Annamalai University

(Accredited with 'A' Grade by NAAC)

M.Sc. Biotechnology (Five-Year) Integrated Programme

Regulations & Curriculum-2019

UGC-SAP and DST-FIST Assisted

Department of Biochemistry and Biotechnology

ANNAMALAI UNIVERSITY

REGULATIONS FOR THE FIVE YEAR INTEGRATED POST GRADUATE PROGRAMMES UNDER CHOICE BASED CREDIT SYSTEM (CBCS)

These Regulations are common to all the students admitted to the Five Year Integrated Master's Programmes in the Faculties of Arts, Science, Languages, Marine Sciences, and Education 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 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 of 90 working 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 Experiential Learning is a process of learning through experience. It is specifically defined as "learning through reflection on doing".

1.15 Extension activities are the activities that provide a link between the University and the community such as lab-to-land, literacy, population education, and health awareness programmes. These are integrated within the curricula with a view to sensitise the students about Institutional Social Responsibility (ISR).

1.16 Credit refers to the quantum of course work in terms of the 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.

1.17 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.

1.18 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.

1.19 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.

1.20 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.

1.21 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.

1.22 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.

1.23 Cumulative Grade Point Average (CGPA) is a measure of the overall cumulative performance of a student in all the semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters.

1.24 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, and RA.

2. Programmes Offered and Eligibility Criteria

The Integrated Programmes offered by the University and the eligibility criteria are detailed below.

Programme	Eligibility Criteria

M.Sc. Biotechnology	A pass in H.S.E. (10+2 level) OR Equivalent thereto under academic stream with a minimum aggregate of 40% marks in any one of the following combinations: 1. Physics, Chemistry & Mathematics 2. Physics, Chemistry & Biology 3. Physics, Chemistry & Botany 4. Physics, Chemistry & Zoology 5. Physics, Chemistry & Biochemistry.

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 Five Year Master's Programmes consist of five academic years and ten semesters.

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 Five Year Integrated Programme consists of Language Courses, Core Courses, Allied Courses, Elective Courses, Soft Skills, Experiential Learning and Project. Students shall also participate in Extension Activities as part of their curriculum.

5.2 Language Courses

5.2.1 Each student shall take two languages of four courses each, one in each semester for the first two years of the programme.

5.2.2 Language-I shall be Tamil or another language such as Hindi or French.

5.2.3 Language-II shall be English.

5.3 Core courses

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

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

5.**4 Allied Courses**

5.4.1 Each student shall take courses in two disciplines allied to the main subject (Allied-I and Allied-II) of the programme in the first four semesters.

5.4.2 In Arts, Languages, and Education, there will be three Theory Courses each for Allied-I and Allied-II.

5.4.3 In Science and Marine Sciences, there will be two Theory courses and one Practical course each for Allied-I and Allied-II.

5.5 Elective Courses

5.5.1 Departmental Electives (DEs) are the electives that students can choose from a range of Electives offered within the Parent Department offering the Programme.

5.5.2 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.

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

5.6 Soft Skills

5.6.1 Soft skills are intended to enable students to acquire attributes that enhance their performance and achieve their goals with complementing hard skills.

5.6.2 Soft skills include communication skills, computer skills, social skills, leadership traits, team work, development of emotional intelligence quotients, among others.

5.6.3 Each student shall choose four courses on soft skills from a range of courses offered from the First to the Sixth Semester.

5.7 Value Education

All students shall take a course on Value Education that includes human values, sustainable development, gender equity, ethics and human rights.

5.8 Experiential Learning

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

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

5.9 Extension Activities

5.9.1 It is mandatory for every student to participate in extension activities.

5.9.2 All the students shall enrol under NSS/NCC/YRC/RRC or any other Service Organisation in the University.

5.9.3 Students shall put in a minimum attendance of 40 hours in a year duly certified by the Programme Co-ordinator.

5.9.4 Extension activities shall be conducted outside the class hours.

5.10 Project

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

5.10.2 The Head of the Department shall assign a Project Supervisor to the student.

5.10.3 The Project Supervisor shall assign a topic for the project and monitor the progress of the student periodically.

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

5.11 Value Added Courses (VACs)

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

5.11.2 VACs enhance the students' employability and life skills. VACs are listed on the University website and in the Handbook on Interdepartmental Electives and VACs.

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

5.11.4 Classes for VACs are conducted beyond the regular class hours and preferably in the VIII and IX Semesters.

5.12 Online Courses

5.12.1 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.

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

5.12 Credit Distribution

The credit distribution is detailed in the Scheme.

5.13 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 students 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 should earn a minimum of 75% attendance in 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.

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 a 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 for 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 one 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 (ESEs)

8.5.1 The ESEs for the odd semester will be conducted in November and for the even semester in May.

8.5.2 A candidate who does not pass the examination in any course(s) will be permitted to reappear in such course(s) 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. 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.

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

9.3 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	5
Assignment	5
Total	25

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

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

9.3 Assessment of End-Semester Examinations

9.3.1 Double Evaluation for the ESE is done by the University Teachers.

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 Review of literature, 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 of the Head of the Department, Project Supervisor, and a senior faculty.

9.4.6 The marks shall be distributed as follows:

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

9.5 Assessment of Value Added Courses

9.5.1 VACs shall be evaluated completely by Internal Examiners.

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 candidate 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.

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

10. Conferment of the Master's Degree

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

11. Marks and Grading

11.1 The performance of students in each course is evaluated in terms of 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

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

is the Grade Point obtained by the student for the Course
and 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.

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

is the Grade Point obtained by the student for the Course and
is the number of Courses passed in that semester.

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 to 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 candidate 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 completed successfully, 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 student has re-appeared.

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 or more 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.

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

12.4 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.

12.5 Withdrawal is **not** granted for arrear examinations of courses in previous semesters (for which the student has secured RA Grade) and for the final semester examinations.

12.6 Candidates who have been granted permission to withdraw from the examination shall reappear for the course(s) in the subsequent semester.

12.7 Withdrawal shall not be taken into account as an appearance for the examination when considering the eligibility of the student 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 department library or computer resources, stealing other students' notes/assignments, 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 Five Year Integrated 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. Biotechnology (Five Year Integrated) Programme

Programme Code: SBIO51

Programme Structure

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

Course Code	Course Title	Hours/ Week			Marks		
		L	P	C	CIA	ESE	Total
Semester-I							
19ITAC11	Language-I: Course 1	3		3	25	75	100
19IENC12	Language–II: Course 1	3		3	25	75	100
19ICEC13	Civics, Health Sciences & Environmental Awareness	3		3	25	75	100
19IBTT14	Core 1: Fundamentals of Biochemistry	5		5	25	75	100
19IMBA15	Ancillary-I: Microbiology Course 1	4		4	40	60	100
	Elective 1: Department Elective	3		3			
	Total Credits			**21**			
Semester-II							
19ITAC21	Language-I: Course 2	3		3	25	75	100
19IENC22	Language– II: Course 2	3		3	25	75	100
19ICAC23	Computer Applications - I	3		3	25	75	100
19IBTT24	Core 2: Basic Cell Biology and Genetics	4		4	25	75	100
19IBTP25	Core 3: Practical–I–Biomolecules, Basic Cell Biology and Genetics		10	5	40	60	100
19IMBA26	Ancillary- I: Microbiology Course 2	4		4	25	75	100
19IMBP27	Ancillary Practical I Microbiology Course 3		06	2	40	60	100
	Total Credits			**24**			
Semester-III							
19ITAC31	Language-I: Course 3	3		3	25	75	100
19IENC32	Language–II: Course 3	3		3	25	75	100
19IBTT33	Core 4: Physiology	4		4	25	75	100
19IBTP34	Core 5: Practical–II Physiology		10	5	40	60	100
19ICHA35	Ancillary- II- Chemistry Course 1	4		4	40	60	100
	Elective 2: Department Elective	3		3			
	Total Credits			**22**			
Semester-IV							
19ITAC41	Language–I: Course 4	3		3	25	75	100
19IENC42	Language–II: Course 4	3		3	25	75	100
19IBTT43	Core 6: Bioinstrumentation	5		5	25	75	100
19IBTT44	Core 7: Basic Immunology	5		5	25	75	100
19IBTP45	Core 8: Practical-III Bioinstrumentation and Bssic Immunology		10	5	40	60	100
19ICHA46	Ancillary-II: Chemistry Course 2	4		4	25	75	100
19ICHP47	Ancillary Practical-II Chemistry Course 3		06	2	40	60	100
	Total Credits			**27**			
Semester-V							
19IBTT51	Core 9: Metabolism	5		5	25	75	100
19IBTT52	Core 10: Molecular Biology	5		5	25	75	100
19IBTT53	Core 11: rDNA Technology	5		5	25	75	100
19IBTP54	Core 12: Practical- IV Metabolism, Molecular Biology and rDNA technology		12	6	40	60	100
	Elective 3: Department Elective	3		3			
	Total Credits			**24**			

Semester-VI							
19IBTT61	Core 13: Cell and Tissue Culture	5		5	25	75	100
19IBTT62	Core 14: Pharmaceutical Biotechnology	5		5	25	75	100
19IBTT63	Core 15: Bioprocess Technology	5		5	25	75	100
19IBTT64	Core 16: Biotechnology and Human welfare	5		5	25	75	100
19IBTP65	Core 17: Practical-V Cell Culture, Pharmaceutical Biotechnology and Bioprocess Technology		12	6	40	60	100
	Total Credits			**26**			
Semester-VII							
19IBTT71	Core 18: Biomolecules and Metabolism	4		4	25	75	100
19IBTT72	Core 19: Molecular Cell Biology	4		4	25	75	100
19IBTT73	Core 20: Enzyme Technology	4		4	25	75	100
19IBTP74	Core 21: Practical-VI Biomolecules, Cell Biology and Enzymes		12	6	40	60	100
	Elective 4: Interdepartmental Elective	3		3	25	75	100
	Total Credits			**21**			
Semester-VIII							
19IBTT81	Core 22: Applied Microbiology and Immunotechnology	4		4	25	75	100
19IBTT82	Core 23: Advanced Molecular Biology	4		4	25	75	100
19IBTT83	Core 24: Genetic Engineering	4		4	25	75	100
19IBTP84	Core 25: Practical-VII Immunotechnology, Molecular Biology and Genetic Engineering		12	6	40	60	100
	Elective 5: Interdepartmental Elective	3		3	25	75	100
	Elective 6: Department Elective	3		3	25	75	100
	Total Credits			**24**			
Semester-IX							
19IBTT91	Core 26: Analytical Techniques and Nanobiotechnology	5		4	25	75	100
19IBTT92	Core 27: Industrial and Environmental Biotechnology	4		4	25	75	100
19IBTT93	Core 28: Plant Biotechnology	4		4	25	75	100
19IBTT94	Core 29: Animal Biotechnology	4		4	25	75	100
19IBTP95	Core 30: Practical-VIII Analytical Techniques, Nanobiotechnology, Industrial and Environmental Biotechnology and Animal Biotechnology		10	6	40	60	100
	Elective 7: Interdepartmental Elective	3		3	25	75	100
	Elective 8: Department Elective	3		3	25	75	100
	Total Credits			**28**			
Semester-X							
19IBTT101	Core 31: Food and Medical Biotechnology	4		4	25	75	100
19IBTT102	Core 32: Genomics, Proteomics and Bioinformatics	4		4	25	75	100
19IBTP103	Core 33: Practical-IX Bioinformatics and Food and Medical Biotechnology		12	6	25	75	100
19IBTPJ104	Project Work/In-plant training		10	6	25	75	100
	Total Credits			**20**			
	Semesters I-X Total Credits			**237**			

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 Course listed in the University website.

Ancillary Courses Offered to Other Departments

Course Code	Course Title	Hours /week		C	Marks		
		L	P		CIA	ESE	Total
19IBTA15	Biochemistry Course 1	4	-	4	25	75	100
19IBTA26	Biochemisty Course 2	4	-	4	25	75	100
19IBTP27	Biochemistry Practical I Course 3	-	4	2	40	60	100

Elective Courses

Department Electives (DE)

S.No.	Course Code	Course Title	Hours/ week		C	Marks		
			L	P		CIA	ESE	Total
1.	19IBTTE16.1	Biofertilizers	3		3	25	75	100
2.	19IBTTE16.2	Evolutionary Biology	3		3	25	75	100
3.	19IBTTE16.3	Public Health and Management	3		3	25	75	100
4.	19IBTTE36.1	Natural Resource Management	3		3	25	75	100
5.	19IBTTE36.2	Animal Behaviour and Chronobiology	3		3	25	75	100
6.	19IBTTE36.3	Plant Biochemistry	3		3	25	75	100
7.	19IBTTE55.1	Ecology	3		3	25	75	100
8.	19IBTTE55.2	Biodiversity	3		3	25	75	100
9.	19IBTTE55.3	Wild Life Conservation and Management	3		3	25	75	100
10.	19IBTTE85.1	Clinical Biochemistry	3	-	3	25	75	100
11.	19IBTTE85.2	Basic Endocrinology	3	-	3	25	75	100
12.	19IBTTE85.3	Developmental Biology	3	-	3	25	75	100
13.	19IBTTE96.1	Medical Laboratory Technology	3	-	3	25	75	100
14.	19IBTTE96.2	Biotechnology Management	3	-	3	25	75	100

Interdepartmental Electives (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	0	3	25	75	100
2.	19 MATE 215.1	Discrete Mathematics	Mathematics	3	0	3	25	75	100
3.	19 MATE 215.2	Numerical Methods		3	0	3	25	75	100
4.	19 MATE 315.1	Differential Equations		3	0	3	25	75	100
5.	19 STSX 215.1	Statistical Methods	Statistics	3	0	3	25	75	100
6.	19 STSX 215.2	Mathematical Statistics		3	0	3	25	75	100
7.	19 STSX 315.1	Bio-Statistics		3	0	3	25	75	100
8.	19 PHYX 215.1	Classical Mechanics and Special Theory of Relativity	Physics	3	0	3	25	75	100
9.	19 PHYX 215.2	Physics of the Earth		3	0	3	25	75	100
10.	19 PHYX 315.1	Bio-Medical Instrumentation		3	0	3	25	75	100
11.	19 PHYX 315.2	Energy Physics		3	0	3	25	75	100
12	19 CHEX 215.1	Applied Chemistry	Chemistry	3	0	3	25	75	100
13	19 CHEX 315.1	Basic Chemistry		3	0	3	25	75	100
14	19 CHEX 315.2	Instrumental Methods of Analysis		3	0	3	25	75	100
15	19 BOTX 215.1	Plant Tissue Culture	Botany	3	0	3	25	75	100
16	19 BOTX 215.2	Plant Science – I		3	0	3	25	75	100
17	19 BOTX 315.1	Gardening and Horticulture		3	0	3	25	75	100
18	19 BOTX 315.2	Plant Science – II		3	0	3	25	75	100
19	19 ZOOX 215.1	Animal Culture Techniques	Zoology	3	0	3	25	75	100
20	19 ZOOX 315.1	Environmental Science		3	0	3	25	75	100
21	19 GEOX 215.1	Environmental Geosciences	Earth Sciences	3	0	3	25	75	100
22	19 GEOX 315.1	Applied Geophysics		3	0	3	25	75	100
23	19 MIBX 315.1	Microbiology	Microbiology	3	0	3	25	75	100
24.	19 CISX 215.1	R Programming	Computer & Information Science	3	0	3	25	75	100

Electives Offered to Other Departments

S. No.	Course Code	Course Title	Hours/ week		C	Marks		
			L	P		CIA	ESE	Total
1.	19BIOE215.1	Basic Biochemistry	3	0	3	25	75	100
2.	19BIOE215.2	Basic Biotechnology	3	0	3	25	75	100
3.	19BIOE315.1	Biochemical Techniques	3	0	3	25	75	100
4.	19BIOE215.2	Immunology	3	0	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	0	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 organisational skills and the ability to manage time and resources.

PO6: **Individual and team work**: Exhibit the potential to effectively accomplish tasks independently and as a member or leader in diverse teams, and in multidisciplinary settings.

PO7: **Effective Communication**: Communicate effectively in spoken and written form as well as through electronic media with the scientific community as well as with society at large. Demonstrate the ability to write dissertations, reports, make effective presentations and documentation.

PO8: **Environment and Society**: Analyse the impact of scientific and technological advances on the environment and society and the need for sustainable development.

PO9: **Ethics**: Commitment to professional ethics and responsibilities.

PO10: **Life-long learning:** Ability to engage in life-long learning in the context of the rapid developments in the discipline.

Programme Specific Outcomes
At the end of the programme, the student will be able to

PSO1: Understand and apply basic science to biotechnological problems.

PSO2: Characterize biological samples using experimental techniques.

PSO3: Appreciate the pharmacokinetics of drugs and principles involved in drug manufacture and drug approval and biopharmaceuticals in development

PSO4: Appreciate and apply the benefits of biotechnology interventions for mankind in relation to environment, industry, medicine and agriculture.

PSO5: Use modern software tools for sequence alignment and structure prediction, molecular modeling and data acquisition for genome and proteome analysis.

PSO6: To realize personal and social responsibilities related to modern biotechnological research, environmental safety, ethical issues and intellectual property and develop entrepreneurship skills.

Semester-I **19IBTT14: Fundamentals of Biochemistry** **Credits: 5**
Hours: 5

Learning Objective (LO): To understand the structure - function relationship of biomolecules.

Unit - 1 Amino acids and Proteins

Acids, bases, pH, buffers, the Henderson-Hasselbach equation. Amino acids: 3-letter and 1-letter abbreviation, classification, stereoisomerism, and general properties. Non-standard amino acids. The peptide bond. Biologically important peptides.

Proteins: classification, properties, function, denaturation. Orders of protein structure: Primary, secondary, supersecondary, tertiary and quaternary structures. The structure of collagen and hemoglobin. Determination of the amino acid sequence of proteins. Merrifield synthesis of peptides

Unit - 2 Carbohydrates

Classification and general properties of carbohydrates. Biologically important monosaccharides- structure and stereoisomeric forms. Disaccharides of biological importance. Homopolysaccharides - structure and biological functions of starch, glycogen, and cellulose. Heteropolysaccharides - structure and biological role of glycosaminoglycans. Bacterial cell wall polysaccharides.

Unit - 3 Lipids and Hormones

Classification of lipids. Fatty acids and triglycerides. Phospholipids and sphingolipids - structure and biological functions. Structure and functions of cholesterol. Eicosanoids - structure and functions. Brief account on lipoproteins.

Brief account of hormones - classification, mechanism of action (brief account) and second messengers.

Unit - 4 Nucleic Acids and Vitamins

DNA double helical structure - Watson and Crick model. A, B and Z forms of DNA. Hairpins and palindrome, DNA supercoiling. DNA denaturation and renaturation. Differences between DNA and RNA. Major classes of RNA- structure and biological functions. Fat-soluble vitamins - sources, requirements, biological actions of vitamins A, D, E, and K. Water-soluble vitamins - sources, requirements, biological actions of thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, biotin, folic acid and vitamin B_{12}.

Unit - 5 Enzymes

Classification and IUB nomenclature, Holo and apo enzyme, coenzymes and cofactors, definition and examples of isoenzymes and multimeric enzymes. Enzymes specificity - Fischer and Koshland's theory. Enzyme units - IU, katal. Specific activity. Active site, activation energy and transition state. Effect of pH, temperature, and substrate on enzyme activity. Concept of Km and Vmax. Irrersible, Reversible and Feedback inhibition.

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. M.A. Lieberman and R. Ricer. BRS Biochemistry. Molecular Biology and Genetics (Board Review series). LippinCott Williams and Wilkins.7th ed.

Course Outcomes:

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

CO1: Understand the concept of pH, acids, bases and buffers and discuss the orders of protein structure, properties and functions in detail.
CO2: Know how simple precursors give rise to large molecules like protein carbohydrates, lipids and nucleic acids.
CO3: Classify lipids and understand their biological functions
CO4 : Describe the structures of purines and pyrimidines, the organization of nucleic acids and different structural forms of DNA and properties.
CO5: Understand the biological functions of vitamins and correlate with the deficiency states.
CO6: Understand the characteristics of enzymes.

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	3	3	2	3	2	3
CO2	3	3	2	2	2	2	3	2	2	3	3	3	3	2	3	2
CO3	3	3	2	2	2	2	3	2	2	3	3	3	3	3	2	3
CO4	3	3	3	2	2	2	3	3	2	3	3	3	3	2	2	2
CO5	3	3	3	2	2	2	3	3	2	3	3	3	3	2	2	3
CO6	3	3	2	3	3	3	3	2	3	3	3	3	2	3	3	3

Semester- II **19IBTT24: Basic Cell Biology and Genetics** **Credits:5 Hours:5**

Learning Objective (LO): To gain an understanding on cell structure and functions, membrane structure and transport, cell division and basic concepts of genetics.

Unit 1 – Cell structure and function

Cell theory. Comparison between prokaryotic and eukaryotic cells and plant and animal cells; Structure and Functions of Cell wall; Plasma membrane; Mitochondria; Chloroplast; ER; Golgi complex; Lysosome, Endosome and Microbodies; Ribosome; Centriole; structure of nucleus and nucleolus. Cytoskeletal structures (actin, microtubules, intermediate filament).

Unit 2 – Cell Membrane and Communication

Models of membrane structure, Membrane lipids, proteins and carbohydrates; Solute transport by simple diffusion, Facilitated diffusion and Active transport. Phagocytosis, Pinocytosis and Exocytosis. Cell - Cell communication-cell junction, adhesion and cell recognition

Unit 3 – Chromosomes and Cell cycle

Morphology and Structure of bacterial and eukaryotic Chromosome **-** Euchromatin and heterochromatin, Giant chromosomes - Lampbrush and polytene chromosomes. Types of chromosomes based on centromere position- Karyotyping. Cell cycle - phases, control points, Mitotic and Meiotic cell division.

Unit 4 – Genetics-I

Definition and introduction to phenotype, genotype, heterozygous, homozygous, allele (dominant, recessive, wild type, mutant), character, gene, gene locus, pure line, hybrid. Organisms suitable for genetic experiments

Mendel's laws of inheritance - Monohybrid and dihybrid crosses, Test and back crosses. Allelic interaction: Concept of incomplete dominance, co-dominance, multiple alleles, Non allelic interaction - Complementary genes, Epistasis.

Unit 5 – Genetics-II

Chromosomal variations in number and structure - euploidy, aneuploidy, deletion, duplication, inversion, translocation. Human chromosomal disorders - Monosomy, trisomy, nullisomy.

Sex determination - Barr bodies, dosage compensation, Fragile X – syndrome and sex linked inheritance.

Genetic linkage, crossing over, Molecular mechanism of crossing over, Recombination of genes in a chromosome, Population genetics - Hardy Weinberg law - Allelic & genotype frequencies, Natural selection, genetic drift.

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. Karp. Cell and Molecular Biology. Wiley. 8th ed. 2016
2. Lodish et al. Molecular Cell Biology. Freeman. 8th ed. 2017
3. Nelson and Cox. Lehninger Principles of Biochemistry. Freeman. 7th ed. 2017
4. Fletcher et al. Instant notes in Genetics. Taylon and Francis. 3rd ed. 2012.
5. Elrod and Stansfield Sahaum's outline of Genetics. McGraw Hill. 5th ed. 2010

Supplementary Reading

Alberts et al. Molecular Biology of the Cell. Garland Sci. 6th ed. 2014

Course Outcomes

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

CO1 : Differentiate prokaryotic and eukaryotic cells.
CO2 : Understand the organizational and functional aspects of cells and organelles.
CO3: Learn membrane structure and transport.
CO4: Learn how cells undergo mitosis and meiosis.
CO5: Learn the basic concepts of genetics.
CO6: Understand the chromosomal variation and its effects.

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	3	2	3	3	2	3	3	3	2	2	3	2
CO2	3	2	2	2	2	2	3	2	2	3	3	2	2	2	2	2
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	2	2	2	2	2	3	2	2	3	3	2	2	2	2	2
CO5	3	3	2	3	3	2	3	3	2	3	3	3	2	3	3	2
CO6	3	3	2	3	3	2	3	3	2	3	3	3	3	3	3	2

Semester-II **19IBTP25: Core Practical – I** **Credits:5**

Practicals in Biomolecules, Cell Biology and Genetics **Hours:10**

Learning Objective (LO): To learn preparation of standard solutions and buffers, to quantitate biomolecules and to acquire skills on the separation of aminoacids, proteins and lipids.

1. Preparation of standard, normal, molar and percentage solutions. Preparation of buffers.
2. Qualitative analysis of carbohydrates.
3. Principles of colorimetry, calibration curve. Verification of Beer Lambert's law.
4. Estimation of proteins by Biuret method.
5. Estimation of glucose by anthrone method.
6. Determination of acid number of a fat.
7. Identification of tissue types, phases of cell division.
8. Microscopic examination of epithelial cells, plant cells.
9. Wild type and mutants (*vestigial*, *ebony* and *cry^b*) of *Drosophilla melanogaster*
10. Karyotyping analysis with the help of photographs
11. Study of polyploidy in onion root tip by colchicine treatment
12. Demonstration of Barr body
13. Pedigree charts of some characters like blood group and color blindness

Supplementary Reading

1. Nigam. Lab Manual of Biochemistry. Tata McGraw-Hill Education, India. 2008.
2. David Plummer. An Introduction to Practical Biochemistry. Paperback. 2017.
3. Joseph Sambrook, David William Russell., CSHL Press, New York. Vol 3, 3rd ed .2001.
4. H.N. Thatoi, Supriya Dash, Swagat Kumar Das, Practical Biotechnology: Principles and Protocols . 2017

Course Outcomes:

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

CO1: Prepare buffers and standard solutions
CO2 : Perform qualitative analysis of carbohydrates and proteins using colorimetry.
CO3 : Identify rancid fat by determining acid by determining acid number.
CO4: Identify and examine plant cells, tissue types and the phases of cell division.
CO5: Carry out karyotyping chromosomes, differentiate wild type and mutants of *Drosophila*

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

Semester-III **19IBTT33: Physiology** **Credits: 4**
Hours: 4

Learning Objective (LO): To learn in detail about the physiology of mammalian systems, phases of cell division and cell cycle and basic concepts in developmental biology

Unit–1 Nervous system
Structure of a neuron. Propagation of action potential. Neurotransmitters - examples, release and cycling of neurotransmitters. The neuromuscular junction. The acetylcholine receptor.

Unit-2 Muscular system
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-3 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-4 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.

Unit-5 Fundamental Concepts of Cell Division and Development
Mitosis and meiosis. Phases of cell cycle. Development, differentiation and morphogenesis-Development in *Drosophila* - homeotic genes, maternal genes and segmentation genes

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. Karp. Cell & Molecular Biology. Wiley. 8th ed. 2016.
2. Lodish et al Molecular Cell Biology. Freeman. 8th ed. 2017.
3. Nelson and Cox. Lehninger Principles of Biochemistry. Freeman, 7th ed. 2017.
4. Smith et al. Principles of Biochemistry. Mammalian Biochemistry. McGraw Hill. 7th ed.
5. Graaf & Rees. Schaum's Easy Outline of Human Anatomy & Physiology. 2nd ed. 2010.

Supplementary Reading

1. Alberts et al Molecular Biology of the Cell. Garland Sci. 6th ed. 2014.
2. Barrett et al. Ganong's Review of Medical Physiology. Lange. 24th ed. 2012.
3. Rodwell et al. Harper's Illustrated Biochemistry. McGraw Hill. 31th ed. 2018.

Course Outcomes:
At the end of the course, the student will be able to:
CO1: Discuss the structure and functions of neuron and the events at neuromuscular junctions
CO2: Know the types of muscle, muscle proteins and events occurring during contraction and relaxation.
CO3: Describe the organs and functions of digestive and excretory system.
CO4: Understand the composition and role of body fluids.
CO5: Understand the concept of cell division , cell cycle and *Drosophila* development

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

Semester-III | **19IBTP34: Core Practical – II** | **Credits: 5**

Practicals in Physiology | **Hours: 10**

Learning Objective (LO): To acquire skills in analyzing in hematology, quantitative analysis of body fluids and understand mammalian physiology.

1. Enumeration of RBCs.
2. Enumeration of WBCs (total and differential count).
3. Estimation of bleeding time, clotting time and prothrombin time.
4. Preparation of serum and plasma from blood
5. Estimation of hemoglobin.
6. Determination of ESR
7. Qualitative analysis of saliva
8. Qualitative analysis of bile
9. Qualitative analysis of gastic juice. Estimation of total and free acidity
10. Qualitative analysis of urine
11. Computer-based learning for physiological systems.
12. Measurement of blood pressure (Demonstration)
13. Electrocardiogram (Demonstration)

Supplementary Reading

1. Cathcart EP. Practical Physiology, Forgotton books (publishers), London. 2018
2. G.K.Pal & P.Pal. Textbook of Practical Physiology. 4th ed. Orient Blackswan. 2016.

Course Outcomes:

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

CO1 : Enumerate blood cell count
CO2 : Estimate bleeding, clotting and prothrombin time, haemoglobin and ESR
CO3 : Prepare serum and plasma from blood
CO4: Perform qualitative analysis of saliva, bile, gastric juice and urine.
CO5: Appreciate mammalian physiology visually through computer simulation
CO6: Understand the methodology for BP and ECG measurement

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	3	3	2	3
CO2	3	3	3	3	3	3	3	3	2	3	3	3	3	2	3	2
CO3	3	3	3	3	3	3	3	2	1	3	3	3	3	2	2	3
CO4	3	3	3	3	3	3	3	2	2	3	3	3	3	2	2	2
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	2	3	3	3	3	2	3	2

Semester-IV **9IBTT43: Bioinstrumentation** **Credits: 5**
Hours: 5

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

Unit-1 Microscopy
Microscopy – Light, bright and dark field microscopy, Phase contrast, fluorescence and electron microscopy (TEM and SEM).

Unit-2 Spectroscopy and Centrifugation
Principles and laws of absorption. Colorimetry - UV-visible spectrophotometry, and spectrofluorimetry. Centrifugation – Principle, Svedberg unit, Analytical and preparative, ultracentrifugation, subcellular fractionation and applications.

Unit-3 Chromatography
Principle - Adsorption , partition, Rf value and applications – Paper- ascending, descending and circular. Thin layer chromatography, Column- Gel filtration, ion-exchange and affinity chromatography - GC, HPLC - applications.

Unit-4 Electrophoresis
Introduction to electrophoresis, gel electrophoresis- paper, Starch gel, polyacrylamide (Native, SDS-PAGE) and agarose gel electrophoresis. Lipoprotein separation by electrophoresis.

Unit-5 Radioisotope techniques
Radioisotopes Units of radioactivity - Curie and Bequerel. Measurement of radioactivity- Solid and liquid scintillation counting. Types of isotopes used in Biology ^{32}P, ^{35}S,^{14}C and ^{3}H-Applications of radioisotopes in biology. Radiation hazards- safety measures.

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.

Supplementary Reading

1. Friefelder and Friefelder. Physical Biochemistry - Applications to Biochemistry and Molecular Biology. WH Freeman & Co. 2nd ed. 1983
2. Pavia, Lampman, Kriz, Vyvyan. Introduction to Spectroscopy. Cengage Learning. 5th ed. 2015.
3. Rodney. F. Boyer. Modern Experimental Biochemistry. Pearson Education. Inc. 3rd ed. 2000.

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

CO1 : Apprehend the principles and applications of basic instruments in a biochemistry laboratory.
CO2 : Understand the principles, components and applications of spectroscopy and radioisotope techniques.
CO3: Learn the principle, procedure and applications of different chromatography techniques.
CO4: Apply electrophoretic and hybridization techniques for biomolecule separation.
CO5: Use the principles and applications of microscopy in various biological fields.

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

Semester-IV **19IBTT44: Basic Immunology** **Credits: 5**
Hours: 5

Learning Objective (LO): To gain comprehensive knowledge on cells and organs of the immune system, immune types of response, mechanisms of protection and types of available and new vaccines of immunology.

Unit-1 Cell and Organs of the Immune System
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.

Unit-2 Antibodies
Structure, classification, functions, Isotypes, allotypes and idiotypes. Complement system-components, nomenclature, pathways of complement activation, classical pathway and alternate pathway. Biological functions of complement. Types of immunity.

Unit-3Immune Mechanisms
Maturation of T and B-cells. Antigen recognition, Antigen presentation, Immunological memory, Immuno tolerance. Phagocytosis, cell mediated cytotoxicity, antibody dependent CMC.

Unit-4 Vaccines
Vaccines-killed, attenuated organisms, toxoids, recombinant vaccines, subUnit-5accines, DNA vaccines, synthetic peptide vaccines, antiidiotypic vaccines. Antibody diversity - mechanisms contributing to diversity - somatic recombination, rearrangement and generation of antibody diversity.Class switching.

Unit-5 Major Histocompatibility Complex, Hypersensitivity and Transplantation
Major histocompatibility complex- gene organisation - HLA genes class I and II antigens. Structure and function histocompatibility testing, cross matching. MHC & disease association. Hypersensitivity - definition and classification - type I to type V (brief account only). Transplantation-types: autograft, syngraft, allograft, xenograft.

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. 9th ed. 2017.
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 : Specify the lymphoid organs, cells of the immune system and their functions
CO2 : Apprehend the definition, properties and role of antigens and antibody types and comprehend the role of complement system
CO3: Understand the genetic mechanism for antibody diversity and know in detail about classical and newer vaccines
CO4: Understand the immune mechanisms, hypersensitivity and tissue transplantation
CO5: Describe the function and role of HLA protein and disease association

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

Semester-IV | **19IBTT45: Core Practical-III** | **Credits: 5**

Practicals in Bioinstrumentation and Basic Immunology | **Hours: 10**

Learning Objective (LO): To learn practical skills in Bioinstrumentation and Basic Immunology techniques

1. Principles of colorimetry. callibration curve. Verification of Beer-Lambert's law.
2. Microscopy – phase contrast and fluorescence - demonstration
3. Separation of amino acids by paper chromatography.
4. Separation of lipids by thin layer chromatography.
5. Separation of proteins by gel filtration- Demonstration.
6. Separation of plant pigments by adsorption chromatography.
7. Agarose gel electrophoresis- Demonstration
8. Latex agglutination test
9. Preparation of cell suspension from spleen
10. Identification of various immune system cells (NK cells, Neutrophils and Monocytes)
11. Precipitation reaction- Widal test.
12. Immunodiffusion test
13. ELISA- Demonstration.

Supplementary Reading

1. Hay FC, Westwood OMR. Practical Immunology 4th edition, Wiley, New Jersey, USA. 2008
2. Webster JG Bioinstrumentation, Wiley, New Jersey, USA, 2007
3. Fulekar MH, Pandey B. Bioinstrumentation, IK International Pvt. Ltd. New Delhi, 2013

Course Outcomes

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

CO1 : Understand basic principles of spectrophotometry
CO2 : Demonstrate microscopy techniques
CO3: Perform chromatography techniques
CO4: Separate macromolecules by agarose gel electrophoresis
CO5: Identify various types of immune cells and to prepare cell suspension from spleen
CO6: Understand and perform ELISA technique

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	2	3	3	3	2	3
CO2	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2	3	3	2	3	3	2	2	3
CO4	3	3	3	3	3	3	3	2	2	3	3	3	3	2	2	2
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3
CO6	3	3	3	3	3	3	3	3	2	3	2	3	3	3	3	2

Semester-V **19IBTT51: Metabolism** **Credits: 5**
Hours: 5

Learning Objective (LO): To understand the role of mitochondria in energy production and to learn the synthesis and degradation pathways for carbohydrate, lipid, aminoacids, purines and pyrimidines.

Unit-1 Bioenergetics

Laws of thermodynamics, Free energy and entropy. The ATP/ADP cycle. Enzymes involved in redox reactions. The electron transport chain. Oxidative phosphorylation - F_1F_0 ATPase, the chemiosmotic theory. Inhibitors of respiratory chain and oxidative phosphorylation - uncouplers, ionophores. Regulation of oxidative phosphorylation. Mitochondrial transport systems- ATP/ADP exchange, malate and glycerophosphate shuttle.

Unit-2 Carbohydrate metabolism

Anabolism and catabolism. Glycolysis - pathway, key enzymes and co-ordinate regulation. The citric acid cycle. Gluconeogenesis - pathway. The pentose phosphate pathway. Metabolism of glycogen- glycogenesis, glycogenolysis.

Unit-3 Lipid metabolism

Oxidation of fatty acids: β-oxidation. Oxidation of unsaturated fatty acids, α- and ω-oxidation. Metabolism of ketone bodies - formation, utilization, excretion and clinical significance. Biosynthesis of fatty acids. Metabolism of triglycerides, phospholipids, and cholesterol.

Unit-4 Metabolism of amino acids

Overview of biosynthesis of nonessential amino acids. Catabolism of amino acid nitrogen- transamination, deamination, ammonia formation, the urea cycle. Overview of the catabolism of carbon skeletons of amino acids to amphibolic intermediates.

Unit-5 Metabolism of purines and pyrimidines

De novo and salvage pathways of purine biosynthesis, purine catabolism. Biosynthesis and catabolism of pyrimidines. 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's Principles of Biochemistry. Freeman. 7th ed. 2017.
2. Rodwell et al. Harper's Illustrated Biochemistry. McGraw Hill. 31th ed. 2018.
3. Voet and Voet, Fundamentals of Biochemistry. Wiley. 5th ed. 2018.
4. Kuchel et al. Schaum's Outline of Biochemistry. Mc Graw Hill. 3rd ed. 2011.

Supplementary Reading

1. Miriam D. Rosenthal Medical Biochemistry: Human Metabolism in Health and Disease. 1st ed. 2011
2. David A. Bender. Introduction to Nutrition and Metabolism. CRC Press. 5th ed. 2014.
3. Kaden Hunt. Nutrition and Metabolism. 2017

Course Outcomes

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

CO1 : Understand the basic bioenergetic principles and cellular synthesis of ATP

CO2 : Understand the reaction pathways of glucose and glycogen metabolism

CO3 : Describe the oxidation and biosynthesis of lipids.

CO4 : Understand the function of ammonia, metabolic fate of amino acids, synthesis of urea, and generation of intermediates of TCA cycle.

CO5: Understand the *de novo* and salvage pathways of purine and pyrimidine metabolism and the concept of metabolomics.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PS O5	PSO6
CO1	3	2	3	2	3	2	3	2	3	3	3	2	3	2	2	3
CO2	3	3	2	3	3	3	3	3	2	3	3	3	2	3	3	3
CO3	3	2	3	2	2	2	3	2	3	3	3	2	3	2	2	3
CO4	3	2	2	2	3	2	3	2	2	3	3	2	3	2	2	3
CO5	3	3	2	3	2	3	3	3	3	3	3	3	3	2	3	3

Semester-V **19IBTT52: Molecular Biology** **Credits: 5**
Hours: 5

Learning Objective (LO): To gain an insight into chromatin organization, replication, mutation and DNA repair mechanisms, transcription and translation.

Unit-1 Chromatin

The central dogma of molecular biology. The *E.coli* chromosome and plasmids. Eukaryotic chromatin: nucleosomes, 30 nm fiber and higher order chromatin structure. Mitochondria and chloroplast genomes. Definitions of the following: gene, cistron, coding region (ORF), transcription unit, untranslated region (UTR). Split genes- exons and introns.

Unit-2 DNA Replication

Conservative, semi conservative and dispersive types. Bidirectional mode of DNA replication. θ and rolling circle mechanism. DNA polymerases other enzymes and protein factors involved in protein replication. Mechanism of replication in prokaryotes and eukaryotes. Okazaki fragments. Inhibitors of replication.

Unit-3 Mutation and Repair

Mutation- molecular basis of mutation, spontaneous and induced mutation Types of mutation- Transition, tranversion, frame shift, insertion, deletion, suppresser sensitive, germinal and somatic. DNA repair - Excision repair, uracil DNA glycoxylase, repair of thymine dimers. Xeroderma pigmentosum.

Unit-4 Transcription

E.coli: RNA polymerase, promoter sequence. Steps in transcription - template recognition, initiation, elongation and termination. Transcription in eukaryotes: RNA polymerases - I, II and III. Promoters, transcription factors. Steps in transcription. Inhibitors of transcription.

Post-transcriptional processing. RNA splicing in eukaryotes.

Unit-5 Genetic Code and Translation

The genetic code: universal and mitochondrial. Mutations: point mutations and frameshift mutations. Mechanism of protein synthesis in bacteria and eukaryotes: amino acid activation, initiation, elongation and termination. Inhibitors of protein synthesis. Post-translational modifications. Brief account on protein degradation.

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. David P, Clark BA. Molecular Biology. Academic Cell. 3rd ed. 2018.

Supplementary Reading

1. Krebs JE et al. Lewin's. Genes XI. Jones & Bartlett Publ. 2012.
2. James Watson. Molecular Biology of the Gene. Pearson Education. 7th ed. 2017.
3. Richard Twyman. Advanced Molecular Biology. Garland Science. 2018
4. Harvey Lodish, Arnold Berk. Mol. Cell Biology. WH Freeman Co. 8th ed. 2016.

Course Outcomes

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

CO1 : Acquire knowledge on the complexity of eukaryotic genome organization.
CO2 : Understand the molecular mechanism of DNA replication.
CO3 : Understand the types of mutation and repair.
CO4 : Understand the transcription in prokaryotes and eukaryotes, post transcriptional processing and RNA splicing
CO5: Assimilate the information flow and steps for protein synthesis and the mechanisms involved.
CO6: Understand the use of protein synthesis inhibitors and dynamic nature of proteins.

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	2	3	3	2	3	3	3	2	3	3	2	3
CO2	3	3	2	2	3	2	3	3	2	3	3	3	2	2	3	2
CO3	3	2	3	3	2	3	3	2	3	3	3	2	3	2	2	3
CO4	3	2	2	2	2	2	3	2	2	3	3	2	2	3	2	2
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	3	3	2	2	1	2	3	3	2	3	3	3	2	2	3	2

Semester-V **19IBTT53: Recombinant DNA Technology** **Credits: 5**
Hours: 5

Learning Objective (LO): To learn the basic principles and applications of rDNA Technology.

Unit-1 Restriction Enzymes and Cloning Vectors
Basic principles of rDNA technology. Restriction endonucleases - nomenclature and actions of Hind III, Eco RI and Bam HI.
Cloning vectors - essential features. Cloning in plasmid (pBR322) and phage (λ phage) vectors. Cosmids. Brief introduction to BACs and YACs. Expression vectors (brief outline).

Unit-2 Cloning and rDNA Transfer
Methods of splicing of DNA molecules: cohesive end method, homopolymeric tailing, blunt-end ligation. Linkers and adaptors. Ligase - free joining.
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), restriction digestion, colony PCR, colony hybridization. Cloning strategies: Construction of genomic and cDNA libraries. Differences between genomic and cDNA libraries.

Unit-4 Transgenic Plants and Animals
Methods of gene transfer in plants - *Agrobacterium* - mediated transformation and particle gun method. Transgenic plant technology - development of insect resistance plants. Methods for producing transgenic animals- retroviral, microinjection.

Unit-5 Techniques
DNA sequencing. Chemical, and enzymatic methods. Southern, Northern, Western and Southwestern hybridization. DNA fingerprinting- principle and applications. PCR: principle and applications. The human genome project (elementary details). 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. Nicholls DTS. An Introduction to Genetic Engineering. Cambridge University Press. 3rd ed. 2008.
2. Glick and Pasternak. Molecular Biotechnology. ASM Press. 4th ed. 2010.
3. Richard J. Reece. Analysis of Genes and Genomes. Wiley. 2004.

Supplementary Reading

1. Winnacker EL. From Genes to Clones. VCH Publ. 4th ed. 2003.
2. James D. Watson et al. Recombinant DNA: Genes and Genomes-A Short Course. W. H. Freeman. 3rd ed. 2006.
3. Sandy 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 : Gain knowledge about cloning and expression vectors and use of restriction enzymes in construction of vectors
CO2 : Study various expression systems and markers
CO3 : Learn and apply the methods of screening recombinants and construction of genomic and cDNA libraries.
CO4: Learn about gene transfer mechanisms and transgenesis in plants and animals
CO5: Describe the principle and applications of versatile techniques in molecular biology such as DNA sequencing, DNA finger printing and PCR.

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

Semester-V **19IBTP55: Core Practical– IV**

Credits: 6

Practicals in Metabolism, Molecular Biology and rDNA Technology **Hours: 12**

Learning Objective (LO): To learn the isolation, separation, characterization and quantification of nucleic acids and basic immunology techniques.

1. Cellular respiration in *Saccharomyces cerevisiae*
2. Isolation of DNA.
3. Isolation of RNA from yeast.
4. Thermal denaturation of DNA.
5. Quantitative analysis of protein and DNA using spectrophotometer
6. Isolation of bacterial chromosomal and plasmid DNA and characterization by electrophoresis.
7. DNA electrophoresis in agarose gel.
8. Bacterial conjugation- Demonstration.
9. Bacterial transformation- Demonstration.
10. Determination of molecular size of DNA.
11. Restriction enzyme digestion of DNA.

Supplementary Reading

4. Schleif RF, Pieter WP. Practical methods in Molecular Biology Springer, Berlin, Germany. 2011
5. J Sambrook & D.W.Russell. Molecular cloning: a laboratory manual Vol 1,2 & 3, CSHL Press. 2001.
6. G. K. Pal & P. Pal. Textbook of Practical Physiology. Orient Blackswan 4th ed. 2016.

Course Outcomes

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

CO1 : Demonstrate cellular respiration in yeast
CO2 : Isolate and quantitatively analyze DNA and RNA from bacteria and yeast.
CO3: Differentiate chromosomal and plasmid DNA
CO4: Demonstrate chromosome/gene transfer in bacteria by conjugation and transformation.
CO5: Analyze the properties of DNA like molecular size, light absorption, thermal denaturation, and restriction enzyme digestion.
CO6: To perform restriction enzyme digestion of DNA

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	2	3	2	3	3	2	3	2
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3
CO3	3	3	3	3	3	3	3	2	2	3	2	3	3	2	1	2
CO4	3	3	3	3	3	3	3	2	2	3	2	3	3	2	2	2
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3

Semester-VI **19IBTT61 Cell and Tissue Culture** **Credits: 5**
Hours: 5

Learning Objective (LO): To learn the fundamentals of cell and tissue culture, media preparation and understand the commercial applications of tissue culture.

Unit-1 Introduction
History and scope. Advantages and limitations of tissue culture. Laboratory facilities for tissue culture. Substrates, gas phase. Culture media: natural, defined media (with serum and serum free). Aseptic techniques - sterilization of glassware, media, workstation. Freeze storing of cells and transport of cultures. Biosafety.

Unit-2 Primary culture, Cell lines, and Cloning
Primary cell culture: Disaggregation (enzymic, mechanical), separation of viable cells. Maintenance of cell lines. Advantages and disadvantages of finite and continuous cell lines. Cloning of cell lines. Large scale cell cultures.

Unit-3 Animal Cell Culture
Slide, flask, and test tube culture. Media components. Cell culture contamination - sources, consequences, prevention. Types of animal cell culture- primary, continuous and cancer cell lines. Subculturing, and cell quantitation. Whole embryo culture.

Unit-4 Plant Cell Culture
Growth and development of plant cells and tissues *in vitro*. Laboratory requirements, aseptic techniques. Nutrient media. Plant growth regulators: mode and mechanism of action. Callus culture, cell suspension culture, organ culture, protoplast culture.

Unit-5 Applications of Tissue Culture
Applications of plant cell and tissue culture in breeding and industry: Organogenesis and embryogenesis, synthetic seeds, disease elimination. Commercial applications of animal tissue culture for diagnosis, development of vaccines and biologically important compounds.

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. Martin BM. Tissue Culture Techniques- An Introduction. Birkhauser. 1994.
2. Smith RH. Plant tissue culture. Elsevier. 3rd ed. 2013.
3. Singh B.D. Biotechnology. Expanding horizons. Kalyani Publ. 4th ed. 2012

Supplementary Reading

1. Mather JP and Barnes D. Animal Cell Culture Methods. Vol 57. Elsevier
2. Freshney RI. Culture of Animal Cells: A manual of basic technique. Wiley-Liss. 6th ed. 2010.

Course Outcomes
At the end of the course, the student will be able to
CO1 : Acquire knowledge on organization of cell and tissue culture lab and methods of aseptic maintenance and nutritional requirements.
CO2 : Learn techniques for culturing animal cell line and cloning of cell lines.
CO3 : Understand the types of animal cell culture.
CO4 : Understand the techniques employed for plant tissue culture including single cell, protoplast and callus culture.
CO5 : Appreciate the commercial applications of plant and animal tissue culture in breeding and industry.

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

Semester-VI **19IBTT62: Pharmaceutical Biotechnology** **Credits: 5**
Hours: 5

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

Unit -1 Introduction
Pharmacetuical Biotechnology and biopharmaceuticals. Sources of biopharmaceuticals - yeast, animal cell cultures, bacteria, fungi, plants, animals, transgenic plants. Drug isolation and evaluation. Formulation of biopharmaceutical products. Shelf life of protein based pharmaceuticals. Site specific delivery of protein drugs.

Unit-2 Pharmacokinetics and Dynamics
Routes of drug administration. Absorption of drugs. Bioavailability - factors influencing absorption and bioavailability. Drug distribution - plasma protein binding, placental transfer, blood-brain barrier. Mechanism of drug action, receptor theory, adverse effects of drugs, drug interactions.

Unit-3Drug Metabolism and Manufacturing
Chemical reactions (proteolysis, deamidation, oxidation, disulfide exchange), reduction, hydrogenation, dehydrogenation. Excretion
Manufacturing principles - compressed tablets, controlled and sustained release dosage forms-enteric coated tablets and capsules.

Unit-4 Biopharmaceuticals
Vaccines, modern vaccine technologies, pharmaceutical aspects. 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 I, II and III.
Regulatory authorities - Food and Drug Administration (USA), European regulations- National security authorities, European medicine agency and new EU drug approval system.

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

Text Books

1. Gilman et al. Goodman and Gilman's The Pharmacological Basis of Therapeutics. McGraw Hill.12th ed. 2011.
2. Satoskar, Bhardarkar and Rege. Pharmacology and Pharmacotherapeutics. Poular Prakashan. 24th ed. 2015
3. Kayser O, Muller RH. Pharmaceutical Biotechnology- Drug Discovery and Clinical Applications. Wiley-VCH. 2004.
4. Klefenz H. Industrial Pharmaceutical Biotechnology. Wiley-VCH. 2002.
5. Shargel L, Yu ABC, Wu-Pong S. Applied Biopharmaceuticals and Pharmacokinetics. McGraw-Hill. 6th ed. 2012.

Supplementary Reading

Spada S, Walsh G. Directory of Approved Biopharmaceuticals CRC Press. 2004

Course Outcomes

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

CO1 : Understand the scope of pharmaceutical biotechnology.
CO2 : Understand pharmacokinetics, metabolism and dynamics of drugs
CO3 Apply the manufacturing principles in formulation of drugs and biopharmaceuticals.
CO4 : Comprehend the production of recombinant proteins, enzymes and carbohydrate and nucleic acid based biopharmaceuticals.
CO5: Explain the regulatory aspects in drug development and drug approval
CO6: Understand the steps in drug discovery process

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	3	2	3	3	3	3	3	2	3	3	2	3
CO2	3	2	3	2	3	2	3	3	3	3	3	1	3	3	1	3
CO3	3	3	2	3	3	1	3	3	3	3	3	2	3	3	2	3
CO4	3	2	2	2	3	2	3	3	3	3	3	2	3	3	2	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Semester-VI **19IBTT63: Bioprocess Technology** **Credits: 5**
Hours: 5

Learning Objective (LO): To learn the principle, techniques and applications of Bioprocess Technology.

Unit-1 Bioprocessing

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

Unit-2 Fermentation

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

Unit-3 Downstream processing

Downstream processing - Overview - separation methods - filtration, centrifugation, sedimentation, flocculation, microfiltration, extra and intracellular products - cell disruption methods, purification methods, crystallization, drying, storage and packaging. Treatment of effluent and disposal

Unit-4 Industrial Production

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

Unit-5 Biotransformation

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

Current Streams of Thought

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

Text Books

1. John E. Smith. Biotechnology. Cambridge Univ Press. 5th ed. 2009.
1. Ratledge and Kristiansen. Basic Biotechnology. Cambridge Univ. Press. 3rd ed. 2006.
2. Gupta PK. Elements of Biotechnology. Rastogi Publication. 2005.
3. Primrose, Twyman and Old. Principles of gene manipulation and Genomics. Blackwell Sci. 7th ed. 2006.

Supplementary Reading

1. Flickinger and Drew (eds). Encyclopedia of Industrial Biotechnology. 8 vol. set. John Wiley & Sons. 2010.
2. Singh BD. Encyclopedia of Molecular Biotechnology. Anmol Publ. 2011.
3. L.E.Casida. Industrial Microbiology. Wiley Eastern reprint. John Wiley and Sons Inc. 3rd ed. 2007.

Course Outcomes

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

CO1 : Exhibit knowledge on the industrially important microrganisms, their growth, isolation, screening and inoculum preparation.

CO2 : Understand and apply the methodology, requirements for different types of fermentation.

CO3 : Learn the steps in downstream processing from product isolation to packaging

CO4 : Apprehend the use of biotechnology for production of high value compounds

CO5: Know the principles and applications of bioprocessing, metabolic engineering and SCP production.

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

Semester-VI **19IBTT64: Biotechnology and Human Welfare** **Credits: 5**
Hours: 5

Learning Objective (LO): To learn the industrial, agricultural and environmental applications of biotechnology for the benefit of mankind.

Unit-1 Industry
Waste management - Composting. Application of biotechnology in vermi culture, mushroom technology and biogas production. Applications of protein and enzyme engineering. Protein engineering - enzyme and polysaccharide synthesis. (Brief account only) Alcohol and antibiotic production. Applications in food industry

Unit-2 Agriculture
Biofertilizer, Biopesticides, transfer of nitrogen fixing and pest resistance genes to plants. Qualitative improvement of livestock. Production of SCP. Transgenic plants- BT cotton, Flavr-Savr tomato and golden rice (Brief treatment only).

Unit-3 Environment
Control of pollution through biotechnology - degradation of chlorinated and non-chlorinated or general pollutant degradation. Xenobiotic degradation. Bioleaching. Superbug in bioremediation, development of biodegradable polymers (PHB) (Basic ideas only).

Unit-4 Forensic medicine and tissue engineering
DNA fingerprinting - principle. Solving claims of paternity, theft and violent crimes. Application of DNA profiling in forensic medicine. Tissue engineering**-** Organogenesis. Production of complete organs. (Brief outline) Applications of tissue engineering.

Unit-5 Health
Applications of stem cell technology. Transgenic Applications - transgenic animals- mice, sheep, fish. Gene therapy, Diagnostics, Biopharmaceuticals, Recombinant live vaccines, Applications of Human Genome Project (HGP). Nanotechnology for drug targeting (outline only).

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

Text Books

1. Ronneau C, Bitchavla C. Biotechnology for waste and wastewater treatment. Om Publications, New Delhi. 2017.
2. Nag A. Text book of Agricultural Biotechnology. PHI Learning Private Ltd. New Delhi. 1st ed. 2008.
3. Gaur VK. Agricultural Biotechnology. Sonali publications, New Delhi. 2012.
4. Indu Shekhar Thakur. Environmental Biotechnology: Basic Concepts and Applications. IK International Publishing house Ltd. New Delhi. 2nd ed. 2010
5. Balasubramanian D. Concepts in Biotechnology. University press. 2004

Supplementary Reading

1. Cheremisinoff P. Biotechnology for Waste Management and Site Restoration. Springer (1997).
2. Raman K et al. Advances in Environmental Biotechnology. Springer. 2017.

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

CO1 : List some applications of biotechnology in wide domains of biological sciences.
CO2: Explain the technology for development of biotechnology product.
CO3 : Understand and solve biomedical and biological problems using biotechnology
CO4 : Understand the technology used in forensic medicine and tissue engineering.
CO5: Comprehend the applications of stem cell technology, gene therapy and nanobiotechnology

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

Semester-VI **19IBTP65: Core Practical – V** **Credits: 6**

Practicals in Cell Culture, Pharmaceutical Biotechnology and Bioprocess Technology **Hours: 12**

Learning Objective (LO): To learn practical skills in cell culture techniques and bioprocessing.

1. Tissue culture techniques: Surface sterilisation techniques, media preparation and storage, serum inactivation.
2. Staining of cell cultures and observations under microscope.
3. Cell count, protein estimation, mitotic index.
4. Role of additives on various explant cultures.
5. *In vitro* antioxidant activities of pharmaceutical drugs
6. Immobilization of yeast/microbes
7. Determination of growth curve of a microorganism and substrate degradation profile.
8. Computation of specific growth rate (m) and growth yield $Y_{x/s}$.
9. Comparative studies of ethanol production using different substrates.
10. Microbial production of citric acid using *Aspergillus niger*.

Supplementary Reading

1. Joseph Sambrook, David William Russell. (2001). Volume 3, 3rd ed, CSHL Press, New York.
2. John R.W Masters. Animal Cell Culture: A practical approach . 3rd ed.
3. H.N. Thatoi , Supriya Dash, Swagat Kumar Das. Practical Biotechnology: Principles and Protocols by 2017

Course Outcomes

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

CO1 : Learn the basic techniques like staining and identification of cell culture using microscope and media preparation and sterilization.
CO2 : Evaluate cell division through mitotic index.
CO3 : Analyze the antioxidant properties of important drugs.
CO4: Learn the immobilization of yeast/microbes
CO5: Determine the growth curve, growth rate, yield and hydrolytic activity of microorganisms.
CO6: Comprehend microbial production of compounds of commercial importance.

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	1	3	2	3
CO2	3	3	3	3	3	3	3	3	2	3	3	3	2	3	2	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	2	3	3	3	2	3	2	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	2	3	3	3	2	3	2	3

Semester-VII **19IBTT71: Biomolecules and Metabolism** **Credits: 4**
Hours: 4

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

Unit-1 Proteins-I

Amino acids - structure and properties. 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 of fibrous proteins.
Supersecondary 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, α+β domains. Structural motifs - protein family and superfamily. Quarternary 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. Collagen triple helix.

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. 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. DNA-protein interaction- HTH, HLH, Zinc finger, Leucine Zipper motifs.

Unit-4 Glycosaminoglycans, glycoconjugates and lipids

Glycosaminoglycans - location and biological role of hyaluronic acid, chondroitin sulfate, keratin sulfate, heparin, dermatan sulfate. Sialic acid - significance. Proteoglycans. Glycoproteins and their biological importance. Lectins – function and applications. O-linked and N-linked glycoproteins, GPI linked oligosaccharides. Carbohydrates as information molecules - the sugar code. Blood group antigens and bacterial cell wall polysaccharides.

Fatty acids - saturated, unsaturated and hydroxyl fatty acids. Eicosanoids - biological actions of prostaglandins, thromoxanes, leukotrienes and lipoxins. Phospholipids and glycosphingolipids – biological functions. Steroids - plant and animal sterols, structure, properties and functions of cholesterol. Lipoproteins - classification and composition. Micelles, emulsions and liposomes. Novel role of lipids as signals, cofactors and pigments (an overview).

Unit-5 Metabolism

Bioenergetics: High energy phosphate compounds. Electron transport chain: Oxidative phosphorylation. Anabolism and catabolism. Carbohydrate metabolism (structure not required) – Brief outline of glycolysis and citric acid cycle. Lipid metabolism (structure not required): Brief outline of fatty acid oxidation and lipogenesis. Catabolism of amino acid nitrogen and urea cycle. Catabolism of carbon skeleton (structure not required).

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. Berg, Tymoczko. Stryer Biochemistry. Freeman. 8th ed. 2015.

Supplementary Reading

Blackburn et al. Nucleic acids in Chemistry and Biology. Royal Soc Chem. 3rd ed. 2006.

Course Outcomes

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

CO1 : Know the structural organization of proteins and understand the terms domains and motifs in describing protein structure.

CO2 : Understand the basic and alternate structural forms of DNA, types of RNA and their functions.

CO3 : Identify the motifs by which proteins interact with DNA

CO4: Apprehend the significance of major glycoconjugates, the biological functions of lipids and the composition of lipoproteins.

CO5: Describe the anabolic and catabolic reactions of major biomolecules.

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

Semester-VII **19IBTT72: Molecular Cell Biology** **Credits: 4**
Hours: 4

Learning Objective (LO): To learn in detail about the molecular organization of cells, cell division, membrane transport and cellular response to external stimuli.

Unit-1 Cell and Tissue Organization

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

Unit-2 Membrane Composition and Transport

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

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

Unit-3 Cell-cell Adhesion and Secretory Pathway

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

Overview of secretory pathway, Translocation of secretory proteins across the ER Membrane. Golgi and Post-Golgi Protein Sorting and Proteolytic Processing. Receptor-Mediated Endocytosis and the Sorting of Internalized Proteins. Molecular Mechanisms of Vesicular Traffic.

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

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

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

Unit-5 Cell Signaling

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

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. Karp. Cell and Molecular Biology. Wiley. 8th ed. 2016
2. Lodish et al. Molecular Cell Biology. Freeman. 8th ed. 2017
3. Nelson and Cox. Lehninger Principles of Biochemistry. Freeman. 7th ed. 2017
4. De Robertis, E.D.P. and De Robertis, E.M.F, Cell and Molecular Biology. Lippicott Williams & Wilkins. 8th ed. 2016

Supplementary Reading

Alberts et al. Molecular Biology of the Cell. Garland Sci. 6th ed. 2014

Course Outcome:

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

CO1 : Differentiate prokaryotic and eukaryotic cells.

CO2 : Understand the organizational and functional aspects of cells and organelles.

CO3 : Learn cell-cell communication as well as interaction with outside environment through transport of molecules.

CO4 : Learn how cells respond to external stimuli through the signal transduction mechanisms.

CO5 : Appreciate the molecular events involved in cell division, cell cycle and cell death.

Oucome 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	1	2	2	1	2	3	3	2	3	3	3	2	3	3	2
CO2	3	2	3	3	2	2	3	2	1	3	3	2	3	2	2	3
CO3	3	3	2	2	3	3	3	3	2	3	3	3	2	3	3	2
CO4	3	3	2	1	2	2	3	3	2	3	3	3	2	3	3	2
CO5	3	2	3	3	3	3	3	2	3	3	3	2	3	3	2	3
CO6	3	3	2	2	2	3	3	3	2	3	3	3	3	2	3	2

Semester-VII **19IBTT73: Enzyme Technology** **Credits: 4**
Hours: 4

Learning Objective (LO): To understand the basic concepts of enzyme action, kinetics, and use of enzymes in industry and medicine.

Unit-1 Enzyme - classification, kinetics and inhibition.
Enzymes **-** Classification and IUB nomenclature. Enzyme kinetics steady state kinetics. Effect of pH, temperature, enzyme and substrate concentration. Michaelis - Menten plot, Lineweaver-Burk plot, significance of Km and Vmax.
Kinetics of allosteric enzymes, positive and negative cooperativity. MWC and KNF models. Sequential and nonsequential bisubstrate reactions. Reversible and irreversible inhibition. Effect of competitive, non-competitive and un-competitive inhibitors on Km and Vmax. Brief account on non-protein enzymes and extremozymes.

Unit-2 Functional forms of enzymes and enzymic regulation
Coenzymic role of thiamine pyrophosphate, FAD, NAD, pyridoxal phosphate, coenzyme A, biotin, folic acid and cobalamine. Multienzyme complexes (PDH). Metal-dependent and metalloenzymes. Isoenzymes (LDH).
Enzyme regulation: feedback inhibition and feedforward stimulation. Enzyme repression, induction and degradation. Zymogen activation. Covalent modification of enzymes – phosphorylation. Compartmentation.

Unit-3 Enzyme reactors, engineering and production
Types of reactors (stirred tank, continuous flow), Immobilization of enzymes: principles, parameters, carriers (inorganic, polysaccharides, polymers), binding methods (adsorption, covalent), applications.
Enzyme engineering: principles, steps, enzyme engineering with reference to lysozyme. Enzyme production and purification: enzyme sources (plant, animal, wild type and recombinant microorganisms), Downstream processing of enzymes and chromatographic purification (brief account), processes to improve enzyme yield.

Unit-4 Analytical and Industrial Applications of enzymes
Enzyme electrodes. Biosensors: components, types, (calorimetric, potentiometric, amperometric), applications. Synzymes and solvent engineering. Soluble enzymes- introduction and applications in food, starch processing and detergents. Enzymes of industrial significance: use of enzymes in detergents, textiles, and leather industry, production of glucose syrup, cheese production.

Unit-5 Therapeutic uses of enzymes
Enzymes as diagnostic aids. Therapeutic uses of enzymes: enzymes as thrombolytic agents and digestive aids. Regulations and safety criteria for production of enzymes and their use. Regulations governing use of enzymes produced in wild-type or recombinant organisms.

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

Text Books

1. Palmer T. Understanding Enzymes. Printice Hall. 2004.
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. 2007.

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 basic concepts and the kinetics and regulatory role of enzymes.
CO2 :	Comprehend the methods for enzyme production and immobilization
CO3 :	Design the strategies of enzyme engineering
CO4 :	Apply the methods for large scale isolation, purification and downstream processing of enzymes
CO5:	Apprehend the applications of enzymes as tools in industry and as therapeutics in medicine.

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

Semester-VII **19IBTP74: Core Practical – VI** **Credits: 6**

Practicals in Biomolecules, Cell Biology and Enzyme Technology **Hours: 12**

Learning Objective (LO): To quantitate biomolecules, determine the kinetic parameters of enzymes, identify cells and tissue types.

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

Text Books

1. Nigam. Lab Manual of Biochemistry. Tata McGraw-Hill Education, New Delhi, India. 2008.
2. Becker WM Kleinsmit, LJ, Hardin J, and Bertoni GP. The World of the Cell, seventh edition. Pearson/Benjamin-Cummings, Boston, MA. 2009.

Supplementary Reading

Alan H. Gowenlock. Varley's Practical Clinical Biochemistry. CBS. 6th ed. 2006

Course Outcomes

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

CO1 : Analyze amino acids by qualitative and quantitative methods.

CO2: Estimate nucleic acid by chemical methods.

CO3 : Identify and examine plant cells, tissue types and the phases of cell division.

CO4: Evaluate the factors affecting enzyme activity and immobilize enzymes.

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

Semester-VIII **19IBTT81: Applied Microbiology and Immunotechnology** **Credits: 4**
Hours: 4

Learning Objective (LO): To learn the classification of microorganisms, mechanism of infection and their role in food borne diseases. Also, to know in detain about immune mechanisms advances in immunization practices and immunotechniques.

Unit-1 Introduction
Microbiology - classification of microbes. Ultrastructure of bacteria, cell envelope, cell wall - Difference between Gram positive and Gram negative bacteria, slime, flagella, capsule, pili. Microbial staining principle and types. Viruses Classification, ultrastructure plant, animal and bacterial. Life cycle of bacteriophage - Lytic and Lysogeny.

Unit-2 Food and Medical Microbiology
Infectious diseases - Methods of transmission. Host pathogen interactions and establishment of disease. Antibiotics mode of action. Antibiotic resistance. Antimicrobial agents.
Food poisoning - food borne diseases - bacterial and non-bacterial. Investigation of food borne diseases. Microbial quality and safety. Determination of microorganisms in food -culture, microscopy and sampling methods. Microbiology in food sanitation.

Unit-3 Immunity
Innate and adaptive immunity - Lymphoid organs and cells of immune system. Complement classical and alternate pathways. T-cells and B-cell receptors. Effector mechanisms- phagocytosis, cell mediated immunity- antibody-dependent cellular cytotoxicity (ADCC), MHC proteins - Antigen processing and presentation. Inflammatory response to infection. Transplantaion types. Graft vs host reaction.

Unit-4 Immunization practices and Immune Disorders
Immunization practices - active and passive immunization. Vaccines - killed, attenuated- toxoids. Recombinant vector vaccines - DNA vaccines, synthetic peptide vaccines. Production and applications of polyclonal and monoclonal antibodies. Genetically engineered antibodies. AIDS - pathogenesis. Tumor immunology - tumor antigens, cancer immunotherapy. Elementary details of anti-immunodisorder-SLE

Unit-5 Immunotechniques
Agglutination and precipitation techniques. Immunodiffusion techniques, Immunoelectrophoresis, RIA, Immunoblotting, Avidin - biotin mediated immunoassay. Immunohistochemistry, immunofluorescence. Complement fixation test. HLA typing. ELISA - principle and applications. 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. Joanne m. Willey, Linda Sherwood, Christopher J. Woolverton, Prescott, Harley and Klein's Microbiology. McGraw-Hill Higher Education. 7th ed. 2008.
2. Doyle M.P. and Buchanan R.L. (Ed.) Food Microbiology: Fundamentals and Frontiers. ASM press. 4th ed. 2013
3. Greenwood D et al. Medical Microbiology. Elsevier Churchill Livingstone. 18th Edn. 2012
4. Jenni Punt, Sharon Stranford et al. Kuby Immunology. WH Freeman & Co. 8th ed. 2018.
5. Abbas et al. Cellular and Molecular Immunology. Elsevier. 9th ed. 2018.

Supplementary Reading

1. Roitt et al. Roitt's Essential Immunology. Wiley-Blackwell Sci. 13th ed. 2017.
2. Janeway, C. (Ed), Paul Travers. Immunobiology. Garland Publ. 9th ed. 2017.
3. Brooks G et al. Jawetz Melnick and Adelberg Medical Microbiology. Lange Medical Publications. 27th ed. 2015

Course Outcomes

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

CO1 : Understand the classification of microorganisms and principles of staining.

CO2 : To know about disease transmission, antimicrobial agents and food sanitation

CO3 : Apprehend the importance of immunization practices and the development of novel vaccines.

CO4 : Interpret the association of immune system with cancer, AIDS, autoimmunity and transplantation.

CO5: Demonstrate techniques involving antigen-antibody reactions and learn their biological applications.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO 6
CO1	3	3	3	3	2	2	3	3	3	3	3	3	2	3	2	1
CO2	3	3	3	2	3	3	3	3	2	3	3	3	3	2	3	2
CO3	3	3	2	3	2	2	3	3	3	3	3	2	3	3	3	3
CO4	3	3	3	3	2	3	3	3	3	3	3	3	2	3	3	3
CO5	3	3	3	2	1	2	3	3	2	3	3	2	3	3	2	3

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

Unit-1 Genome Complexity and DNA Replication

DNA sequence elements: unique sequence DNA, repetitive DNA- SINEs, LINEs, satellite, minisatellite and microsatellite DNA. C-value paradox. Structure of protein coding genes. Brief account of gene families, pseudogenes. DNA replication. 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.

Unit-2 Mutation and Recombination

DNA damage by physical and chemical agents. DNA repair - photoreactivation, excision repair, mismatch repair, SOS response, double strand break repair.

Mutations: types. Point mutations, frameshift mutations, and Suppressor mutations - nonsense and missense suppression. Recombination: Homologous recombination - the Holliday model, molecular basis. Site-specific recombination - generation of immunoglobulin receptor diversity. Transposition - transposons. Mechanism of transposition in bacteria and eukaryotes. Consequences and applications of transposition.

Unit-3Transcription 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, 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 in Prokaryotes and Eukaryotes

Basic principles of gene regulation - levels of gene expression, definition of housekeeping genes, upregulation and downregulation.

Regulation of gene expression in prokaryotes: The *lac* operon. Attenuation and the *trp* operon. Regulation of r-protein operons. Regulation of gene expression in eukaryotes - Transcriptional regulation by steroid hormone receptors, phosphorylation (STAT proteins). Translational regulation (globins). Translational regulation of GAL genes transcription in yeast - Gene silencing - RNA interference. Epigenetic regulation: DNA methylation, HATs and HDACs.

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 XI. Jones & Bartlett Publ. 2012.
3. Alberts et al Molecular Biology of the Cell. Garland Sci. 6th ed. 2014.
4. Watson. Molecular Biology of the Gene. Pearson Education. 7th ed. 2017.

Supplementary Reading

1. James D. Watson et al. Recombinant DNA: Genes and Genomes- A Short Course. Freeman. 3rd ed. 2006.
2. Richard Twyman. Advanced Molecular Biology. Gardlend Science. 2018.

Course Outcomes

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

CO1 : Comprehend genome complexity and the steps in replication

CO2: Appreciate repair mechanisms and the consequences of DNA mutations and recombination.

CO3 : Figure out the steps in transcription and the significance of post transcriptional processing

CO4 : Gain in-depth knowledge on genetic code, mechanism of protein synthesis and protein sorting.

CO5 : Understand the mechanism involved in gene expression regulation at transcriptional, translational and epigenetic levels.

Outcome Mapping

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

Semester-VIII **19IBTT83: Genetic Engineering** **Credits: 4**
Hours: 4

Learning Objective (LO): To acquire knowledge on cloning strategies, gene expression analysis, genetic engineering techniques and protein and metabolic engineering.

Unit-1 Cloning Strategies
Restriction endonucleases - nomenclature and action. Cloning vectors: Cloning in plasmid vectors (pBR322, pUC18). Bacteriophage lambda vectors - lambda biology, *in vitro* packaging, insertion methods of ligation of insert and vector-host organisms screening methods for recombinant and replacement vectors. M13 vectors. Cosmids. Expression vectors. BACs and YACs. Methods of ligation of insert and vector - host-organisms for cloning. Genomic and cDNA cloning. Screening methods for recombinants. Genomic libraries: construction, evaluation, growing and storing a genomic library. cDNA libraries.

Unit-2 Expression of Cloned Genes
Factors affecting expression of cloned genes. Expression of cloned genes in bacteria. Fusion proteins, increasing protein stability and secretion. Expression in eukaryotic cells: Expression in yeast- yeast vectors. The GAL system, overexpression and secretion of heterologous proteins in yeast. Expression in insect cells: baculovirus system. Mammalian cell expression systems. Tagged proteins and secretion signals.

Unit-3 Gene Expression Analysis
Analysis of transcription by northern, RNase protection, RT-PCR, *in situ* hybridization, and primer extension assays. Comparison of transcriptomes by differential screening, subtractive hybridization, differential display, array-based methods and microarray. Reporter genes - types and uses. Translational analysis by western, immunocytochemistry, immunohistochemistry, and 2-D electrophoresis.

Unit-4 Techniques
Extraction and purification of nucleic acids- cell lysis, extraction, precipitation, centrifugation, denaturation, purification, detection and quantification. Probe preparation and screening libraries with gene probes, antibodies, rescreening, subcloning. PCR: basic principles, optimization, applications. Reverse Transcriptase (RT)-PCR, real-time PCR, RACE, RAPD, inverse PCR, ligase chain reaction. Gene knock - in and knock-out technology. Characterization of DNA-protein interaction - Gel retardation assay, DNase I foot printing.

Unit-5 Site-directed Mutagenesis (SDM), protein and metabolic engineering
SDM-Cassette, oligonucleotide-directed mutagenesis, PCR - based methods. Use of SDM for protein engineering to improve enzymes and therapeutic proteins. Protein engineering by directed evolution and DNA shuffling. Metabolic engineering: designed overproduction of phenylalanine, novel routes to small molecules. Combinatorial biosynthesis. Synthetic biology (Brief outline). Hazards and safety aspects of genetic engineering.

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

Text Books

1. Glick and Pasternak. Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press. 4th ed. 2010.
2. Dale and von Schantz. From Genes to Genomes: Concepts and applications of DNA technology. Wiley-Interscience. 3rd ed. 2011.
3. Sandy B. Primrose and Richard Twyman and Bob Old. Principles of Gene Manipulation. Wiley-Blackwell. 6th ed. 2002.

Supplementary Reading

1. Winnacker EL. From Genes to Clones. VCH Publ. 1987.
2. Sandy B. Primrose and Richard Twyman. Principles of Gene Manipulation and Genomics.Wiley-Blackwell. 7th ed. 2006.
3. James D. Watson et al. Recombinant DNA: Genes and Genomes- A short course. Freeman. 3rd ed. 2006.

Course Outcomes

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

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

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

Semester-I **19IBTP84: Core Practical – VII** **Credits: 6**

Practicals in Immunotechnology, Molecular Biology and Genetic Engineering **Hours: 12**

Learning Objective (LO): To isolate and analyze nucleic acids and proteins by molecular biology techniques and perform antigen - antibody reaction *in vitro.*

1. Identification of blood groups and Rh typing.
2. Radial Immunodiffusion.
3. Double diffusion.
4. Agglutination, rosette formation, complement fixation.
5. Immunoelectrophoresis.
6. Isolation of DNA.
7. Isolation of RNA from yeast.
8. Thermal denaturation of DNA.
9. UV absorption spectrum of proteins and nucleic acids- Demonstration.
10. Isolation of bacterial chromosomal and plasmid DNA and characterization by electrophoresis.
11. DNA electrophoresis in agarose gel and southern hybridization
12. SDS-PAGE of proteins and Western hybridization.
13. RNA isolation and cDNA synthesis.
14. RT-PCR
15. Real-time qPCR (Demonstration)

Text Books

1. J Sambrook & D. W. Russell. Molecular cloning: a laboratory manual. Vol 1,2 & 3, CSHL Press. 2006
2. G.K.Pal & P. Pal. Textbook of Practical Physiology. 2nd ed. Orient Blackswan. 2006
3. T S Work and E Work. Laboratory techniques in biochemistry and molecular biology. Amsterdam, North-Holland Pub. Co. 2009

Course Outcomes

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

CO1 : Perform and interpret immunodiffusion and immuno electrophoresis.

CO2 : Isolate and analyze nucleic acids from various sources.

CO3 : Separate proteins in a biological sample by SDS-PAGE and study protein abundance by western blotting.

CO4 : Identify blood groups and Rh factor

CO5: Undertake PCR analysis and know about real time qPCR

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

Semester-IX **IBTT91: Analytical Techniques and Nanobiotechnology** **Credits: 4**
Hours: 4

Learning Objective (LO): To learn the principle, operation and applications of bioanalytical instruments and about the principles of nanobiotechnology.

Unit-1 Spectroscopic and Microscopic Techniques

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

Basic principles and components of light, bright field, phase contrast, fluorescence microscopy. Principles and applications of TEM, SEM and confocal microscopy.

Unit-2 Chromatographic Techniques

General principles of partition and adsorption chromatography. Principle, instrumentation and applications of paper, thin layer and gas chromatography. Column chromatography - packing, loading, eluting and detection.

Principle, procedure, and applications of ion-exchange, molecular exclusion, and affinity chromatography. HPLC, HPTLC- principle, instrumentation and applications.

Unit-3 Electrophoresis and Blotting Techniques

Electrophoresis: General principles. SDS-PAGE, isoelectric focusing and 2-D PAGE. Agarose gel electrophoresis, Detection, estimation and recovery of proteins in gels. Pulsed field gel electrophoresis.

Hybridization techniques: Southern, Northern, Western and Southwestern.

Unit-4 Centrifugation and Radioisotope Techniques

Basic principles of sedimentation. Low - speed and high-speed centrifuges. Ultracentrifuges. Analytical and preparative ultracentrifuge - instrumentation and applications. Basic principle and technique of subcellular fractionation by differential centrifugation. Density - gradient centrifugation-rate zonal and isopycnic.

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

Unit-5 Nanobiotechnology

Nanobiology - concepts, definitions. Basics of nanobiotechnology. Techniques for visualization of biomolecules at nanoscale - atomic force microscopy, optical microscopy TEM, SEM, FRET, magnetic resonance microscopy. Production of nanaparticles: collision/coalescence mechanism. Biological synthesis of nanoparticles by fungi, bacteria, yeast and actinomycetes.

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. Goodsell G S. Bionanotechnology: Lessons from nature. John Wiley. 2006.
4. Dinh V. Nanotechnology in Biology and Medicine: Methods, Devices and Applications. CRC Press. 2007

Supplementary Reading

1. Sambrook. Molecular Cloning. Cold Spring Harbor Laboratory. 4th ed. 2012.
2. Sambrook and Russell. The Condensed Protocols from Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory. 2006.
3. Friefelder and Friefelder. Physical Biochemistry- Applications to Biochemistry and Molecular Biology. WH Freeman & Co. 1983.
4. Pavia, Lampman, Kriz and Vyvyan. Introduction to Spectroscopy. Cengage Learning. 5th ed. 2015.
5. Rodney. F. Boyer. Modern Experimental Biochemistry. Pearson education, Inc. 3rd ed. 2000.

Course Outcomes

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

CO1 :	Understand the principle, components and applications of spectroscopic and radioisotope techniques.
CO2 :	Learn the principle, procedure and applications of different chromatographic techniques.
CO3:	Apply electrophoretic and hybridization techniques for biomolecule separation.
CO4:	Apply the techniques of sedimentation and microscopy for research.
CO5:	Understand the concept of nanobiotechnology and apply the scientific knowledge for solving problems in biology and medicine.

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

Semester-XI **19IBTT92: Industrial and Environmental Biotechnology** **Credits: 4**
Hours: 4

Learning Objective (LO): To gain knowledge on the principles and techniques of bioprocessing, downstream processing, and to learn the role of biotechnology for environmental management and energy production.

Unit–1 Bioprocessing and bioreactors

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

Unit-2 Downstream processing

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

Industrial production, harvest and uses of enzymes, antibiotics (tetracycline, streptomycin), vitamins (B_2, B_{12}), amino acids (glutamic acid, threonine), organic acid (acetic acid) and organic solvents (acetone, butanol and glycerol).

Unit-3 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: D.O, B.O.D and C.O.D Treatment for wastewaters of distillery, dairy, and tannery industries.

Unit-4 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 cleanup. Bioremediation of contaminated soil and waste land. Biofertilisers - Definition - types and application methods. Biopesticides in integrated pest management- *Bacillus* and baculoviruses as biocontrol agents. Biodegradable plastics. Biofilms.

Unit-5 Alternative Energy Sources and Green Technology

Renewable sources of energy (solar, wind, biogas, energy biofuels, cellulose); Biogas production-hydrogen production using hydrogenase and nitrogenase. Biofuels. Conservation of energy. 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. Development of stress resistant plants. Biodiversity - Alpha and beta diversity. Extinction and endangered species. Conservation of biodiversity. *In situ* and *ex situ*- gene banks, species conservation.

Current Streams of Thought

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

Text Books

1. Ratledge and Kristiansen. Basic Biotechnology. Cambridge Univ. Press. 3rd ed. 2006.
2. Casida L.E. JR Industrial Microbiology. Wiley Eastern reprint. John Wiley and Sons Inc. 3rd ed. 1987.
3. John E. Smith. Biotechnology Cambridge University Press. 5th ed. 2009
4. Gupta PK. Elements of Biotechnology, Rastogi Publication, 2nd ed. 2010.
5. Scragg A. Environmental Microbiology 2nd ed. Am Society for Microbiology. 2005.

Supplementary Reading

1. Flickinger and Drew (eds). Encyclopedia of Bioprocess Technology. 5 vol. John Wiley & Sons, 1999.
2. Primrose Twyman and Old. Principles of Gene Manipulation. Wiley. 6th ed. 2002.
3. Ahmed N. Industrial and Environmental Biotechnology. Horizon Scientific Press. 2014.

Course Outcomes:

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

CO1 :	Understand types of bioreactors, fermentation process and bioprocessing.
CO2 :	Know the requirements for successful operation of downstream processes for production of biopharmaceuticals.
CO3 :	Apprehend the harmful effects of pollution and biotechnological measures for pollution control.
CO4 :	Apply biotechnological process in waste management, cleanup of environment and agricultural improvement.
CO5 :	Comprehend the fundamentals of biodegradation, biotransformation and bioremediation and apply biotechnological innovation in conservation.
CO6:	Recognize the importance of renewable energy sources and green technology.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PS O6
CO1	3	3	2	3	2	3	3	3	3	3	3	3	2	3	3	3
CO2	3	2	3	2	3	3	3	3	2	3	3	2	3	3	2	3
CO3	3	3	2	2	2	3	3	3	3	3	3	3	2	3	3	3
CO4	3	3	2	3	3	3	3	3	3	3	3	3	2	3	3	3
CO5	3	2	3	2	3	3	3	3	2	3	3	2	3	3	2	3
CO6	3	3	2	3	2	3	3	3	3	3	3	3	2	3	3	3

Semester-IX **19IBTT93: Plant Biotechnology** **Credits:4**
Hours:4

Learning Objective (LO):

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

Unit-1 Plant Tissue Culture

Plant tissue culture-Scope and importance in crop improvement. Totipotency and morphogenesis. Use of growth regulators. Callus and suspension cultures. Regeneration. Organogenesis and somatic embryogenesis - techniques and applications. Anther, ovary, embryo and meristem culture. Somatic hybridization. In vitro pollination and fertilization. Synseed production. Large-scale culture of plant cells. Production of biochemicals from cultured plant cells. Micropropagation. Somaclonal and Gametoclonal variation. Cryopreservation and ex situ conservation of germplasm. Production of haploid plants and uses of haploids in plant breeding. Protoplast isolation, culture and fusion.

Unit-2 Gene Delivery Methods

Agrobacterium tumefaciens mediated transformation- Ti plasmids (cointegrate and binary vectors), direct nuclear transformation (protoplast transformation, particle bombardment), Ri plasmids, viral vectors (CaMV, gemini, TMV), chloroplast transformation and its advantages. Use of reporter genes in transformed plant cells. *Arabidopsis* floral tip transformation.

Unit-3Techniques in transgenesis.

Selectable markers for plants - drug resistance and herbicide resistance markers. DNA markers in plant genome analysis. RFLPs, RAPDs, DNA fingerprinting- general principles and applications in plant biotechnology. Insect resistance plants- *cry* genes of *B.t.,* their proteins and target insects, *cry* gene expression in plants, insect resistance to Cry proteins. Strategies to obtain virus resistant transgenic plants. Herbicide resistance and stress- and senescence - tolerant and disease-resistant plants.

Unit-4 Gene Manipulation

Modification of seed protein quality. Long shelf life of flowers. Suppression of endogenous genes by antisense (delayed ripening) and ribozyme approaches. Cytoplasmic male sterility. Genetic modification of flower pigmentation. Modification of chloroplast and mitochondrial function. Integration and inheritance of transgenes. Terminator technology. Precise genome editing in plants – CRISPR/cas 9 system.

Unit-5 Advantages of transgenic plants and IPR

Production of biochemicals and vaccines by transgenic plants. Plant secondary metabolites. Regulatory mechanisms and manipulation of phenylproponoid pathway, shikimate pathway, production of alkaloids. Purification strategies. Problems in gene transfer in plants.

Intellectual Property Rights (IPR) - Legal protection of biotechnological invention- World Intellectual Property rights Organisation (WIPO).Types of IPR- Benefits of IPR system- patents, trade secrets, copyright, trademark, TRIPS. Patent application procedure in India.

Current Streams of Thought

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

Text Books

1. Smith RH. Plant Tissue Culture. Elsevier. 3rd ed. 2013.
2. Sandy B. Primrose, Richard Twyman and Bob Old. Principles of Gene Manipulation and Genomics. Blackwell Sci. 8th ed. 2016.
3. Glick and Pasternak. Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press. 4th ed. 2010.
5. James D. Watson et al. Recombinant DNA: Genes and Genomes-A Short Course. Freeman. 3rd ed. 2006.

Supplementary Reading

Slater A. Plant Biotechnology: The Genetic Manipulation of Plants. Oxford Univ Press. 2nd ed. 2008.

Course Outcomes:

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

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

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

Semester-IX **19IBTT94: Animal Biotechnology** **Credits: 4**
Hours: 4

Learning Objective (LO):
To gain knowledge on animal cell culture, gene manipulation, principles of cloning and transgenic animal technology and safety. Also, to know the ethical principles underlying biotechnology research and develop entrepreneurship skills.

Unit-1 Animal Cell Culture
Advantages and limitations of animal cell culture. Biology of cultured cells - cell adhesion, proliferation, morphology. Basic equipment and culture procedures - preparation, sterilization, disaggregation of tissue (mechanical and enzymatic), subculture, contamination. Primary culture, secondary culture and continuous cell lines. Cell based assays- cell viability and cytotoxicity testing. Monolayer, suspension and immobilized cultures.
Organ and histotypic culture - advantages, limitations, applications. Cell lines development - stages. 3D cultures. Scaffold preparation and organogenesis (Brief account only). Whole embryo culture. Somatic cell hybridization. stem cells: types (embryonic and adult), isolation, identification, differentiation and uses, stem cell engineering.

Unit-2 Manipulation of Reproduction in Animals
Artificial insemination, embryo transfer, *in vitro* fertilization. Composition of IVF media - steps in IVF – microinsemination - PZD, ICSI, SUZI, MESA. Embryo transfer in cattle and applications. Somatic cell cloning- cloning of Dolly. Ethical issues. Production of recombinant vaccine for foot and mouth disease.

Unit-3 Gene Transfer Methods
Vectors for gene transfer in animals: retrovirus. Gene constructs- promoter/enhancer sequences for transgene expression in animals. Selectable markers for animal cells- thymidine kinase, dihydrofolate reductase, CAT. Transfection of animal cells - calcium phosphate coprecipitation, electroporation, lipofection, peptides, direct DNA transfer, viral vectors, microinjection.

Unit-4 Transgenic Animal Technology
Methods for producing transgenic animals - retroviral, microinjection, engineered stem cell. Targeted gene transfer. Transgene integration and identification methods. Transgenic cattle, sheep, fish and pigs. Uses of transgenic animals. Transgenic animals as models of human disease. Synthetic biology (brief account).

Unit-5 Biosafety, Bioethics and Entrepreneurship
Biosafety - definition. Biological safety cabinets. Recommended biosafety levels for infectious agents and infected animals. Biosafety regulation in India. Bioethics - definition. Ethical criteria in biotechnology. Ethics of genetically engineered crops. Ethical issues in animal biotechnology. Hazards and safety aspects of tissue culture. Guidelines for use of lab animals in research. Entrepreneurship - definition, needs and importance. Factors necessary for entrepreneurship. Promoting bio-entrepreneurship. Bio-entrepreneurship in India.

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

Text Books

1. Glick and Pasternak. Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press. 4th ed. 2010.
2. Primrose Twyman and Old. Principles of Gene Manipulation. Blackwell Sci. 8th ed. 2016.
3. James D. Watson et al. Recombinant DNA. Genes and Genomes–A Short Course. W.H. Freeman. 3rd ed. 2006.
4. Andreas Hofmann and Samuel Clokie. Wilson and Walker's Principles and techniques of Biochemistry and Molecular Biology. Cambridge University Press. 8th ed. 2018.
5. Singh B.D. Biotechnology. Expanding horizons. Kalyani Publ. 4th ed. 2012.

Supplementary Reading

Freshney RI. Culture of animal cells: A manual of Basic Technique and Specialized Applications. Wiley-Blackwell. 6th ed. 2010.

Course Outcomes:

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

CO1 : Understand the fundamental principles that underlie cell culture and carryout cell based assays.

CO2 : Comprehend the steps in manipulation of reproduction and acquire knowledge in animal cloning.

CO3 : Understand the methods of gene transfer in animals.

CO4 : Comprehend the methods of producing transgenic animals and benefits of transgenesis and related issues.

CO5: Recognize the importance of biosafety practices, ethical guidelines for research and entrepreneurship skill development.

Outcome Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO3	PSO 4	PSO 5	PSO 6
CO1	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3	3
CO2	3	3	3	2	3	2	3	2	3	3	3	2	3	3	2	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3
CO5	3	3	3	2	3	2	3	3	3	3	3	2	3	3	2	3

Semester-IX **19IBTT95: Core Practical – VIII** **Credits: 6**

(Practicals in Analytical Techniques, Nanobiotechnology, Industrial and Environmental Biotechnology and Animal Biotechnology) **Hours: 12**

Learning Objective (LO): To acquire skills in establishing and maintaining cell lines , synthesise nanoparticles and analyze water quality.

1. Separation of proteins by SDS-PAGE.
2. GC and HPLC- Demonstration.
3. Preparation of nanoparticles (silver, zinc or chitosan)
4. Microbial production of citric acid using *Aspergillus niger*.
5. Determination of total dissolved solids in water.
6. Determination of D.O. concentration of water sample.
7. Determination B.O.D. of sewage sample.
8. Determination C.O.D. of sewage sample.
9. Estimation of nitrate in drinking water.
10. Immobilization of yeast/microbe
11. Plant tissue culture techniques: preparation of stock solutions of MS basal medium and plant growth regulator stocks.
12. Effect of plant growth regulators on various explants for callus induction.
13. Steps in micropropagation (demonstration)
14. Protoplast isolation and culture.
15. Isolation of lymphocytes and viability testing by trypan blue dye exclusion test.
16. Animal cell culture techniques: Surface sterilization techniques, media preparation and storage, membrane filtration, serum inactivation.
17. MTT assay for cell viability
18. Preparation of metaphase chromosomes from cultured cells
19. Demonstration of apoptosis in cultured cell
20. Educational visit to biotechnology industries.

Text books

1. Joseph Sambrook, David William Russell. Molecular cloning: A laboratory manual. 3rd ed. CSHL Press. New York. 2001.
2. John R.W Masters. Animal Cell Culture: a practical approach. 3rd ed. 2000.

Supplementary Reading

H.N. Thatoi , Supriya, Dash, Swagat Kumar Das. Practical Biotechnology: Principles and Protocols. 2017.

Course Outcomes:

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

CO1: Learn the separation of proteins and biological compounds using electrophoresis and chromatography.
CO2: Assess drinking water purity and microbial abundance in sewage samples.
CO3: Synthesize nanoparticles and immobilize microbial cells.
CO4: Undertake chromosomal studies and test viability of lymphocyte preparation.
CO5 Culture cells *in vitro* and perform cell based assays.

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

Semester-X **19IBTT101: Food and Medical Biotechnology** **Credits: 4**
Hours: 4

Learning Objective (LO): To acquire knowledge on food biotechnology, the use of enzymes in food industry and to understand the molecular basis of diseases, diagnosis and therapy.

Unit–1 Food Spoilage and Preservation

Types and sources of microorganisms associated with food. Conditions influencing microbial growth in food. Composition and spoilage of food, meat, fish, milk and milk products, cereals, pulses, nuts and oil seeds, fruits and fruit products, vegetable and vegetable products. Methods of food preservation. Control of microorganisms by retarding growth - low temperature, drying, intermediate moisture, chemicals. Control of microorganisms by destruction - gas treatments, heat, ionization radiation, ultraviolet radiation. canning and packing (Elementary idea).

Unit-2 Fermented foods and Enzymes in Food Industry

Basic principles of food fermentation. Fermented foods : fermented milk- yoghurt, cheese, bread; fermented vegetables- sauerkraut, olives. Fermented meats and fish. Production of beer, wine and vinegar. Pro-, pre - and syn-biotics. Mushroom farming. Use of enzymes in food industry- proteases in food processing, enzymes in baking and dairy industry, enzymes in fruit juice and brewing industry. Pickling and curing.

Unit-3 Molecular Basis of diabetes, atherosclerosis & cancer

Role of tissues and hormones in blood sugar homeostasis. Diabetes mellitus: classification, diagnosis, management, complications. Atherosclerosis: risk factors and management. Cancer- differences between benign and malignant tumours, growth characteristics of cancer cells, mechanism of radiation, virus and chemical carcinogenesis. Oncogenes and tumor suppressor genes (brief account).

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. Bioethics - Food and drug safety. Ethical issues in human gene therapy, human genome analysis and human cloning.

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. Mathews & Montville et al. Food Microbiology: An introduction. ASM Press. 4th ed. 2017.
2. Borem et al Understanding Biotechnology. Pearson. 2011.
3. Adams and Moss. Food Microbiology. Royal SocChem. 4th ed. 2015.
4. Glick and Pasternak. Molecular Biotechnology. ASM Press. 4th ed. 2010.
5. Singh BD. Biotechnology. Kalyani Publ. 4th ed. 2012.

Supplementary Reading

1. Ward OP. Fermentation Biotechnology. John Wiley. 1991.
2. Maulik and Patel Molecular Biotechnology Wiley-Liss. 1997.
3. James D. Watson et al. Recombinant DNA: Genes and Genomes-A Short Course. Freeman. 3rd ed. 2006.

Course Outcomes:

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

CO1 : Understand the factors influencing food spoilage and apply traditional and modern methods of food preservation.

CO2 : Apprehend the uses of fermented foods, enzymes in food industries and concepts in food safety laws and standards.

CO3 : Understand the risk factors and molecular aspects of human diseases.

CO4 : Use diagnostic kits for screening diseases

CO5 : Know the various new therapeutic approaches like nanotherapy, gene therapy and stem cell therapy and related ethical issues

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

Semester-X **19IBTT102: Genomics, Proteomics and Bioinformatics** **Credits: 4**
Hours: 4

Learning Objective (LO): To learn the principles of genome mapping, sequencing and analysis, structural and functional proteomics and basic concepts of sequence, structural alignment, database searching and protein structure prediction.

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 and Applications
Structural proteomics: X-ray and NMR for protein structure analysis. Comparative and homology modeling, secondary structure prediction, fold recognition and *ab initio* prediction. SCOP. Protein sequence analysis: 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, 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. Oxford Univ Press. 4th ed. 2014.
2. Brown. Genomes. Wiley. 5th ed. 2006
3. Hartwell et al. Genetics: From Genes to Genomes. 5th ed. 2014.
4. Twyman. Principles of Proteomics. 2nd ed. 2013
5. Hodgman et al. Instant Notes in Bioinformatics. Taylor and Francis. 2nd ed. 2010.

Supplementary Reading

1. Gibas and Per Jambeck. Developing Bioinformatics Computer Skills. O'Reilly Associates. 2nd ed. 2013.
2. Andreas D. Baxevanis, B. Francis Ouellette. Bioinformatics. A Practical Guide to the Analysis of Genes and Proteins. Wiley Interscience. 3rd ed. 2004.
3. Dale and von Schantz. From Genes to Genomes: Concepts and Applications of DNA Technology. Wiley-Inter science. 3rd ed. 2011.
4. Primrose. Principles of Genome Analysis and Genomes. Wiley-Blackwell. 3rd ed. 2006.

Course Outcomes:

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

CO1: Understand types of gene map, molecular markers 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 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	2	3	2	3	3	3	2	3	3	3	2	3	3	3
CO2	3	3	3	2	3	2	3	2	3	3	2	2	3	3	3	2
CO3	3	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3
CO4	3	3	2	3	2	3	3	3	2	3	3	3	2	3	3	2
CO5	3	3	3	2	3	2	3	2	3	3	2	2	3	2	3	3
CO6	3	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3

Semester-X **19IBTP103. Core Practical – IX** **Credits: 6**

(Practicals in Bioinformatics, Food and Medical Biotechnology) **Hours: 12**

Learning Objective (LO): To learn and use bioinformatics tools and acquire skills in food microbiology and in analysing biochemical parameters for clinical relevance.

1. Nucleotide and protein databases - Sequence alignment and searching
2. Multiple sequence alignment
3. Phylogenetic analysis
4. Protein sequence analysis, structure prediction
5. Primer designing
6. SNP and ORF finding in DNA sequence
7. Visualization tools.
8. Molecular modeling.
9. Dehydration of fruits and vegetables. Preparation of fruit juice powders.
10. Isolation of microbes from spoiled vegetables.
11. Preparation of fruit juice concentrates and use of enzymes for clarity.
12. Identification & characterization of proteins resolved on 2D PAGE (Demonstration).
13. HPTLC and GC-MS- (Demonstration).
14. Structure determination of proteins and nucleic acids by NMR & XRD- (Demonstration).
15. Aseptic packaging, freeze preservation, drying and dehydration, food fermentation, pickling and curing.
16. Preservation of food products using chemical preservatives.
17. Tissue collection, formalin fixation, sectioning, and staining.
18. Determination of biochemical analytes by autoanalyser (Demonstration).
19. Estimations of cholesterol and blood glucose
20. Use of ELISA for disease diagnosis- (Demonstration).

Text Books

1. Michael Agostino. Practical Bioinformatics,1st ed Garland science. 2013.
2. Ashish **S** Verma. Laboratory Manual for Biotechnology Paperback. 2014 ,Sultan chand and Company.

Course Outcomes:

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

CO1: Retrieve, align and analyze protein and nucleic acid sequences and structures
CO2 : Adopt appropriate tools to model and visualize proteins
CO3 : Acquire skills for preservation of foods and to check food quality
CO4 : Quantitatively analyze blood parameters of clinical importance and acquire skills in histology
CO5 : Gain and insight into the handling of ELISA, HPTLC, autoanalyser, 2D-PAGE, NMR and XRD.

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

Ancillary Offered to Other Departments

19IBTA15: Biochemistry- Paper I

Credits: 4
Hours: 4

Learning Objective (LO): To learn about laws of thermodynamics, basics of enzymology, structure and functions of amino acids, proteins, carbohydrates and lipids.

Unit–1 Bioenergetics

Laws of thermodynamics. Basic concepts of free energy, entropy and enthalpy. Standard free energy change. Exergonic and endergonic reactions. Bioenergetics: high energy phosphate compounds, the ATP/ADP cycle. Electron transport chain: components. Oxidative phosphorylation - Chemiosmotic theory. Introduction to metabolism-anabolism and catabolism.

Unit-2 Enzymes

Nomenclature and classification. Enzyme units. Factors affecting enzyme activity - substrate, pH, and temperature. Michaelis-Menten equation and Lineweaver Burk plot. Enzyme inhibition-competitive, non-competitive and uncompetitive (derivation of rate equation not required), allosteric enzymes, feedback inhibition. Coenzymes and isoenzymes. Applications of enzymes in clinical diagnosis and therapy.

Unit-3 Carbohydrates

Classification and general properties of carbohydrates. Biologically important monosaccharides and disaccharides. Homopolysaccharides: structure and biological functions of starch, glycogen, and cellulose. Heteropolysaccharides: biological role of glycosaminoglycans. Carbohydrate metabolism-glycolysis, citric acid cycle, gluconeogenesis, glycogen metabolism.

Unit-4 Amino acids and Proteins

Classification. Biologically important peptides. Proteins - classification, functions, and denaturation. Orders of protein structure: Primary, secondary (α-helix, β-pleated sheet), supersecondary, tertiary, and quaternary structures Urea cycle, catabolism of carbon skeletons (overview only). Conversion of amino acids to specialized products.

Unit-5 Lipids and Biomembrane

Classification of lipids. Structure and functions of cholesterol. Brief account of lipoproteins. Lipid metabolism: β-oxidation of fatty acids, biosynthesis of fatty acids. Biosynthesis of ketone bodies, utilization and clinical significance. Membrane structure - lipid bilayer, integral and peripheral proteins, the fluid mosaic model.

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 Publishers, 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 bioenergetics principles.
CO2:	Understand the classification, nomenclature, kinetics, inhibition and applications of enzymes
CO3:	Learn the classification, properties of carbohydrate and understand their biological functions.
CO4:	Understand the biochemistry of amino acids and proteins.
CO5:	Know the composition of various types of lipids, their biological functions and membrane structure.
CO6:	Understand the metabolic reaction of carbohydrates, proteins and lipids.

Outcome Mapping

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

19IBTA26: Biochemistry-Paper II

Credits: 4
Hours: 4

Learning Objective (LO): To acquire a comprehensive knowledge on biomolecules and their functions and biochemical basis of diseases.

Unit -1 Vitamins and minerals.
Sources, requirements, biological actions and clinical significance of fat-soluble (A, D, E, and K) and water - soluble (thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, biotin, folic acid and vitamin B_{12}) vitamins. Biological functions and clinical significance of calcium, phosphate, and iron.

Unit-2 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. Minor classes of RNA.

Unit-3 DNA and RNA biosynthesis
The central dogma of molecular biology. DNA replication- enzymes, basic mechanism and inhibitors. DNA damage. DNA repair - photoreactivation, excision repair. Transcription - RNA polymerase, overview of steps, inhibitors. Brief account of post-transcriptional modifications. Reverse transcription (concept only).

Unit- 4 Translation and Recombinant DNA Technology
Genetic code-general features. Translation-steps. Inhibitors. Post-translational modifications. The lac operon model.
Recombinant DNA technology: Basic steps in cloning. Restriction endonucleases, cloning vectors (e.g. pBR322). Gene transfer methods (electroporation, lipofection, microinjection). Screening of recombinants by marker inactivation. Applications of rDNA technology.

Unit-5 Nutritional and biochemical disorders
BMR. Essential amino acids and fatty acids. Protein quality. Protein energy malnutrition: marasmus and kwashiorkor. Obesity: causes and consequences. Inborn errors of metabolism (PKU only). Diabetes mellitus: classification, diagnosis, management. Atherosclerosis: risk factors, and management. Jaundice: classification, diagnosis and management.

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. Nicholls DTS. An Introduction to Genetic Engineering. Cambridge Univ Press. 3rd ed. 2008.
4. Satyanarayana U. Biochemistry. Books and Allied Publishers. 5th ed. 2017.

Supplementary Reading

1. J. L. Jain Fundamentals of Biochemistry. 7th ed.
2. 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 nutritional and biochemical aspects of vitamins and minerals.
- CO2 : Learn the structure and functions of nucleic acids.
- CO3 : Understand the process of DNA replication, damage and repair and the transcription
- CO4 : Gain knowledge on the phases of translation and fundamental aspects of recombinant DNA technology
- CO5 : Understand the clinical conditions arising from malnutrition, over nutrition and in born errors in metabolism and biochemical basis of diabetes mellitus, atherosclerosis and jaundice

Outcome Mapping

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

19IBTP27: Biochemistry Practical (Ancillary)

Credits: 2
Hours: 4

Learning Objective (LO): To learn the preparation of solutions and analyze biomolecules.

1. Preparation of buffers.
2. Qualitative analysis of carbohydrates
3. Qualitative analysis of amino acids.
4. Estimation of protein by Biuret/Lowry et al method
5. Determination of acid number/iodine number/saponification value of a fat.
6. Separation of lipids by TLC (demonstration)
7. Estimation of ascorbic acid in lemon.
8. Isolation of DNA from rat liver and estimation of DNA by diphenylamine method.
9. Estimation of RNA by orcinol method.
10. Estimation of glucose.
11. Estimation of cholesterol.

Supplementary Reading

1. David Plummer. An Introduction to Practical Biochemistry. Paperback. 2017.
2. Alan H. Gowenlock. Varley's Practical Clinical Biochemistry. CBS. 6th ed. 2006
3. Todd & Stanford. Clinical Diagnosis and Management by Laboratory Methods. 16th ed. 2016.

Course Outcomes:

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

CO1: Prepare reagents and buffers
CO2 : Analyze quantitatively / qualitatively carbohydrates, amino acids, and proteins.
CO3 : Determine the characteristics of fatty acids in oil samples.
CO4 : Analyze the concentration of glucose and cholesterol in biological samples.
CO5 : Isolate and estimate DNA and RNA concentrations in biological samples.

Outcome Mapping

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

Department Elective (DE)

Semester-I **19IBTTE16.1: Biofertilizers** **Credits: 3**
Hours: 3

Learning Objective (LO): To gain comprehensive knowledge on types and importance of biofertilizers, cyanobacteria and organic agriculture.

Unit 1: Introduction
Biofertilizers: Introduction and types and importance of biofertilizers. Classification of biofertilizers microorganisms used in biofertilizers production. General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.

Unit 2: Azospirillum
Isolation and mass multiplication – carrier based inoculant, associative, effect of different microorganisms. Azotobacter: classification, characteristics – crop response to Azotobacter inoculum, maintenance and mass multiplication, cultivation and inoculation

Unit 3: Cyanobacteria (blue green algae)
Azolla and Anabaena azollae association, mechanism and enzymes involved in nitrogen fixation, factors affecting growth, blue green algae as bioferilizer and Azolla in rice cultivation.

Unit 4: Mycorrhizal association
Types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

Unit 5: Organic agriculture
Green manuring and organic fertilizers, Recycling of biodegradable, municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – applications.

Text books

1. Dubey, R.C. A Text book of Biotechnology S.Chand & Co, New Delhi. 2007
2. Kumaresan, V. Biotechnology, Saras Publications, New Delhi. 2012
3. John Jothi Prakash, E. Outlines of Plant Biotechnology. Emkay Publication, New Delhi. 2009
4. Sathe, T.V. Vermiculture and Organic Farming. Daya publishers. 2010
5. Subha Rao, N.S. Soil Microbiology, Oxford & IBH Publishers, New Delhi. 2012
6. Vayas,S.C, Vayas, S. and Modi, H.A. 2008 Bio-fertilizers and organic Farming Akta Prakashan, Nadiad. 2008

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

CO1:	Discuss the types and importance of biofertilizers
CO2:	Know the isolation and mass multiplication of Azospirillum
CO3:	Describe the types and characteristics of cyanobacteria
CO4:	Understand the types and importance of mycorrhizal association
CO5:	Understand the risk factors and significance of organic agriculture

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

Semester-I **19IBTTE16.2: Evolutionary Biology** **Credits: 3**
Hours: 3

Learning Objective (LO): To gain comprehensive knowledge on evidences of evolution, sources and forces of evolution, evolution of plants and humans.

Unit 1 - Introduction

Pre-Darwinian ideas – List of contributors influencing Darwin indicated as a *timeline.* Lamarckism – Merits and demerits. Darwinism – Merits and demerits, Post-Darwinian era –
Modern synthetic theory; biomathematics and the theory of population genetics leading to Neo-Darwinism.

Unit 2 - Evidences of Evolution

Chemogeny – An overview of pre-biotic conditions and events; experimental proofs toabiotic origin of micro- and macro-molecules. Paleobiological – Concept of Stratigraphy and geological timescale; fossil study (types,formation and dating methods). Anatomical – Vestigial organs; Homologous and Analogous organs (concept of parallelism and convergence in evolution). living fossils. Phylogenetic – Fossil based, molecule based – Protein model - cytochrome and gene model (Globin gene family).

Unit 3 Sources and Forces of Evolution

Types of variations – Continuous and discontinuous; heritable and non-heritable. Causes, classification and contribution to evolution – Gene mutation; chromosomal aberrations; recombination and random assortment (basis of sexual reproduction). Natural selection as a guiding force – Its attributes and action Basic characteristics of natural selection. Colouration, camouflage and mimicry, Co-adaptation and co-evolution, Man-made causes of change – Industrial melanism; brief mention of drug, pesticide, antibiotic and herbicide resistance in various organisms.

Unit 4 Evolution of Plants and Fungi

Origin of land plants – Terrestrial algae and Bryophytes; alternation of generations. Early vascular plants – Stelar evolution; Sporangium evolution. Angiosperms – Phylogeny of major groups. Fungi.

Unit 5 Human Evolution

Primate characteristics and unique Hominin characteristics. Primate phylogeny leading to Hominin line. Human migration – Theories. Brief reference to molecular analysis of human origin – Mitochondrial DNA and Y-chromosome studies.

Text Books

1. Ridley, M. (2011) Evolution. III Edn. Blackwell
2. Hall, B. K. and Hallgrimson, B. (2012) Strickberger's Evolution. IV Edn. Jones and Barlett
3. Zimmer, C. and Emlen, D. J. (2013) Evolution: Making Sense of Life. Roberts & Co.
4. Futuyma, D. (2014) Evolutionary Biology. III Edn. Sinauer Assoc. Inc.
5. Barton, Briggs, Eisen, Goldstein and Patel. (2017) Evolution. Cold Spring Harbor Laboratory Press.

Course Outcomes

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

CO1: Discuss the Pre-Darwinian ideas
CO2: Know the evidences of evolution
CO3: Describe the sources and forces of evolution
CO4: Understand the evolution of fungi and plants
CO5: Understand the evolution of humans

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

Semester-I **19IBTTE16.3: Public Health and Management** **Credits: 3**
Hours: 3

Learning Objective (LO): To gain an understanding on pollution, waste management, management of communicable and non-communicable diseases.

Unit 1: Introduction
Sources and causes of Environmental hazards, identification and accounting of hazards, fate of toxic and persistent substances in the environment, dose Response Evaluation, exposure assessment and tests.

Unit 2: Pollution
Air pollution: definitions, types of pollutants, causes, sources, effects and prevention. Water pollution: , definitions, types of pollutants, causes, sources, effects and prevention, noise pollution sources and effects. Global warming.

Unit 3: Waste Management and hazards
Types and characteristics of wastes, Biomedical waste handling and disposal, Nuclear wastehandling and disposal, Waste from thermal power plants. Case histories on Bhopal gas tragedy, Chernobyl disaster, Seveso disaster and Three Mile Island accident and their aftermath.

Unit 4: Communicable Diseases
Social and economic factors of disease including role of health services and other organizations: Infectious (Bacterial-Tuberculosis, Typhoid; Viral- AIDS, Poliomyelitis, Protozoan- Leishmaniasis, Malaria);

Unit 5 – Non-communicable Diseases
Lifestyle and Inherited/genetic diseases, brief account of immunological diseases; Risk factors, symptoms, diagnosis and treatment of cancer, diabetes and cardiovascular diseases (brief account only)

Text Books

1. Cutter, S.L. (2009). Environmental Risk and Hazards, Prentice-Hall of India Pvt. Ltd., New Delhi.
2. Kolluru R., Bartell S., Pitblado R. and Stricoff, S. (2006). Risk Assessment and Management Handbook. McGraw Hill Inc., New York.
3. Kofi, A.D. (2012). Risk Assessment in Environmental management, John Wiley and sons, Singapore.
4. Joseph, F. L. and Louver, B.D. (2007). Health and Environmental Risk Analysis fundamentals with applications, Prentice Hall, New Jersey

Course Outcomes:
At the end of the course, the student will be able to:
CO1: Discuss the sources and causes of environmental hazards
CO2: Know the types, causes, sources and prevention of pollution
CO3: Describe the types and characteristics of wastes and disposal
CO4: Understand the social and economic factors of communicable diseases
CO5: Understand the risk factors, symptoms and treatment of non-communicable diseases.

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

Semester-III **19IBTTE36.1: Natural Resource Management** **Credits: 3**
Hours: 3

Learning Objective (LO): To gain comprehensive knowledge on natural resources and sustainable utilization, utilization of land and water, biological resources and forests and contemporary practices in resource management.

nit 1: Natural resources and sustainable utilization
Definition and types of natural resoursce. Concept, approaches of sustainable utilization (economic, ecological and socio-cultural).

Unit 2: Land and water
Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management. Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies.

Unit 3: Biological Resources and forests
Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan). Definition, Cover and its significance (with special reference to India); Major and minor Forest products; Depletion; Management.

Unit 4: Energy
Renewable and non-renewable sources of energy. Growing energy needs, use of alternate energy sources. Case studies. Exponential increase in energy consumption, energy resources including coal, oil, natural gas, nuclear power, wind, and hydroelectricity, impact of energy consumption on global economy, future energy options and challenges

Unit 5: Contemporary practices in resource management
EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management. National and international efforts in resource management and conservation

Text Books

1. Essentials of Environmental Science (2006) Vasudevan, N. Narosa Publishing House, (New Delhi).
2. Ecology, Environment and Resource Conservation (2013) Singh, J. S., Singh, S.P. and Gupta, S. Anamaya Publications, (New Delhi).
3. An Introduction to Sustainable Development (2008) Rogers, P.P., Jalal, K.F. and Boyd, J.A. Prentice Hall of India Private Limited, (New Delhi).

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

CO1 : Understand the natural resources and sustainable utilization
CO2 : Apprehend the utilization of land and water
CO3: Understand the biological resources and forests
CO4: Understand the renewable and non-renewable sources of energy
CO5: Describe the contemporary practices in resource management

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

Semester-III **19IBTTE36.2: Animal Behaviour and Chronobiology** **Credits: 3**
Hours: 3

Learning Objective (LO): To gain comprehensive knowledge on patterns and mechanisms of behaviour, anatomy and physiology of circadian clocks, basics of chronoendocrinology, chronopharmacology, chronotherapy and molecular chronobiology

Unit 1 - Patterns and Mechanisms of Behaviour
Reflexes: Types of reflexes, reflex path, characteristics of reflexes (latency, after discharge, summation, fatigue, inhibition) and its comparison with complex behavior. Orientation: Primary and secondary orientation; kinesis-orthokinesis, klinokinesis; taxis-tropotaxis and klinotaxis, menotaxis (light compass orientation). Learning: Associative learning, classical and operant conditioning, Habituation, Imprinting. Innate behaviour, Instinct, Stimulus filtering, Sign stimuli, Code breakers

Unit 2 - Social Behaviour and altruism
Insects' society; Honey bee: Society organization, polyethism, foraging, round dance, waggle dance, Experiments to prove distance and direction component of dance, learning ability inhoney bee, formation of new hive/queen. Reciprocal altruism, Hamilton's rule and inclusive fitness with suitable examples

Unit 3 – Anatomy and physiology of circadian clocks
Chronobiology – introduction, ubiquity of biological rhythms. Fundamental properties of biological rhythms. Anatomy and physiology of biological clocks. Suprachiasmatic nuclei (SCN) – neuroanatomy and neurochemistry. Afferent and efferent pathways of central biological clock, peripheral clocks.

Unit 4 – Chronoendocrinology, chronopharmacology and chronotherapy
Endocrine rhythms in mammals, ultradian rhythms of hormones, abnormal circadian rhythms of adrenal hormones in Addison's disease and Cushing's syndrome. Basics of chronopharmacology – circadian dependence of drug pharmacokinetics with suitable examples. Circadian rhythms and cancer chemotherapy. Chronotherapy of cancer. Chronobiology of asthma, blood pressure and sleep disorders

Unit 5 - Molecular chronobiology
Circadian clock genes in *Drosophila* (*per*, *tim*, *dbt*, *dclock*, *cycle* and *cryptochrome*), regulation of expression of clock genes, basic actions and interactions among clock gene products, circadian clock genes in mammals and autoregulatory transcriptional feedback loops of clock genes in mammals.

Text Books

1. McFarland D, Animal Behaviour, Pitman Publishing Limited, London, UK. (2014)
2. Manning, A. and Dawkins, M. S, An Introduction to Animal Behaviour, Cambridge University Press, UK. (2012)
3. Williams Text Book of Endocrinology, S. Melmed et al. Saunders. 13th ed. 2015
4. Columbus FH 2010 Trends in Chronobiology Nova Sci Pub Inc. 2010
5. Refinetti R 2012 Circadian physiology 4th edition. CRC Press, Boca Raton, USA 2012
6. Hall FC Genetics and molecular biology of rhythms in Drosophila and other insects, Elsevier, USA 2013

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

CO1 : Understand about patterns and mechanisms of behaviour
CO2 : Apprehend the concepts of social behaviour and altruism
CO3: Understand about anatomy and physiology of circadian clocks
CO4: Understand the basic concepts of chronoendocrinology, chronopharmacology and chronotherapy
CO5: Describe the function and role of circadian clock genes in *Drosophila* and mammals

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

Semester-III **19IBTTE36.3: Plant Biochemistry** **Credits: 3**
Hours: 3

Learning Objective (LO): To gain comprehensive knowledge on plant cell structure, respiration, nitrogen metabolism, plant hormones and secondary metabolites

Unit 1 - Plant cell structure, photosynthesis and carbon assimilation
Plasma membrane, Vacuole and tonoplast membrane, cell wall, plastids and peroxisomes. Structure of PSI and PSII complexes, Light reaction, Cyclic and non cyclic photophosphorylation, Calvin cycle and regulation; C4 cycle and Crassulacean acid metabolism (CAM), Photorespiration.

Unit 2 - Respiration
Overview of glycolysis, Alternative reactions of glycolysis, Regulation of plant glycolysis, translocation of metabolites across mitochondrial membrane, TCA cycle, Alternative NAD(P)H oxidative pathways; Cyanide resistant respiration. Respiration rate

Unit 3 - Nitrogen metabolism
Biological Nitrogen fixation by free living and in symbiotic association, structure and function of enzyme nitrogenase. Nitrate assimilation: Nitrate and Nitrite reductase. Primary and secondary ammonia assimilation in plants; ammonia assimilation by Glutamine synthetase-glutamine oxoglutarate amino transferase (GS-GOGAT) pathway. Seed storage proteins in legumes and cereals.

Unit 4 - Plant hormones and regulation of plant growth
Plant Hormones: Biosynthesis, Physiological effects and mechanism of action of Auxins, Gibberellic acids, Cytokinins, Abscisic acid, Ethylene, Brassinosteroids and Polyamines. Influence of plant hormones on plant growth and development, regulation of plant morphogenetic processes by light.

Unit 5 - Secondary metabolites
Representatives alkaloid group and their amino acid precursors, function of alkaloids, Examples of major phenolic groups; simple phenylpropanoids, Coumarins, Benzoic acid derivatives, flavonoids, tannins and lignin, biological role of plant phenolics, Classification of terpenoids and representative examples from each class, biological functions of terpenoids.

Text Books
1. Plant Biochemistry (2008), Caroline Bowsher, Martin steer, Alyson Tobin, Garland science
2. Biochemistry and molecular Biology of plant-Buchanan. (2005) 6th edition. I K International.
3. Plant Biochemistry by P.M Dey and J.B. Harborne (Editors) (2014) Academic Press

Course Outcomes
At the end of the course, the student will be able to
CO1 : Understand plant cell structure and photosynthesis
CO2 : Apprehend the concepts of respiration in plants
CO3: Understand about nitrogen metabolism
CO4: Understand the basic concepts of plant hormones and regulation of plant growth
CO5: Describe the functions of secondary metabolites

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

Semester-V **19IBTTE55.1: Ecology** **Credits: 3**
Hours: 3

Learning Objective (LO): To understand the importance of ecology, population ecology, ecosystem, community ecology and behavioural ecology.

Unit 1 Introduction
Introduction to Ecology, importance of ecology, History of ecology, Autecology and synecology, levels of organization, major biomes. Laws of limiting factors - Leibigs law of minimum and Shelfords law of tolerance), ecological range (Eury, Steno). Biotic and abiotic ecological factors. Importance of temperature and light as physical factors. Soil- characteristics and horizons

Unit 2 Population Ecology
Population traits, unitary and Modular populations, metapopulation : Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion; population dynamics, r and K selection, density-dependent and independent population regulation; Competition, Niche concept, Gause's Principle

Unit 3 Ecosystem
Concept, components and types of ecosystem with examples. Pond ecosystem (abiotic and biotic components, BOD, eutrophication). Primary and secondary production. Energy flow, linear and Y-shaped energy flow model, food web. Ecological pyramids and Ecological efficiencies with examples. Nutrient cycles

Unit 4 Community Ecology
Community ecology: Community structure: Dominance, diversity, species richness, abundance, stratification; Diversity indices; Ecotone and edge effect; Community dynamics, Viewpoint of succession, Primary and secondary succession, Climax: monoclimax and polyclimax concepts. Concept of keystone, indicator, umbrella and flagship species.

Unit 5 Behavioural ecology
Social, reproductive & territorial behavior, kin selection. Evolution of social behaviour and communication, behavioural adaptations for survival, evolution of habitat selection, tradeoffs, semelparity and iteroparity, reproductive structure and mating system

Text Books
1. Wilkenson DM - Fundamental Processes in Ecology, Oxford University Press, UK, 2012
2. Aber J.D. & Melillo J M - Terrestrial Ecosystems, Saunders Publishers, USA, 2011
3. Smith R.L. Elements of ecology, Leo Smith Publishers, USA, 2015
4. Ricklefs - Economy of nature, Macmillan Learning Publishers, 2018
5. Odum, E.P., (20). Fundamentals of Ecology; 6th Revised edition, Brooks/Cole Publishers 2014

Course Outcomes
At the end of the course, the student will be able to
CO1 : Understand the importance of ecology
CO2 : Understand the concepts in population ecology
CO3 : Describe the components and types of ecosystem
CO4 : Understand the salient features of community ecology
CO5: Understand the fundamentals of behavioural ecology

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

Semester-V **19IBTTE55.2: Biodiversity** **Credits: 3**
Hours: 3

Learning Objective (LO): To understand the components of biodiversity and to learn the tools in the study of biodiversity, bio-prospecting, plant diversity and microbial diversity

Unit 1 Introduction
Components of Biodiversity. Biodiversity crisis and biodiversity loss. Introduction, principles and rules of taxonomy, importance of biodiversity in daily life. Biodiversity and climate change. Types of Ecosystems: India as mega biodiversity Nation. Hot spots and biodiversity in India. Biodiversity and Ecosystem functioning. Plant and Animal systematic. Species concept in biodiversity studies.

Unit 2 Tools in the study of Biodiversity
Endemism, endemic plants and animals**;** Assessment of mapping of biodiversity**;** GIS/Remote sensing**;** Biotechnology and Conservation, IUCN**;** ICZN rules, Germplasm banks, National Parks, Botanical Gardens**;** Wildlife Sanctuaries, Bioresources. Methods of Field data collection for taxonomic studies Use of techniques like net sweeping, pit fall traps, light traps, Berlese funnel, smoking, aspirators, mark-recapture Use of Taxonomic literature and study of key characters for identification of the specimen.

Unit 3 Plant Diversity
Wild relatives of cultivated plant; Domesticated diversity; Spice diversity; Forest diversity and wild life. Plant diversity application, economic botany, Medicinal plants (Plants commonly used in traditional, modern medicine with their uses) Spices and Condiments (Cinnamon, Clove, Pepper) , Beverages (Tea, Coffee, Cocoa) and Timber (Teak, Sal).

Unit 4 Bio-prospecting
Representative type (one each) studies from Cryptogams, Phanerogams, Non-chordates and Chordates**;** Sacred flora and fauna. Bio-prospecting Botanicals for Biocontrol, Health and biodiversity

Unit 5 Microbial diversity
Microbial Diversity. Microbes and Earth History. Magnitude, occurrence and distribution of diverse microorganisms. Concept of species, Criteria for classification, Outline classification microorganisms (bacteria, viruses, algae, fungi and Protozoa). Overview of methods in taxonomy of bacteria

Text Books
1. Aber, J.D.and Melillo J.M., Terrestrial Ecosystems: W.B.Saunders, 2011
2. Ingrowille, M Diversity and Evolution of land plants Chapman and Hall, 2002
3. Gaston KJ, Spicer JI. Biodiversity – an introduction 4th edition, Blackwell, 2014
4. Wilson EO, The diversity of life, Harvard University Press, 2010
5. Krishnamurthy KV, Textbook of biodiversity, Taylor and Francis, 2017

Course Outcomes
At the end of the course, the student will be able to
CO1 : Understand the components of biodiversity
CO2 : Understand the tools in the study of biodiversity
CO3 : Describe the basics of plant diversity
CO4 : Understand the salient features of bio-prospecting
CO5: Understand the fundamentals of microbial diversity and Overview of methods in taxonomy of 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	2	3	2	2	3	3	3	3	3	3	2	1	3	1	3
CO2	3	3	2	3	3	2	3	3	3	3	3	3	2	3	2	3
CO3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	2	2	1	2	3	3	3	3	3	3	2	3	2	3
CO5	3	2	3	3	2	3	3	3	3	3	3	2	3	3	3	3

Semester-V **19IBTTE55.3: Wild Life Conservation and Management** **Credits: 3**
Hours: 3

Learning Objective (LO): To understand about habitat analysis, human-wildlife interactions, concepts of management and sustainable wildlife management

Unit 1 Introduction
Values and ethics of wildlife conservation; importance of conservation. Conservation Vs protection Concept of Buffer zones, Wildlife corridors Strategies to reduce human-wildlife interactions

Unit 2 Habitat analysis
Types of Habitats & their major ecological factors Ecological Succession & climax ecosystems (e.g. Sholas) Maximizing usage of Habitat resources by populations Insular habitats & insular flora & fauna Extreme Habitats and their flora & fauna (Dark Caves, deep sea etc.) Evaluation and management of wild life - Physical parameters and Biological Parameters; Standard evaluation procedures: Faecal analysis of ungulates and carnivores. Geographical Information System (GIS), Global Positioning System (GPS), and Remote Sensing (RS).

Unit 3 Human-wildlife interactions
Poaching, illegal trading, conflict management and shifting from extraction to preservation; effect of extinction of a species on ecosystem; Forest landscape restoration. Conservation Vs protection Concept of Buffer zones, Wildlife corridors Strategies to reduce human-wildlife interactions Role of Government and NGOs in controlling human-wildlife interactions Socio-economic issues related to human-wildlife interaction

Unit 4 Concepts of management
Protected Area Network (PAN), WWFN, IUCN, and CITES. Wild life Legislation – Wild life Protection act (1972), its amendments and implementation. IUCN Red data book and red list categories (only names), Protected areas National parks & sanctuaries, Community reserve; Important features of protected areas in India; Project Tiger and Project Elephant.

Unit 5 Sustainable wildlife management
Natural resource management. Eco tourism / wild life tourism in forests; various Environmental movements in India: Bishnoi movement, Chipko movement, Narmada bachao andolan, Silent valley movement, Baliyapal movement.

Text Books

1. Caughley, G., and A.R.E. Sinclair Wildlife Ecology and Management, Blackwell Science. 2004
2. Woodroffe R., S. Thirgood and A. Rabinowitz. People and Wildlife, Conflict or Coexistence? Cambridge University Press, 2011
3. Bookhout, T.A. Research and Management Techniques for Wildlife and Habitats, 5th edition. The Wildlife Society, Allen Press. 2006
4. Sutherland, W.J. The Conservation Handbook: Research, Management and Policy. Blackwell Sciences 2010
5. Hunter M.L., J.B. Gibbs and E.J. Sterling. Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing. 2009

Course Outcomes
At the end of the course, the student will be able to
CO1 : Understand the ethics of wildlife conservation
CO2 : Understand the salient features of habitat analysis
CO3 : Describe the basics of human-wildlife interactions
CO4 : Understand the concepts of management
CO5: Understand the fundamentals of sustainable wildlife management

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

Semester-VIII **19IBTTE85.1 Clinical Biochemistry** **Credits: 3**
Hours: 3

Learning Objective (LO): This course will enable students to understand the biochemical basis of diseases.

Unit–1 Genetic diseases

Genetic diseases: Patterns of inheritance. Chromosomal disorders: Brief account of Down syndrome. Monogenic disorders (autosomal dominant, autosomal recessive, sex-linked). Prenatal and neonatal screening for inborn errors. Treatment strategies for inborn errors. Collection of blood and urine samples for analysis: precautions and changes on keeping.

Unit-2 Liver and kidney disorders

Structure and functions of the liver. Composition and functions of bile. Jaundice: classification, causes and biochemical findings.

Normal and abnormal constituents of urine. Pathogenesis, biochemical findings and management of nephrotic syndrome.

Unit-3 Diabetes mellitus

Diabetes mellitus - classification, diagnosis and management. Acute complication - diabetic ketoacidosis. Long-term complications - retinopathy, neuropathy, nephropathy and diabetic foot. Atherosclerosis: Risk factors and management.

Unit-4 Cancer

Differences between benign and malignant tumors. Growth characteristics of cancer cells, Morphological changes in tumor cells. Invasion and metastasis. Agents causing cancer - radiation, viruses, chemicals. Oncogenes and tumor suppressor genes (brief account only).

Unit-5 AIDS, obesity and malnutrition disorders.

AIDS - Incidence and clinical diagnosis. The HIV genome, HIV life cycle. Brief account on treatment strategies.

Protein Energy Malnutrition: Marasmus and Kwashiorkor: clinical features and biochemical findings. Obesity: Causes, consequences and management (brief account only).

Text Books

1. Rodwell et al. Harper's. Biochemistry. McGraw-Hill. 31th ed. 2018.
2. Varley. Practical Clinical Biochemistry. CBS Publ. 6th ed. 2006
3. Mayne. Clinical Chemistry in Diagnosis and Treatment. 6th ed. ELBS. 1994
4. Marshall et al. Clinical Chemistry. Mosby. 8th ed. 2016.

Supplementary Reading

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

Course Outcomes:

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

CO1. Comprehend the genetic diseases
CO2. Understand the complications and treatment of liver and pancreatic disorders
CO3. Appreciate the biochemical and molecular basis of cancer and AIDS.
CO4. Gain knowledge on protein energy malnutrition and obesity.

Outcome Mapping

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

Semester-VIII **19IBTTE85.2: Basic Endocrinology** **Credits: 3**
Hours: 3

Learning Objective (LO): To understand the general features of hormone action, physiological and biochemical effects of hormones and to learn about the disorders related to hormonal action.

Unit–1 Hypothalamic and Pituitary Hormones

Definition, classification of hormones, hormone receptor interaction and general mechanism of action. Hypothalamic and pituitary hormones. HPA axis, Hypothalamic releasing factors. Anterior pituitary hormones: growth hormone, ACTH, thyrotrophins, gonadotropins and prolactin. - Biosynthesis and secretion, POMC peptide, biological actions. Neuroendocrine hormones - endorphins, enkephalins, leptin .

Posterior pituitary hormones - biological actions of vasopressin and oxytocin. Hypo and hyper pituitarism - Gigantism, Acromegaly, Cushing syndrome, dwarfism, diabetes insipidus and syndrome of inappropriate ADH secretion (SIADH)

Unit-2 Thyroid and Parathyroid Hormones

Thyroid hormones - synthesis, secretion, regulation, transport, metabolic fate and biological actions. Antithyroid agents. Thyroid function tests. Abnormalities of thyroid function.

Hormonal regulation of calcium and phosphate metabolism - PTH, calcitonin and calcitriol secretion and biological actions. Hypo and hyper parathyroidism, Hypo and hypercalcemia - Rickets and osteomalacia.

Unit-3 Adrenal Hormones

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

Adrenal medullary hormones - Epinephrine and nor epinephrine - synthesis, secretion, metabolism, regulation and biological effects. Pheochromocytoma.

Unit-4 Pancreatic Hormones and Gastrointestinal Hormones

Pancreatic islets - Biosynthesis, metabolic and biological effects and mechanism of action of insulin, glucagon, somatostatin and pancreatic polypetide. Regulation of insulin secretion, Insulin receptor. Hypo and hyperglycaemia - Type I and type II diabetes.

Gastrointestinal hormones -Actions of major GI hormones- Gastrin, secretin, cholecystokinin (CCK) and others - gastro inhibitory polypeptide (GIP), glucagon-like peptide -1 (GLP-1) and ghrelin

Unit-5 Gonadal Hormones

Biosynthesis, regulation, transport, metabolism and biological actions of male sex hormones - androgen and testosterone. Hypogonadism and gynecomastia.

Biosynthesis, regulation, transport, metabolism and biological effects of female sex hormones oestrogen and progesterone. The menstrual cycle. Synthetic estrogens

Text Books

1. S. Melmed et al Saunders. Williams Text Book of Endocrinology. 13th ed. 2015
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. Robert K Murray et al. Harper's. Biochemistry. Appeleton & Lange. 25th ed. 1999.
5. Prakash S Lohar. Endocrinology Hormones and Human Health. MJP publishers. 2005.

Course Outcomes:

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

CO1: Understand the general characteristics of hormone and hypothalamic and pituitary hormone
CO2:. Learn the functions of thyroid and parathyroid secretions and disorders associated with hypo and hyper secretions.
CO3: Gain an understanding of the biological effects of adrenal hormones.
CO4.: Know the hormones of the pancreas and clinical conditions associated with pancreatic insufficiency as well as about GI tract hormones.
CO5: Understand the gonadal hormone functions and associated clinical conditions.

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

Semester-VIII **19IBTTE85.3: Developmental Biology** **Credits: 3**
Hours: 3

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

Unit- I 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. Scott F. Gilbert. Developmental Biology. Sinauer Associates Inc., 10th ed. 2013
4. Lewis Wolpert & Cheryll Tickle. Principles of Development. Oxford University Press, 4th ed. 2011.
5. Klaus Kalthoff. Analysis of Biological Development. McGraw-Hill. 2nd ed. 2000.

Online Resource
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	2	2	2	2	2	3	3	3	3	3	2	2	2	2	2
CO2	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO3	3	2	2	2	2	2	3	2	3	3	3	2	2	2	2	2
CO4	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO5	3	2	2	2	2	2	3	2	3	3	3	2	2	3	3	2

Semester-IX **19IBTTE96.1: 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. Specimen preservation.

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. Tests for specific amino acids, determination of proteins in serum and plasma. Determination of glucose, glucose tolerance test, ketone bodies, 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. Data acquisition and data bank.

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

Semester-IX **19IBTTE96.2 Biotechnology Management** **Credits: 3**
Hours: 3

Learning Objective (LO): This course is intended to train students in different aspects of management pertaining to biotechnology industry in addition to principles of economics and accountancy.

Unit 1 Principles of Management
Concepts of Management: Administrative Management (Planning, Organizing, Staffing, Directing and Controlling), policy formulation, Operative Management (Personnel, Materials, Production, Financial, Marketing, Time/space, Margin/Morale). Motivation, Communication, Decision-making, leadership, Innovation, Creativity, Delegation, Responsibility, Record keeping.

Unit 2 Economics & Accountancy
Economics: Principles of economics with special reference to the laws of demand and supply, demand schedule, demand curves, labour welfare, general principles of insurance and inland and foreign trade, procedure of exporting and importing goods.
Accountancy: Principles of Accountancy, Ledger posting and book entries, preparation of trial balance, columns of a cash book, Bank reconciliation statement, rectification of errors, Profits and loss account, balance sheet. Structure of Indian financial systems.

Unit 3 Portfolio and Project Management
Portfolio Management in the Biotechnology Industry- Balancing corporate need with product delivery to the market, impact of organizational size. Feasibility study. Project Management in Biotechnology Industry Sectors- objectives, sociotechnical considerations, insurance for projects, developing program strategy, risk assessment and management, tracking process, resources planning, management of uncertainty and safety issues. Clinical trials- introduction, organization, investigation, ethics. Regulatory affairs- Regulatory bodies for biotechnology products and compliance. Quality systems and control.

Unit 4 Production and Materials Management
Production Management: Concepts, Visible and Invisible inputs, Methodology of Activities, Performance Evaluation Technique, Process-Flow, Process Knowhow, Product development planning- rationale, targeted product profile, product development plan (clinical, project management, regulatory, nonclinical, quality control). Developing products with added value. Supply chain management- strategy, process.
Materials Management: Basic principles of materials management, major areas, scope, purchase, stores, inventory control and evaluation of materials management. TQM, quality systems and control.

Unit 5 Marketing Management & Entrepreneurship
Principles of marketing, The Product Concept, Brand, Product positioning, Product strategy. Marketing communication, new product launching/development, Principles of advertising. Market Research: Measuring & Forecasting Market Demands, Estimating current demand, Estimating industry sales, Market share & Future demand. Distribution: Channels of distribution, wholesale, retail, departmental store, Chain stores. Transportation and storage. Copyrights, patents.
Entrepreneurship- Entrepreneurial traits, self appraisals, sources of funds. Business planning in Biotech.

Text Books

1. Harpum P. Portfolio, Program and Project Management in the pharmaceutical and biotechnology industries. 2010.
2. M.J. Roy. Biotechnology operations: Principles & Practices. CRC Press. 2011.
3. Biren N Shah, Bhavesh S Nayak, Vineet C Jain; Textbook Of Pharmaceutical Industrial Management; 2010; 1st edition; Elsevier India; ISBN: 9788131225394.

Course Outcomes:

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

CO1: Develop an understanding of the fundamental topics on management.
CO2: Gain knowledge on business economics and project management.
CO3: Get a strong foundation on commercialization of biotechnology products.
CO4: Get the required knowledge to lead and administer biotechnology companies.
CO5: Undertake entrepreneurship ventures.

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

Interdepartment Electives Offered to Other Departments

19BIOX215.1: 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-5 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	3	2	2	3	3	3	3	3
CO2	3	3	2	3	3	2	3	3	2	3
CO3	3	2	3	2	2	3	3	3	3	3
CO4	3	3	2	3	3	2	3	3	2	3

19BIOX215.2: 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	3	2	3	3	2	3
CO2	3	3	3	2	2	3	3	3	3	3
CO3	3	3	2	3	2	2	3	3	2	3
CO4	3	3	3	2	3	3	3	3	3	3
CO5	3	3	2	3	3	2	3	3	2	3

19BIOX315.1: 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. 2009.

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

19BIOX315.2: 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	3	2	2	3	3	2	3	3
CO2	3	3	2	2	3	2	3	3	2	3
CO3	3	2	3	3	2	3	3	2	3	3
CO4	3	3	2	3	3	2	3	3	2	3

Value Added Course
(Offered to Other Faculties Except Faculty of Science)

Phytochemistry and Biological Activities of Medicinal Plants

Credits: 3
Hours: 3

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.

Supplementary Reading

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