metabolism, mechanism of action, drug design and development.

Unit-1 Pharmacokinetics

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. Drug metabolism: Phase I & Phase II reactions. Excretion of drugs.

Unit-2 Drug Metabolism

Physiochemical properties, mechanism of drug action. Drug receptors: Structure, types of receptors, second messengers, ligand gated ion channel, G - protein coupled receptor. Tyrosine kinase enzyme coupled receptors, steroid receptors. Dose - response relationship. Therapeutic Index. Adverse drug reactions.

Factors affecting drug action: drug – drug interaction, synergism, antagonism, additive effects. Drug tolerance and dependence.

Unit-3 Drug Designing

Drug design: lead discovery, lead modification, bioisosterism. Lipinski's rule. Quantitive structure – activity relationship: Physiochemical and electronic parameters used for quantifying drug action. Enzyme inhibition as a tool for drug design.

Drug stereochemistry: basic concepts, chirality and drug action, influence of geometric isomerism on drug action. Conformational flexibility and multiple modes of action. Applications of NMR spectroscopy and X – ray crystallography in drug design.

Unit-4 Biopharmaceuticals

Modern vaccine technologies. Recombinant proteins as pharmaceutical drugs. Protein engineering, peptide chemistry and peptidomimetics. Catalytic antibodies. Monoclonal antibody based pharmaceuticals. Hematopoietic growth factors. Nucleic acid therapy in development. Pharmaceutical enzymes. Development of adhesion molecules. Glycoprotein and carbohydrate based pharmaceuticals (Elementary details only).

Unit-5 Drug Development and Approval

Strategies for new drug discovery, lead compound, combinatorial approaches to drug discovery, pre-clinical and clinical trials- Phase 1, II and III.

Regulatory authorities - Food and Drug Administration (USA), European regulations- National security authorities, European medicine agency and new EU drug approval system.

Text Books

1. Patrick GLAn. Introduction to Medical Chemistry. Oxford University press. 5th ed. 2013.
2. Smith and William's. Introduction to the principles of Drug Design and Action. Taylor and Francis. 4th ed. 2005.
3. Thomas G. Fundamentals of Medical Chemistry. John Wiley & Sons. 2003.
4. Gareth Thomas. Medicinal Chemistry and Introduction. John Wiley & Sons. 2nd ed. 2008.
5. Gilman *et al.* Goodman & Gilman's The Pharmacological basis of therapeutics. 12th ed. 2011

Course Outcomes

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

CO1: Understand the basic concepts of pharmacokinetics
CO2 : Know about mechanism of drug action
CO3 : Gain knowledge concepts on drug designing
CO4 : Understand the technologies used in drug development
CO5: Understand the strategies for new drug discovery and regulatory bodies concerned with drug approval

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	**2**	3	2	3	2	3	3
CO2	3	3	**2**	3	3	3	3	3	3	3
CO3	3	3	3	3	3	2	3	2	3	3
CO4	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	**3**	3	2	3	2	3	3

Interdepartmental Electives Offered to Other Departments

19BIOX 215.1 Basic Biochemistry

Credits: 3
Hours: 3

Learning Objective (LO): To understand the structure, functions and metabolism of major biomolecules.

Unit–1 Carbohydrates
Classification of carbohydrates. Functions of biologically important monosaccharides, disaccharides, homopolysaccharides, and heteropolysaccharides. Carbohydrate metabolism: glycolysis, citric acid cycle, gluconeogenesis, glycogen metabolism (overview only, structures not required). Diabetes mellitus (elementary details).

Unit–2 Amino Acids and Proteins
Amino acids: classification and acid-base properties. Biologically important peptides. Proteins - classification, functions, denaturation and renaturation. Orders of protein structure: Primary, secondary (α-helix, β-pleated sheet), supersecondary, tertiary, and quaternary structures. Urea cycle, (overview only, structures not required).

Unit–3 Lipids
Classification of lipids. Structure and functions of cholesterol. Lipid metabolism: β-oxidation of fatty acids, biosynthesis of fatty acids (overview only, structures not required). Coronary heart disease (elementary details).

Unit–4 Enzymes
Enzymes: Classification and nomenclature. Specificity, factors affecting enzyme activity - substrate, pH and temperature. Michaelis-Menten equation and L-B plot. Coenzymes and Isoenzymes (brief account only). Allosteric enzymes. Applications of enzymes in clinical diagnosis, therapeutics and industry.

Unit–6 Nucleic acids
DNA structure - Watson and Crick model. A, B, and Z forms of DNA. DNA denaturation. Differences between DNA and RNA. Major classes of RNA- structure and biological functions.

Text books
1. Nelson and Cox. Lehninger Principles of Biochemistry. Freeman. 7th ed. 2017.
2. Rodwell et al. Harper's Illustrated Biochemistry. McGraw Hill. 31th ed. 2018.
3. Satyanarayana U. Biochemistry. Books and Allied Publ. 5th ed. 2017.

Supplementary Reading
Voet and Voet. Fundamentals of Biochemistry. Wiley. 5th ed. 2018.

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

CO1: Understand the structure, classification and properties of carbohydrates and amino acids
CO2: Gain knowledge on the hierarchical organisation and properties of proteins, structure and properties of lipids and nucleic acids
CO3: Comprehend the functions and kinetic characteristics of enzymes
CO4: Understand the major metabolic pathways of biomolecules

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	1	3	2	3	3	3	3	2
CO2	3	1	2	3	3	3	3	3	3	3
CO3	3	3	3	2	3	3	3	2	3	2
CO4	3	3	2	3	3	3	3	3	3	3

19BIOX 215.2 Basic Biotechnology

Credits: 3
Hours: 3

Learning Objective (LO): To master the basic principles and applications of biotechnology.

Unit–1 Bioprocess Engineering and Downstream Processing
Bioprocess engineering: Isolation and screening of industrially important microbes. Bioreactors - fermentation media. Downstream processing: solid-liquid separation, release of intracellular compartments, concentration of biological products, purification, preservation and stabilization. Industrial production of ethanol.

Unit–2 Environmental and Energy Biotechnology
Wastewater treatment - physical, chemical and biological treatment processes. Effluent treatment. Bioremediation, oil spill cleanup. Biodegradable plastics. Bioleaching- use of microorganisms in mining. Renewable sources of energy, biogas production.

Unit–3 Enzyme and Food Technology
Immobilization of enzymes: methods, and applications. Biosensors. Use of enzymes in detergents, textiles, leather and food industry. Production of glucose syrup. Methods of food preservation. Elementary idea of canning and packing. Basic principles of food fermentation. Production of beer.

Unit–4 Recombinant DNA Technology
Basic steps in cloning. Restriction endonucleases, cloning vectors e.g. pBR322. Introduction of rDNA into host cells by calcium phosphate coprecipitation, electroporation, lipofection, microinjection. Screening of recombinants by marker inactivation. Applications of rDNA technology.

Unit–5 Plant, Animal, and Medical Biotechnology
Biofertilisers. Biopesticides (*Bacillus thuringiensis*). Transgenic plant technology: gene transfer by *Agrobacterium*-mediated method, development and uses of transgenic plants. Development and uses of transgenic animals. Gene therapy - basic principles. The human genome project (elementary details). Hazards and safety aspects of biotechnology.

Text Books

1. John E. Smith. Biotechnology. Cambridge Univ Press. 5th ed. 2009.
2. Singh B.D. Biotechnology. Expanding Horizons. Kalyani Publ. 3rd ed. 2010
3. Nicholls DTS. Genetic Engineering. Cambridge Univ Press. 3rd ed. 2008.
4. Ratledge and Kristiansen. Basic Biotechnology. Cambridge Univ. Press. 3rd ed. 2006.

Supplementary Reading

Watson at al. Recombinant DNA. Sci Am Publ. 3rd ed. 2006.

Course Outcomes
On Successful completion of the course, the students will be able to
- CO1: Know the principles of bioprocess engineering and downstream processing,
- CO2: Understand the methods applied for waste water treatment and uses of enzymes in industries
- CO3: Learn the steps involved in cloning and the importance of biofertilizers and biopesticides.
- CO4: Know the basics of food biotechnology and applications of enzymes in food industry.
- CO5: Learn about the production of transgenic plants and animals.

Outcome Mapping

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

19BIOX 315.1 Biochemical Techniques

Credits: 3
Hours: 3

Learning Objective (LO): To learn the principle, operation, and applications of various techniques for analyzing biomolecules.

Unit–1 Spectroscopic Techniques
Laws of absorption and absorption spectrum. Principle, instrumentation and applications of UV-visible spectrophotometry, spectrofluorimetry and atomic spectroscopy.

Unit–2 Radioisotope Techniques
Nature and units of radioactivity. Detection and measurement of radioactivity - Geiger-Muller counter, solid and liquid scintillation counting. Autoradiography. Applications of radioisotopes in biology. Radiation hazards.

Unit–3 Electrophoresis and Blotting Techniques
Principle, technique and applications of PAGE, SDS-PAGE, agarose gel electrophoresis and isoelectric focusing. Blotting techniques: Southern and Western.

Unit–4 Chromatography
General principles of partition and adsorption chromatography. Principle, operation and applications of thin layer, ion-exchange, molecular exclusion, and affinity chromatography. HPLC - principle, instrumentation and applications.

Unit–5 Centrifugation
Basic principles. Types of centrifugation: analytical and preparative. Subcellular fractionation. Ultracentrifugation.

Text Books
1. Andreas Hofmann and Samuel Clokie. Wilson and Walker. Principles and Techniques of Biochemistry and Molecular biology. Cambridge University Press. 8th ed. 2018.
2. Upadhyay, Upadhyay and Nath. Biophysical Chemistry Principles and Techniques. Himalaya Publ. 2010.

Supplementary Reading
Rodney. F. Boyer. Modern Experimental Biochemistry. Pearson Education. Inc. 3rd ed. 2000.

Course Outcomes
On Successful completion of the course, the students will be able to

CO1: Understand the basic principle, instrumentation and applications of spectroscopy and
CO2: Comprehend the principle and application of radioisotope techniques
CO3: Understand the principle, instrumentation and applications of electrophoresis and blotting
CO4: Appreciate the principles and applications of chromatography and centrifugation Technique

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3	3	2	3	3	1	3
CO2	3	3	3	3	3	2	3	3	2	3
CO3	3	3	3	3	3	2	3	2	2	3
CO4	3	3	3	3	3	2	3	2	2	3

19BIOX 315.2 Immunology

Credits: 3
Hours: 3

Learning Objective (LO): To acquire knowledge on immunological mechanism and immunotechniques.

Unit–1
Types of immunity - innate and acquired. Humoral and cell mediated immunity. Central and peripheral lymphoid organs. Cells of the immune system - lymphocytes, mononuclear phagocytes-dendritic cells, granulocytes, NK cells and mast cells. Antigens - antigenicity, epitopes, haptens. Immunoglobulins - structure, classification and functions.

Unit–2
T-cell, B-cell receptors, Antigen recognition - processing and presentation to T-cells. Immunological memory. Effector mechanisms - macrophage activation. Complement activation. Organization and expression of immunoglobulin genes. Generation of antibody diversity.

Unit–3
Transplantation types. MHC antigens in transplantation. Immunodeficiency disorders - AIDS: The HIV genome and life cycle. Autoimmunity and elementary details of autoimmune disorders (systemic lupus erythematosus).

Unit–4
Immunization practices - active and passive immunization. Vaccines - killed, and attenuated. Recombinant vaccines - DNA vaccines, synthetic peptide vaccines. Production of applications of polyclonal and monoclonal antibodies.

Unit-5
Agglutination and precipitation techniques. Immunoelectrophoresis, RIA, Immunoblotting, Avidin-biotin mediated immunoassay. Immunohistochemistry, immunofluorescence. ELISA - principle and applications.

Text Books

1. Jenni Punt, Sharon Stranford et al. Kuby Immunology. WH Freeman & Co. 8th ed. 2018.
2. Abbas et al. Cellular and Molecular Immunology. Elsevier. 9th ed. 2018.
3. Janeway, C. (Ed), Paul Travers. Immunobiology. Garland Publ. 9th ed. 2016.
4. Coico and Sunshine. Immunology: A short course. Wiley. 7th ed. 2015.

Supplementary Reading

Roitt et al. Essential Immunology. Willey-Blackwell Sci. 13th ed. 2017.

Course Outcomes
On Successful completion of the course, the students will be able to

CO1: Know the cells and organs of the immune system and about antigens and antibodies
CO2: Appreciate complement system and types of immunity.
CO3: Understand vaccination, antibody diversity and transplantation
CO4: Gain knowledge on immunochemical techniques

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	2	2	3	2	2	3
CO2	3	3	2	3	3	2	3	3	2	3
CO3	3	2	3	2	2	3	3	2	2	3
CO4	3	3	2	3	3	2	3	2	2	3

Value Added Course

(*Offered to Other Faculties Except Faculty of Science*)

Phytochemistry and Biological Activities of Medicinal Plants

Unit-1

Extraction – purification of bio-active compounds from plants - cold & hot extract extraction- Soxhlet extraction - crude extracts purification by various solvents.

Unit-2

Isolation of bioactive compounds- chromatographic techniques - thin layer chromatography- liquid chromatography - HPLC and UPLC.

Unit-3

Structural analysis of bioactive compounds - IR spectroscopy - Mass spectroscopy - NMR spectroscopy.

Unit-4

Herbal medicine - History of herbal medicine - different types of herbal medicine - Ayurveda, Siddha and Unani - Pharmacological action - clinical research and traditional uses of Indian medicinal plants - *Eclipta alba, Gymnema sylvestre, Ocimum sanctum, Curcuma longa*.

Unit-5

Phytopharmaceuticals and their health benefits - anthocyanins, carotenoids, lycopene, isoflavones, polyphenols, omega 3 - fatty acids, biological effects of resveratrol.

Activity

1. Extraction of active ingredients from medicinal plants.
2. Demonstration of *in vitro* antioxidant activity of phytochemicals.

Text Books

1. Harbone, J.B. Phytochemical Methods: A guide to modern techniques of plant analysis, Springer (India) Private Limited, 3rd ed. New Delhi. 1998.
2. Silverstein R. M., Wester F. X. - Spectroscopic identification of organic compounds. John-Wiley. 1998.
3. Willard H.H., Merrit L. L., Dean J. A.. Instrumental Methods of Analysis, 1987.
4. Godte V. M.. Ayurvedic pharmacology and therapeutic uses of medicinal plants. Bharathiya Vidya Bhavan, Mumbai. 2000.
5. Grewal R.C. Medicinal Plants. Campus Books International, New Delhi. 2000.