ALAGAPPA UNIVERSITY

(A State University Established in 1985)

Karaikudi - 630003. Tamil Nadu, India

2017 Accredited with A+ Grade by NAAC (CGPA : 3.64)

2018 MHRD Govt. of India UGC Graded as Category - I Granted Autonomy

2018 MHRD Swachh Campus Rank : 4

2021 nirf NATIONAL INSTITUTIONAL RANKING FRAMEWORK Rank : 33

2021 UNIVERSITY RANKINGS Asia Rank : 199

FACULTY OF SCIENCE

DEPARTMENT OF BIOTECHNOLOGY

M.Sc., BIOTECHNOLOGY

REGULATIONS AND SYLLABUS

(For the candidates admitted from the Academic Year 2022 - 2023)

DEPARTMENT OF BIOTECHNOLOGY

M.Sc., Biotechnology

REGULATIONS AND SYLLABUS

[For the candidates admitted from the Academic Year 2022 – 2023 onwards]

ALAGAPPA UNIVERSITY

(A State University Accredited with "A+" grade by NAAC (CGPA: 3.64) in the Third Cycle andGraded as Category-I University by MHRD-UGC)

Karaikudi -630003, Tamil Nadu.

ALAGAPPA UNIVERSITY
DEPARTMENT OF BIOTECHNOLOGY
Karaikudi-630003, Tamil Nadu.

REGULATIONSANDSYLLABUS-(CBCS-University Department)
[ForthecandidatesadmittedfromtheAcademicYear2022 –2023onwards]

Name of the Department	: Biotechnology
Name of the Programme	: M.Sc., Biotechnology
Duration of the Programme	: Full Time (Two Years)

Choice-Based Credit System

A choice-Based Credit System is a flexible system of learning. This system allows students to gain knowledge at their own tempo. Students shall decide on electives from a wide range of elective courses offered by the University Departments in consultation with the Department committee. Students undergo additional courses and acquire more than the required number of credits. They can also adopt an inter-disciplinary and intra-disciplinary approach to learning, and make the best use of the expertise of available faculty.

Programme

"Programme" means a course of study leading to the award of a degree in a discipline.

Courses

„Course‟ is a component (apaper) of a programme. Each course offered by the Department is identified by a unique course code. A course contains lectures/ tutorials/laboratory work/seminar/project work / practical training/report writing /Viva-voce, etcora combination of these, to meet effectively the teaching and learning needs.

Credits

The Term "Credit" refers to the weightage given to a course, usually in relation to the instructional hours assigned to it. Normally in each of the courses credits will be assigned on the basis of the number of lectures/tutorials/laboratory and other forms of learning required to complete the course contents in a 15-week schedule. One credit is equal to one hour of lecture per week. For laboratory/field work one credit is equal to two hours.

Semesters

An Academic year is divided into two **Semesters.** In each semester, courses are offered in 15 teaching weeks and the remaining 5 weeks are to be utilized for conduct of examination and evaluation purposes. Each week has 30 working hours spread over 5 days a week.

Medium of instruction

English

Departmental committee

The Departmental Committee consists of the faculty of the Department. The Departmental Committee shall be responsible for admission to all the programmes offered by the Department including the conduct of entrance tests, verification of records, admission, and evaluation. The Departmental Committee determine the deliberation of courses and specifies the allocation of credits semester-wise and course-wise. For each course, it will also identify the number of credits for lectures, tutorials, practicals, seminars etc. The courses (Core/Discipline Specific Elective/Non-Major Elective) are designed by teachers and approved by the Departmental Committees. Courses approved by the Departmental Committees shall be approved by the Board of Studies. A teacher offering a course will also be responsible for maintaining attendance and performance sheets (CIA -I, CIA-II, assignments and seminar) of all the students registered for the course. The Non-major elective programme and MOOCs coordinator are responsible for submitting the performance sheet to the Head of the department. The Head of the Department consolidates all such performance sheets of courses pertaining to the programmes offered by the department. Then forward the same to be Controller of Examinations.

Programme Educational Objectives- (PEO)

PEO-1	Understand the basic concepts of cellular structure, its organization and the functions and importance of various biomolecules. Learn various energy production mechanisms in cells
PEO-2	Understanding the importance of microbial community and cellular/Molecular changes in Animal and Plant system
PEO-3	Describe basics of Physics, Chemistry and Mathematics and their importance in biological field
PEO-4	To enable the students to acquire knowledge on the fundamental aspects of Biotechnology such as Biochemistry, Cell Biology, Microbiology, Environmental Biotechnology and Molecular Biology
PEO-5	To inculcate knowledge to the students with recent advancements and developments in the fields of Genomics, Proteomics, Genetic Engineering, Bioinformatics, Gene therapy, Cell Culture, modern drug discovery and pharmacogenomics approaches
PEO-6	To develop trained biotechnology professionals who can contribute to the continuous improvement of biotechnological services and products
PEO-7	Augmentation of problem-solving skills of students through industry-oriented training programs at various levels
PEO-8	Molding the graduates to effectively disseminate formal scientific written communications and deliver oral presentation
PEO-9	To supplement the academic input of students by periodically conducting seminars, conferences, guest lectures, workshops, publications of papers, books and so on
PEO-10	To facilitate them to understand the advanced concepts of Biotechnology so that the students can take up any challenging career in this field

Programme Specific Objectives (PSO)

PSO-1	To impart basic knowledge in Cellular Molecular Biology, rDNA Technology, Immunobiology and Genetics
PSO-2	To introduce students to developments/ advances made in field of microbial technology, IPR, Biosafety and Bioethics, Pharmacogenomics for use in human welfare and solving problems of the society
PSO-3	To describe fundamental molecular principles of Genetic Engineering which include, genetic mapping, gene expression and molecular diagnostics
PSO-4	To Differentiate and understand immune responses in relation to infection and to understand importance of conventional and new emerging technologies such as vaccination technology
PSO-5	To gain hands- on experience in gene cloning, protein expression and purification

Programme Outcome-(PO)

PO-1	Acquire knowledge on the building blocks of the macromolecules, their chemical properties and their modification and their importance in normal functioning of living organisms. Understand the metabolic pathways and identify how the genetic abnormalities disturb the normal homeostasis and link with pathological conditions.
PO-2	Species specific molecular alterations during different developmental and pathological conditions with specific read-outs as biomarkers
PO-3	Understand the applications of fundamental sciences for various field of biology in the context of Biotechnology.
PO-4	To develop a sense of innovation, creativity and self-confidence to the students in order to help them address the skill gaps in the rapidly expanding field of biotechnology .The student can be aware of environmental Pollution and its related research
PO-5	Application skills and knowledge will be gained from basics to advanced research. Skills to differentiate normal versus abnormal biological system for therapeutic interventions.
PO-6	Improve the skills of investigation, designing and conduct experiments, analyzing and interpreting data, and apply the laboratory skills to solve problems/driven hypothesis
PO-7	Technical and hands-on skills will be applicable in industry and/or institutes wherever necessary which will make them globally competitive
PO-8	Candidates will be enabled to employ the acquired theoretical knowledge
PO-9	Learning the fundamentals of modern biology and advanced technologies improve student's capacity to apply their knowledge of a subject to solve current issues on both a local and global scale is a function of their critical thinking abilities
PO-10	Appreciate their relevance for investigating specific contemporary biological questions

Program Specific Outcomes (PSOs)

PSO-1	Understanding the science in all possible ways and creation of own ideas among the students
PSO-2	Skills will be improved by taking the seminars and assignments. Students will be improved by knowing the rules and regulations to be followed for filing a patent
PSO-3	Understanding genetics will provide disease progression and hereditary importance. Find employment opportunities in R&D of Biotech/Pharma industry, Medical or hospital related organizations, Regulatory Agencies, & Academia.

PSO-4	Encouraging students to pursue research field in future to meet out the challenges (for ex. Pandemics, drug-resistance etc.,)
PSO-5	To enhance student proficiency and encourage them to pursue higher education at reputable National and international levels. Self-assessment to develop scientific career for future leadership

Eligibility for admission

To be able to pursue M.Sc. Biotechnology, the candidate must have passed Bachelor‟s degree in any branch of Science (Biotechnology, Microbiology, Zoology, Botany and Biochemistry) / Agriculture / Pharmacy / Veterinary / Engineering / Medicine (MBBS)/ Medical Lab Technology/ Nursing with a minimum of 50% marks

Minimum Duration of programme

The programme is for a period of two years. Each year shall consist of two semesters viz. Odd and Even semesters. Odd semesters shall be from June / July to October / November and even semesters shall be from November / December to April / May. Each semester there shall be 90 working days consisting of 6 teaching hours per working day (5 days/week).

Components

A PG programme consists of a number of courses. The term "course" is applied to indicate a logical part of the subject matter of the programme and is invariably equivalent to the subject matter of a "paper" in the conventional sense. The following are the various categories of the courses suggested for the PG programmes:

A. Core courses (CC)- "Core Papers" means "the core courses" related to the programme concerned including practicals and project work offered under the programme and shall cover Core competency, critical thinking, analytical reasoning, and research skill.

B. Discipline-specific electives (DSE) means the courses offered under the programme related to the major but are to be selected by the students, and shall cover additional academic knowledge, critical thinking, and analytical reasoning.

C. Projects/Dissertation (Maximum Marks: 200**)**

The student shall undertake the Project/Dissertation during the fourth semester.

Project/Dissertation

The candidate shall undergo Project/Dissertation Work during the final semester. The candidate should prepare a scheme of work for the dissertation/project and should get approval from the guide. The candidate, after completing the dissertation /project work, shall be allowed to submit it to the university departments at the end of the final semester.

If the candidate is desirous of availing the facility from other departments/ universities/ laboratories/ organizations they will be permitted only after getting approval from the guide and HOD. In such a case, the candidate shall acknowledge the same in their dissertation/project work.

- **Format to be followed for dissertation/project report**

The format/certificate for thesis to be followed by the student are given below

- Title page
- Certificate
- Acknowledgment
- Contentas follows:

ChapterNo	Title	Page number
1	Introduction	
2	Aim and objectives	
3	Review of literature	
4	Materials and methods	
5	Result	
6	Discussion	
7	Summary	
8	References	

- **Format of the title page**

Title of Dissertation/Project work

Dissertation submitted in partial fulfillment of the requirement for the degree of MasterofScienceinBiotechnologytotheAlagappaUniversity,Karaikudi-630003.

By

(Student Name)
(RegisterNumber)
University Logo

Department of Biotechnology

Alagappa University

(AStateUniversityAccreditedwith"A+"gradebyNAAC(CGPA:3.64)intheThird Cycle and Graded as Category-I University by MHRD-UGC, 2019: QS ASIA Rank- 216, QS BRICS Rank-104, QS India Rank-20)

Karaikudi-630003

(Year)

- **Format of certificates-**

Certificate-Guide

This is to certify that the thesis entitled"---------- " submitted to Alagappa University, Karaikudi-630 003 in partial fulfilment for the degree of Master of Science in Biotechnology by Mr/Miss----------(Reg No) under my supervision. This is based on the results of studies carried out by him/her in the Department of Biotechnology, Alagappa University, Karaikudi-630 003. This dissertation/Project or any part of this work has not been submitted elsewhere for any other degree, diploma, fellowship, or any other similar titles or record of any University or Institution.

Place: Karaikudi Research Supervisor

Date:_____

Certificate-(HOD)

This is to certify that the thesis entitled**"----------"** submitted by Mr/**Miss ----------(Reg No: ----------)** to the Alagappa University, in partial fulfilment for the award of the degree of **Master of Science** in **Biotechnology** is a bonafide record of research work done under the supervision of **Dr ----------, Professor/** Assistant Professor, Department of Biotechnology, Alagappa University. This is to further certify that the thesis or any part thereof has not formed the basis of the award to the student of any degree, diploma, fellowship, or any other similar title of any University or Institution.

Place: Karaikudi Head of the Department

Date:_____

Declaration (student)

I hereby declare that the dissertation entitled**"----------"** submitted to Alagappa University for the award of the degree of Master of Science in Biotechnology has been carried out by me under the guidance of **Dr**_____, Professor/ Assistant Professor, Department of Biotechnology, Alagappa University, Karaikudi – 630003. This is my original and independent work and has not previously formed the basis of the award of any degree, diploma, associateship,fellowship,oranyothersimilartitleofanyUniversityor Institution.

Place: Karaikudi **(----------)**

Date:_____

Internship

The students shall undergo Internship / industrial training in the reputed organizations for minimum of two weeks to acquire industrial knowledge during the summer vacation of second semester. The students have to find industry related to their discipline (Public limited/Private Limited/owner/NGOs etc.,) in consultation with the faculty in charge/Mentor and get approval from the Head of the Department and Departmental Committee before going for an internship / industrial training.

Format to be followed for Internship report

The format for internship report to be followed by the student are given below

Format of the title page

Title of internship report

Internship report submitted in partial fulfillment of the requirement for the Master of Science in Biotechnology to the Alagappa University, Karaikudi -630003.

By

(Student Name)

(Register Number)

University Logo

Department of Biotechnology

Alagappa University

(A State University Accredited with "A+"grade byNAAC(CGPA:3.64)in the Third Cycle and Graded as Category-I University by MHRD-UGC, 2019: QS ASIA Rank-216, QS BRICS Rank-104, QS India Rank-20)

Karaikudi-630003

(Year)

Format of certificate

(Faculty in-charge)

This is to certify that the internship report entitled"----------" submitted to Alagappa University, Karaikudi-630 003 in partial fulfilment for the Master of Science in Biotechnology by Mr/Miss----------(Reg.No.:----------) under my supervision. This is based on the work carried out by him/her in the organization M/S ----------.This Internship report or any part of this work has Not been submitted elsewhere for any other degree, diploma, fellowship, or any other similar record of any University or Institution.

Place: Research Supervisor
Date:

(HOD)

This is to certify that the Internship report entitled "----------"
Submitted by Mr./Miss.----------(Reg No:----------)to the Alagappa University, in partial fulfillment for the award of the Master of Science in Biotechnology is a bonafide record of Internship report done under the supervision of ---------- Professor/Assistant Professor, Department of Biotechnology, Alagappa University and the work carried out by him/her in the organization M/S----------
---. This is to further certify that the thesis or any part thereof has not formed the basis of the award to the student of any degree, diploma, fellowship, or any other similar title of any University or Institution.

Place: Karaikudi Head of the Department

Date:

(Company supervisor or Head of the Organization)

This is to certify that the Internship report entitled"----------"submitted to Alagappa University, Karaikudi-630003 in partial fulfillment for the Master of Science in Biotechnology by Mr./Miss----------(Reg No----------) under my supervision. This is based on the work carried out by him/her in our organization M/S----------for the period of ----------.This Internship report or any part of this work has not been submitted elsewhere for any other degree, diploma, fellowship, or any other similar record of any University or Institution.

Place: Supervisor or Incharge
Date:

Declaration (student)

I hereby declare that the Internship Report entitled "----------" Submitted to the Alagappa University for the award of the Master of Science in Biotechnology has been carried out by me under the supervision of---------- , Assistant Professor, Department of Biotechnology, Alagappa University, Karaikudi – 630 003.Thisis my original and independent work carried out by me in the organization M/S---------- for the period of---------- and has not previously formed the basis of the award of any degree, diploma, associateship, fellowship, or any other similar title of any University or Institution.

Place:Karaikudi (----------)
Date:_____

- Acknowledgment
- Content as follows:

Field Visit

The students shall undergo Field Visits to various aquaculture farms, fish landing centers, sea food processing industries, Research Institutes, ship building industries etc. to acquire industrial and practical knowledge during the first semester.

Format to be followed for Field Visit report

The format for Field Visit report to be followed by the student are given below

Format of the title page

Field Visit report

Submitted in partial fulfilment of the requirement for the Master of Science in Biotechnology to the Alagappa University, Karaikudi -630003.

By

(Student Name)

(Register Number)

University Logo

Department of Biotechnology

Alagappa University

(A State University Accredited with "A+"grade by NAAC(CGPA:3.64)in the Third Cycle and Graded as Category-I University by MHRD-UGC, 2019: QS ASIA Rank-216, QS BRICS Rank-104, QS India Rank-20)

Karaikudi-630003

(Year)

Format of certificate

(HOD)

This is to certify that the Field Visit report submitted by Mr./Miss---------- -------- (Reg No:----------) to the Alagappa University, in partial fulfilment for the award of the Master of Science in_____is a bonafide record of Field Visit reports carried out by him/her during ----------. This is to further certify that the report or any part thereof has not formed the basis of the award to the student of any degree, diploma, fellowship, or any other similar title of any University or Institution.

Place: Karaikudi Head of the Department

Date:_____

Declaration (student)

I hereby declare that the Field Visit Report submitted to the Alagappa University for the award of the Master of Science in_____has been carried out by me. This is my original and independent work carried out by me during ------ and has not previously formed the basis of the award of any degree, diploma, associateship, fellowship, or any other similar title of any University or Institution.

Place:Karaikudi (----------)
Date:_____

- Acknowledgment
- Content as follows:

S. No.	Date	Field Visit	PageNo.	Signature
1				
2				
3				
4				
5				

- **No.of copies of the dissertation/internship report**

The candidate should prepare three copies of the dissertation report and submit the same for the evaluation of examiners. After evaluation, one copy will be retained in the department library, one copy will be retained by the guide and the student shall hold one copy. The candidate should prepare one copy of the field visit/internship report and submit the same for the evaluation of examiners

Teaching methods

- Classes will be takenusingadvancedtechniques suchas smartclasses, powerpoint projection
- Therequirement/improvementinteachingwillbegatheredbyinteractingwith thestudentstime to time
- Individualstudent will betaken carebytheteachers forhands-on training sessions
- Thetheorieswillbecorrelatedwiththeadvancedimprovementintherespectivefields
- Recentresearcheswillbediscussed whichhelpthemtounderstandtheconceptbetter

Attendance

Students must have earned 75% of attendance in each course for appearing for the examination. Students who have earned 74% to 70% of attendance need to apply for condonation in the prescribed form with the prescribed fee. Students who have earned 69% to 60% of attendance need to apply for condonation in the prescribed form with the prescribed fee along with the Medical Certificate. Students who have below 60% of attendance are not eligible to appear for the End Semester Examination (ESE). They shall re-do the semester(s) after completion of the programme

Examination

The examinations shall be conducted to assess (remembering, understanding, applying, analysing, evaluating, and creating) the knowledge required during the study. There shall be two systems of examinations viz., internal and external examinations. The internal examinations shall be conducted as Continuous Internal Assessment tests I and II(CIA Test I & II).

A. **Internal Assessment**

The internal assessment shall comprise a maximum of 25 marks for each subject. The following procedure shall be followed for awarding internal marks.

Total-25marks

Sr.No	Content	Marks
1	Average marks of two CIA test	15
3	Seminar/group discussion/quiz	5
4	Assignment/field trip report/case study report	5
	Total	25

Project/Dissertation-200 Marks(assessbyGuide/in-charge/HOD/Supervisor/External)

1	Two presentations(mid-term)	150Marks
2	Progress report	50Marks
	Total	200Marks

B. **External Examination**

- There shall be examinations at the end of each semester, for odd semesters in the month of October / November; for even semesters in April / May.
- A candidate who does not pass the examination in any course(s) may be permitted to appear in such failed course(s) in the subsequent examinations to be held in October / November or April / May. However, candidates who have arrears in Practical shall be permitted to take their arrear Practical examination only along with Regular Practical examination in the respective semester.
- A candidate should get registered for the first-semester examination. If registration is not possible owing to a shortage of attendance beyond condonation limit/regulation prescribedORbelatedjoiningORonmedicalgrounds,thecandidatesarepermittedto move to the next semester. Such candidates shall re-do the missed semester after completion of the programme.
- For the Project Report/ Dissertation Work the maximum marks will be 200 marks for project report evaluation and Viva-Voce examination

C. **Scheme of External Examination (Question Paper Pattern)**

Maximum75Marks

Section A	10questions.Allquestionscarryequal marks. (Objective-type questions)	10 x1 =10 Marks	10questions – 2 each from every unit
Section B	5 questions Either / or type like 1.a (or)b. All questions carry equal marks	5 x5 =25	5questions–1each from every unit
Section C	5 questions Either / or type like 1.a (or)b. All questions carry equal marks	5 x8= 40	5question–Should cover all units

Results

The results of all the examinations will be published through the Department where the student underwent the course as well as through University Website

Passing minimum

- A candidate shall be declared to have passed in each course if he/she secures not less than 40% marks in the End Semester Examinations and 40% marks in the Internal Assessmentandnotlessthan50%intheaggregate,takingContinuousassessment and End Semester Examinations marks together.
- The candidates not obtained 50% in the Internal Assessment are permitted to improve their Internal Assessment marks in the subsequent semesters (2 chances will be given)by writing the CIA tests and by submitting assignments.

- Candidates, who have secured the pass marks in the End-Semester Examination and in the CIA but failed to secure the aggregate minimum pass mark (E.S.E + C I.A), are permitted to improve their Internal Assessment mark in the following semester and/or in University examinations.
- A candidate shall be declared to have passed in the Project / Dissertation / Internship if he/she gets not less than 40%in each of the Project / Dissertation / Internship and Viva-Voceandnotlessthan50%intheaggregateofboththemarksforProject/Dissertation /Internship Report and Viva-Voce.
- A candidate who gets less than 50% in the Project Report must resubmit the Project Report. Such candidates need to take again the Viva-Voce on the resubmitted Project.

Grading of the Courses

The following table gives the marks, Grade points, Letter Grades and classifications meant to indicate the overall academic performance of the candidate.

Conversion of Marks to Grade Points and Letter Grade (Performance in Paper/Course)

RANGEOF MARKS	GRADEPOINTS	LETTER GRADE	DESCRIPTION
90 -100	**9.0 – 10.0**	**O**	**Outstanding**
80 -89	**8.0 – 8.9**	**D+**	**Excellent**
75 -79	**7.5 – 7.9**	**D**	**Distinction**
70 -74	**7.0 – 7.4**	**A+**	**VeryGood**
60 -69	**6.0 – 6.9**	**A**	**Good**
50 -59	**5.0 – 5.9**	**B**	**Average**
00 -49	**0.0**	**U**	**Re-appear**
ABSENT	**0.0**	**AAA**	**ABSENT**

a) Successful candidates passing the examinations and earning GPA between 9.0 and 10.0and marks from 90 – 100 shall be declared to have Outstanding (O).
b) SuccessfulcandidatespassingtheexaminationsandearningGPAbetween8.0and8.9 and marks from 80 - 89 shall be declared to have Excellent (D+).
c) SuccessfulcandidatespassingtheexaminationsandearningGPAbetween7.5–7.9 and marks from 75 - 79 shall be declared to have Distinction (D).
d) SuccessfulcandidatespassingtheexaminationsandearningGPAbetween7.0–7.4 and marks from 70 - 74 shall be declared to have VeryGood (A+).

e) SuccessfulcandidatespassingtheexaminationsandearningGPAbetween6.0–6.9 and marks from 60 - 69 shall be declared to have Good (A).

f) SuccessfulcandidatespassingtheexaminationsandearningGPAbetween5.0–5.9 and marks from 50 - 59 shall be declared to have Average (B).

g) Candidates earning GPAbetween0.0andmarksfrom00 - 49shall be declared to have Re-appear (U).

h) Absence from an examination shall not be taken as an attempt.

From the second semester onwards the total performance within a semester and continuous performance starting from the first semester are indicated respectively **by Grade PointAverage (GPA) and Cumulative Grade Point Average (CGPA).** These two are calculatedby the following formulate

GRADEPOINTAVERAGE(GPA)=$\sum_i C_i G_i / \sum_i C_i$

GPA=Sum of the multiplication of Grade Points by the credits of the courses
Sum of the credits of the courses in a Semester

Classification of the final result

CGPA	Grade	Classification of Final Result
9.5 – 10.0	**O+**	First Class– Exemplary*
9.0and abovebut below9.5	**O**	
8.5andabovebut below9.0	**D++**	First Class with Distinction*
8.0andabovebut below8.5	**D+**	
7.5andabovebut below8.0	**D**	
7.0andabovebut below7.5	**A++**	First Class
6.5andabovebut below7.0	**A+**	
6.0andabovebut below6.5	**A**	
5.5andabovebut below6.0	**B+**	Second Class
5.0andabovebut below5.5	**B**	
0.0and abovebut below5.0	**U**	Re-appear

The final result of the candidate shall be based only on the CGPA earned by the candidate. Successful candidates passing the examinations and earning CGPA between 9.5and

10.0 shall be given Letter Grade (O+), those who earned CGPA between 9.0 and 9.4 shall be given Letter Grade (O) and declared to have First Class – Exemplary*.

a) Successful candidates passing the examinations and earning CGPA between 7.5 and 7.9 shall be given Letter Grade (D), those who earned CGPA between 8.0 and 8.4 shall be given Letter Grade (D+), those who earned CGPA between 8.5 and 8.9 shall be given Letter Grade (D++) and declared to have First Class with Distinction*.

b) Successful candidates passing the examinations and earning CGPA between 6.0 and 6.4 shall be given Letter Grade (A), those who earned CGPA between 6.5 and 6.9 shall be given Letter Grade (A+), those who earned CGPA between 7.0 and 7.4 shall be given Letter Grade (A++) and declared to have First Class.

c) Successful candidates passing the examinations and earning CGPA between 5.0 and 5.4 shall be given Letter Grade (B), those who earned CGPA between 5.5 and 5.9 shall be given Letter Grade (B+) and declared to have passed in Second Class.

i)CandidatesthosewhoearnedCGPAbetween0.0and4.9shallbegivenLetterGrade (U)and declared to have Re-appear.

d) Absence from an examination shall not be taken as an attempt.

CUMULATIVEGRADEPOINTAVERAGE(CGPA)=$\sum_n \sum_i C_{ni} G_{ni} / \sum_n \sum_i C_{ni}$

CGPA=$\frac{\text{SumofthemultiplicationofGradePointsbythecreditsoftheentireProgramme}}{\text{Sum of the credits of the courses for the entire Programme}}$

Where,„**Ci**" is the Credit earned forCoursei in anysemester; „**Gi**" is the Grade Point obtainedbythestudentforCourseiand,„n"referstothesemesterinwhichsuchcourseswere credited.

CGPA (Cumulative Grade Point Average) = Average Grade Point of all the Courses passed starting from the first semester to the current semester.

Note:*Thecandidateswhohavepassedinthefirstappearanceandwithintheprescribed Semesters of the PG Programme are alone eligible for this classification.

Maximum duration of the completion of the programme

The maximum period for completion of M.Sc., in Biotechnology shall not exceed eight semesters continuing from the first semester.

Conferment of the Master's Degree

A candidate shall be eligible for the conferment of the Degree only after he/ she has earned the minimum required credits for the Programme prescribed there for (i.e. 90 credits). Programme).

Village Extension Programme

The Sivaganga and Ramnad districts are very backward districts where a majority of people Lives in poverty.Theruralmassiseconomicallyandeducationallybackward.Thustheaim of the introduction of this Village Extension Programme is to extend out to reach environmental awareness, social activities, hygiene, and health to the rural people of this region. The students in their third semester have to visit anyone of the adopted villages within the jurisdiction of Alagappa University and can arrange various programs to educate the rural mass in the following areas for three day based on the theme.1. Environmental awareness 2. Hygiene and Health. A minimum of two faculty members can accompany the students and guide them.

What to do after M.Sc.,

- ✓ Can pursue academic program like MS, M.Phil or Ph.D
- ✓ Can apply jobs in Research and Development companies and Industries
- ✓ Eligible to be Research Fellows/Lab Technician/Project assistant
- ✓ Able to be an entrepreneur with a start-up research companies

Job and Career option for M.Sc.,

Being an inter disciplinary domain with a blend of biological sciences and engineering technology that incorporates an array of career options which includes,

- ✓ Biotechnology, Genetics, Molecular Biology, Cell Biology, Pharmacology etc.
- ✓ Biomedical/Biomechanical Engineer
- ✓ Bioprocess Engineer
- ✓ Clinical Research Related Jobs
- ✓ Clinical Data Analysts
- ✓ Bioinformatics
- ✓ Sales &Marketing-Biomedical Equipment

Employment Areas

- ✓ Drug and pharmaceutical research
- ✓ Public funded laboratories
- ✓ Chemicals
- ✓ Environment control
- ✓ Waste management
- ✓ Energy
- ✓ Food processing
- ✓ Bio-processing industries
- ✓ Clinical Research
- ✓ Agriculture Sector
- ✓ Biopharma companies
- ✓ Vaccination production centre
- ✓ Food quality control department

M.Sc., Biotechnology-Programme structure

SEMESTER I

S. No	Code	Courses	Name of the Course	T/P	Credits	Marks		Total
						Int	Ext	
1	501101	Core	Biochemistry	T	3	25	75	100
2	501102	Core	Cell and Molecular Biology	T	3	25	75	100
3	501103	Core	Plant and Animal Biotechnology	T	3	25	75	100
4	501104	Core	Microbiology	T	2	25	75	100
5	501105	Core	Genetics	T	2	25	75	100
6	501106	DSE	Basics of Mathematics and Statistics	T	2	25	75	100
7	501107	DSE	Basics of Chemistry and Physics	T	2	25	75	100
8	501108	Core	Laboratory I: Biochemistry and Analytical Techniques	P	4	25	75	100
9	501109	Core	Laboratory II: Microbiology	P	2	25	75	100
10	501110	Core	Laboratory III: Plant and Animal Biotechnology	P	2	25	75	100
			Total		25	250	750	1000

SEMESTER II

S. No	Code	Courses	Name of the Course	T/P	Credits	Marks		Total
						Int	Ext	
1	501201	Core	Genetic Engineering	T	3	25	75	100
2	501202	Core	Immunology	T	3	25	75	100
3	501203	Core	Bioinformatics	T	3	25	75	100
4	501204	Core	Genomics and Proteomics	T	2	25	75	100
5	501205	Core	Molecular Diagnostics	T	2	25	75	100
6	501206	Core	Research Methodology and Scientific Communication Skills	T	2	25	75	100
7	501207	Core	Laboratory IV: Molecular Biology and Genetic Engineering	P	4	25	75	100
8	501208	Core	Laboratory V: Immunology	P	3	25	75	100
9	501209		Seminar		1	30	20	50
10	501501	DSE	Elective II	T	2	25	75	100
			Total		25	255	695	950

SEMESTERIII

S. No	Code	Courses	Name of the Course	T/P	Credits	Marks		Total
						Int	Ext	
1	501301	Core	Bioprocess Engineering and Technology	T	3	25	75	100
2	501302	Core	Emerging Technologies	T	2	25	75	100
3	501303	Core	Critical Analysis of Classical Papers	T	2	60	40	100
4	501304	Core	Bio entrepreneurship	T	2	25	75	100
5	501305	Core	Intellectual Property Rights, Biosafety and Bioethics	T	2	25	75	100
6	501306	Core	Project Proposal Preparation and Presentation	T	2	60	40	100
7	501307		Seminar		1	30	20	50
8	501308	Core	Laboratory VI: Bioprocess Engineering and Technology	P	4	25	75	100
9	501309	Core	Laboratory VII: Bioinformatics	P	2	25	75	100
10	501502	DSE	Elective III		2	25	75	100
			Total		22	325	625	950

SEMESTERIV

S. No	Code	Courses	Name of the Course	Credits	Marks		Total
					Int	Ext	
1	501410	Core	Dissertation	20	50	150	200
			Total	20	50	150	200
			Grand Total	**92**	**880**	**2220**	**3100**

Course Structure

M.Sc. Biotechnology

S. No.	Title	Credits
	SEMESTERONE	
1	**Biochemistry**	3
2	**Cell and Molecular Biology**	3
3	**Plant and Animal Biotechnology**	3
4	**Microbiology**	2
5	**Genetics**	2
6	**Basics of Mathematics and Statistics (Elective I)**	2
7	**Basics of Chemistry and Physics**	2
8	**Laboratory I: Biochemistry and Analytical Techniques**	4
9	**Laboratory II: Microbiology**	2
10	**Laboratory III: Plant and Animal Biotechnology**	2
	TOTAL	**25**
	SEMESTERTWO	
1	Genetic Engineering	3
2	Immunology	3
3	Bioinformatics	3
4	**Genomics and Proteomics**	2
5	**Molecular Diagnostics**	2
6	**Research Methodology and Scientific Communication Skills**	2
7	**Elective II**	2
8	**Seminar**	1
9	**Laboratory IV: Molecular Biology and Genetic Engineering**	4
10	**Laboratory V: Immunology**	3
	TOTAL	**25**
	SEMESTERTHREE	
1	**Bioprocess Engineering and Technology**	3
2	**Emerging Technologies**	2
3	**Critical Analysis of Classical Papers**	2
4	**Bio-entrepreneurship**	2
5	**Intellectual Property Rights, Biosafety and Bioethics**	2
6	**Project Proposal Preparation and Presentation**	2
7	**Seminar**	1
8	**Laboratory VI: Bioprocess Engineering and Technology**	4
9	**Laboratory VII: Bioinformatics**	2
10	**Elective III**	2
	TOTAL	**22**
	SEMESTERFOUR	
1	**Dissertation**	20
	TOTAL	**20**
	TOTALCREDITS	**92**

Recommended Electives:

1. Biological Imaging| 2. Computational Biology| 3. Drug Discovery and Development| 4. Environmental Biotechnology| 5. Microbial Technology| 6. Nanobiotechnology| 7.ProteinEngineering| 8.Vaccines

Semester One

Biochemistry

Credits

3

Course Objectives

The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways. The course shall make the students aware of various disease pathologies within the context of each topic.

Student Learning Outcomes On completion of this course, students should be able to:

- Gain fundamental knowledge in biochemistry;
- Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.

SEMESTER I					
Core	**Course code: 501101**	**BIOCHEMISTRY**	**T**	**Credits: 3**	**Hours: 41**
Pre-requisite	Basic Knowledge in Biochemistry		Syllabus Revised		2022-23
Unit I					
Objective 1	To build upon undergraduate level knowledge of biochemical principles with specific emphasis on different biomolecules and its metabolic pathways.				
Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, the composition of living matter; Water – properties of water, essential role of water for life on earth. pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase). Concepts of Bioenergetics: Thermodynamics- laws and quantities, biological oxidation-reduction reactions.					
Outcome 1	Gain fundamental knowledge in biochemistry				**K1**
Unit II					
Objective 2	To make the students aware of various disease pathologies within the context of each topic.				
Amino acids – structure and functional group properties, peptides and covalent structure of proteins. Sugars - mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; Structure of model membrane: lipid bilayer, fluid mosaic model, electrical properties of membranes, membrane proteins (intrinsic, extrinsic, lipid-linked), transport mechanisms (mediated and non-mediated), ion channels and pumps.					
Outcome 2	Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.				**K2**
Unit III					
Objective 3	To understand the significance of structure and storage polysaccharides, their anabolic and catabolic pathways, basics of aminoacids, proteins and lipids.				
Enzymes: Enzyme nomenclature and classification, cofactors, coenzymes; Catalytic power and specificity of enzymes. Enzyme kinetics and general properties of enzymes like the effect of pH, temperature; Michaelis-Menten equation; Km and V max values and their significance. Enzyme inhibition - types of inhibitors –reversible and irreversible inhibition. Allosteric and feedback inhibition; Applications of enzymes in agriculture, industry and therapy.					
Outcome 3	Acquire knowledge in the basic enzymatic reactions that play a vital role in day to day life.				**K3**

Unit IV		
Objective 4	To acquire knowledge in basic structure, function and mechanism of action, kinetics, inhibition and an exposure to the applications of the enzymes and future perspective	
Bioenergetics: High energy phosphate compounds –free energy of hydrolysis of Phosphorylated Compounds and Acetyl-CoA. Oxidative phosphorylation, mitochondrial respiratory complexes, organization of electron carriers, electrochemical gradient, chemiosmotic theory, F1-F0 ATP Synthase and mechanism of ATP synthesis. Photosynthesis – Light dependent and independent reactions.		
Outcome 4	Analyze and understand the relationship between various cellular pathways/mechanisms and the role of the intermediates in connecting several metabolism, fundamentals of energetics in biochemical process and the concepts of oxidative phosphorylation, electron transport, ATP synthesis and photosynthesis.	**K4**
Unit V		
Objective 5	Understand the synthesis and regulation of nucleotides	
Metabolism of carbohydrates (glycolysis; gluconeogenesis; pentose phosphate pathway). Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Lipids (fatty acid oxidation and biosynthesis). Amino acids biosynthesis, nucleotides (de novo synthesis and salvage pathways).		
Outcome 5	Learn how metabolism of carbohydrates, lipids, amino acids and nucleotides takes place in a cell and also understand the deficiency and disorders of these biomolecules.	**K4**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		
	**Suggested Readings:** • Stryer, L. (2015). *Biochemistry*. (8th ed.) New York: Freeman. • Lehninger, A. L. (2012). *Principles of Biochemistry* (6th ed.). New York, NY: Worth. • Voet, D., &Voet, J. G. (2016). *Biochemistry* (5th ed.). Hoboken, NJ: J. Wiley & Sons. • Dobson, C. M. (2003). *Protein Folding and Misfolding*. Nature, 426(6968), 884-890. • doi:10.1038/nature02261. • Richards, F. M. (1991). *The Protein Folding Problem*. Scientific American, • 264(1), 54-63. doi:10.1038/scientificamerican0191-54. **Online Resources:** • World Wide Web Service and Open AI	

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	M (2)	M (2)	M (2)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	M (2)	S (3)	M (2)	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.8**	**2.2**	**2**	**2.8**	**1.9**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 –Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	**S (3)**	**S (3)**	**S (3)**	**S (3)**	**S (3)**
CO2	**S (3)**	**S (3)**	**S (3)**	**S (3)**	**S (3)**
CO3	**S (3)**	**S (3)**	**S (3)**	**S (3)**	**S (3)**
CO4	**S (3)**	**S (3)**	**S (3)**	**S (3)**	**S (3)**
CO5	**S (3)**	**S (3)**	**S (3)**	**S (3)**	**S (3)**
W.AV:	**3**	**3**	**3**	**3**	**3**

Cell and Molecular Biology

Credits

3

Course Objectives

The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules, the understanding of various biological processes becomes deeper and inclusive.

Student Learning Outcomes

Student should be equipped to understand three fundamental aspects in biological phenomenon: a) what to seek; b) how to seek; c) why to seek?

SEMESTER I					
Core	**Course code: 501102**	**CELL AND MOLECULAR BIOLOGY**	**T**	**Credits: 3**	**Hours: 40**
Pre-requisite	Basic Knowledge in cellular function and organization		Syllabus Revised		2022-23
Unit I					
Objective 1	To gain in-depth understanding of cellular structure, organelles, and compartmentalization in prokaryotic and eukaryotic cells.				
Organization of cell: An overview of plant and animal cells; Structure and organization of prokaryotic and eukaryotic cells; Internal organization of the cell - cell membranes and concepts related to compartmentalization in eukaryotic cells; Intracellular organelles: Endoplasmic Reticulum and Golgi apparatus, Peroxisomes, Lysosomes, Mitochondria, Chloroplasts; Nuclear compartment: Nucleus, Nucleolus and Chromosomes; Three-dimensional organization and functions of cytoskeletons.					
Outcome 1	Students will possess the ability to analyse cellular components, membranes, and organelles, interpreting their roles in genetic regulation, cellular processes, and applications across scientific and medical disciplines.				**K1**
Unit II					
Objective 2	To comprehend chromatin structure's impact on DNA replication, repair, and gene expression; grasp transcriptional and translational processes and their control mechanisms.				
Chromatin organization: Chromatin organization - histone and DNA interactome: structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatin- Writers, -Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, transcriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code translation product cleavage, modification and activation.					

Outcome 2	Students will interpret chromatin dynamics, gene regulation, transcription, and translation, linking them to cellular function, genetic stability, and their significance in biomedical and research contexts	**K2**
	Unit III	
Objective 3	To understand molecular mechanisms of cellular and nuclear transport, intracellular protein sorting, vesicular trafficking, and the cell cycle phases and checkpoints.	
Cellular Transport: Molecular mechanisms of membrane transport, nuclear transport, Intracellular protein sorting- Basis, Mechanism and Regulation of intracellular transport of proteins across nucleus, mitochondria, chloroplast, ER and Golgi apparatus; Intracellular vesicular trafficking from Endoplasmic Reticulum through Golgi apparatus to lysosomes; Cell cycle: Different phases, regulation, and checkpoints.		
Outcome 3	Students will interpret and apply knowledge of cellular transport processes, organelle communication, and cell cycle regulation, with implications for cellular function, disease, and research advancement.	**K4**
	Unit IV	
Objective 4	To learn the molecular events in plant cellular differentiation, and hormone-mediated regulation.	
Cellular differentiation in plants: Cellular differentiation in plants – Basic process & mechanism. Specific role of hormones as a regulator of cellular differentiation; Morphogenesis; Plant cell wall-Nature, composition & organization. Organization of shoot & root apical meristem; shoot & root development.		
Outcome 4	Students will interpret mechanisms of plant cellular differentiation, and hormonal influences.	**K4**
	Unit V	
Objective 5	To understand bacteriophage λ biology, including lytic growth and lysogeny, mutation causes and types, repair mechanisms, and cellular stress responses.	
Biology of bacteriophage: Biology of bacteriophage λ. Lytic growth of phage λ: DNA replication and phage production, recombination in the λ life cycle. Lysogeny: Immunity and repression, Lysogeny and prophage integration, prophage excision. Decision between lysis and lysogeny. Mutation - Causes (physical, chemical, and biological) Types (lethal, conditional, biochemical, loss of function, gain of function) and detection. Mechanism of repair- photoreactivation, excision repair, recombinational repair. The SOS and adaptive responses and their regulation. Heat shock response.		
Outcome 5	Students will interpret phage λ life cycles, understand mutation and repair processes, recognize cellular responses to stress, and connect these concepts to genetics, evolution, and biomedical applications	**K5**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008).
- Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
- Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
- Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning
- Cooper, G. M., & Hausman, R. E. (2013). The Cell: a Molecular

	Approach (6th Ed.). Washington: ASM; Sunderland. • A Textbook of Human Genetics (2011) by Amita Sarkar, Wisdom Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston (8th Ed.). Benjamin Cummings. • Ray J. Rose Molecular Cell Biology of the Growth and Differentiation of Plant Cells (2021) CRC Press ISBN: 9780367782917 • Molecular Biology of the Gene, 7th Edition (2014) by James D Watson, Tania A Baker, Stephen P Bell, Alexander Gann, Michael Levine and Richard Losick, Benjamin Cummings. **Online Resources:** • World Wide Web Service and Open AI

Course Outcome VS Programme Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M (2)	M (2)	L (1)	M (2)	L (1)	M (2)	L (1)	S (3)	M (2)	L (1)
CO2	M (2)	L (1)	M (2)	M (2)	M (2)	M (2)	L (1)	M (2)	S (3)	M (2)
CO3	S (3)	M (2)	L (1)	L (1)	L (1)	L (1)	M (2)	M (2)	M (2)	L (1)
CO4	S (3)	L (1)	M (2)	L (1)	M (2)	L (1)	M (2)	M (2)	S (3)	L (1)
CO5	L (1)	M (2)	L (1)	L (1)	M (2)	M (2)	M (2)	M (2)	M (2)	L (1)
W. AV	**2.2**	**1.6**	**1.4**	**1.4**	**1.6**	**1.8**	**1.6**	**2.2**	**2.4**	**1.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome VS Programme Specific Outcomes

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	M (2)	L (1)	M(2)	L (1)
CO2	M (2)	L (1)	M (2)	M (2)	M (2)
CO3	M (2)	L (1)	M (2)	L (1)	M (2)
CO4	L (1)	M (2)	M (2)	S (3)	M (2)
CO5	L (1)	M (2)	M (2)	M (2)	M (2)
W. AV	**1.8**	**1.6**	**1.8**	**2.0**	**1.8**

Plant and Animal Biotechnology

Credits

3

Course Objectives

The objectives of this course are to introduce students to the principles, practices and application of animal biotechnology, plant tissue culture, plant and animal genomics, genetic transformation and molecular breeding of plants and animals.

Student Learning Outcomes Students should be able to gain fundamental knowledge in animal and plant biotechnology and their applications.

SEMESTER I					
Core	**Course code: 501103**	**PLANT AND ANIMAL BIOTECHNOLOGY**	**T**	**Credits: 3**	**Hours: 40**
Pre-requisite			Syllabus Revised		2022-23
Unit I					
Objective 1	To acquire knowledge of plant tissue culture techniques, regeneration processes, media preparation, and molecular markers for genetic diversity analysis.				
Plant tissue culture: Basics of tissue culture; Totipotency; Plant regeneration – Organogenesis and Somatic embryogenesis; Establishment of Callus & Cell suspension culture; Media preparation – nutrients & plant hormones; Sterilization techniques; Micropropagation; Somaclonal variation; Cryopreservation – Principle, Methods, and Applications; Synthetic seed production and its applications; Plant cell tissue and organ cultures for phytochemical production- Principle and methods. Biodiversity conservation and Molecular markers (RAPD, ISSR SCAR and SSR) for analyzing genetic diversity.					
Outcome 1	Students will develop proficiency in tissue and cell culture methods, micropropagation, cryopreservation, and synthetic seed production, alongside the ability to utilize molecular markers for genetic diversity assessment and phytochemical production.				**K1**
Unit II					
Objective 2	To understand plant genetic engineering principles and various gene transfer techniques.				
Plant genetic engineering: Agrobacterium tumefaciens & crown gall tumors. Basis of tumor formation; Ti and Ri plasmids; Mechanism of T-DNA transfer; Disarmed Ti plasmid; Co - integrate, and Binary Ti - plasmid based vectors for plant transformation; Direct gene transfer - PEG-mediated, electroporation, and particle bombardment, Microinjection, Microlaser and Silicon carbide whisker™ methods; Screenable and selectable markers; Genetic Engineering of chloroplast genome and development of transplastomic plants; Strategies for introducing biotic and abiotic stress responsive genes in plants; Molecular Farming – Polyhydroxy butyrate (PHB), Polyfructons & Cyclodextrans. Transgenic crops – Flavr Savr, Bt Cotton, and Golden rice.					
Outcome 2	Students will grasp the basics and mechanisms of transformation methods. Graduates will also recognize the significance of transgenic crops.				**K3**

Unit III		
Objective 3	Top gain an overview of plant and animal genomics, molecular mapping, marker-assisted selection and to explore animal reproductive biotechnology.	
Plant and Animal Genomics: Overview of plant and animal genomics, definitions; Arabidopsis Genome Initiative; Molecular mapping and marker assisted selection; Animal reproductive biotechnology and vaccinology		
Outcome 3	Students will understand the foundations of plant and animal genomics, with insights into the marker-assisted selection. Graduates will also recognize the significance of animal reproductive biotechnology and its role in advancing vaccinology for animal health.	**K4**
Unit IV		
Objective 4	To comprehend various methods of gene transfer - physical, chemical, and biological, including recombinant animal viral vectors construction.	
Transgenesis: Methods of gene transfer- physical, chemical, and biological methods. Methods for the construction of recombinant animal viral vectors for gene transfer into cell lines. Transgenic animals (Mice, Cows, Pigs, Sheep, Goat, Birds, fish, and Insects). Applications of transgenic animals as disease models (neurodegenerative disorders, carcinogenesis, and hypertension) and production of therapeutic proteins. Cloning for conservation of endangered species; ethical issues in cloning. Gene therapy - Ex vivo and in vivo, viral, and non- viral		
Outcome 4	Students will master techniques for gene transfer, transgenic animal creation, and applications in disease models and therapeutic protein production.	**K4**
Unit V		
Objective 5	To learn the methods of animal cell culture techniques and their applications.	
Animal cell culture: Brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, tissues, and organs; primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for virus isolation and in vitro testing of drugs, testing of toxicity of environmental pollutants in cell culture, applications of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins		
Outcome 5	Students will acquire animal cell culture proficiency for diverse applications, including virus isolation, drug testing, toxicity assessment, and pharmaceutical protein production, contributing to biomedical research and production sectors.	**K5**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
- Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science.
- Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: an Introduction to Genetic Engineering. Oxford: Oxford University Press.
- Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). Biochemistry & Molecular Biology of Plants. Chichester, West Sussex: John Wiley & Sons.

- Umesha, S. (2013). Plant Biotechnology. The Energy And Resources.
- Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.
- Brown, T. A. (2006). Gene Cloning and DNA Analysis: an Introduction. Oxford: Blackwell Pub.
- Primrose, S. B., & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
- Slater, A., Scott, N. W., & Fowler, M. R. (2003). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford: Oxford University Press.
- Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International.
- Levine, M. M. (2004). New Generation Vaccines. New York: M. Dekker.
- Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome VS Programme Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L (1)	M (2)	M (2)	L (1)	L (1)	S (3)	M (2)	M (2)	M (2)	L (1)
CO2	L (1)	M (2)	M (2)	M (2)	L (1)	M (2)	L (1)	M (2)	L (1)	L (1)
CO3	M (2)	S (3)	L (1)	M (2)	M (2)	M (2)	M (2)	S (3)	M (2)	S (2)
CO4	M (2)	L (1)	M (2)	M (2)	L (1)	M (2)	S (3)	M (2)	M (2)	L (1)
CO5	L (1)	S (3)	M (2)	L (1)	M (2)	M (2)	M (2)	S (3)	M (2)	L (1)
W. AV	**2.2**	**1.6**	**1.4**	**1.4**	**1.6**	**1.8**	**1.6**	**2.2**	**2.4**	**1.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome VS Programme Specific Outcomes

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	L (1)	L (1)	M (2)	L (1)	M (2)
CO2	M (2)	M (2)	S (3)	M (2)	M (2)
CO3	L (1)	L (1)	M (2)	S (3)	M (2)
CO4	L (1)	M (2)	L (1)	M (2)	M (2)
CO5	M (2)	M (2)	M (2)	M (2)	M (2)
W. AV	**1.8**	**1.4**	**1.8**	**2.0**	**2.0**

*S –Strong (3), M-Medium (2), L- Low (1)

Microbiology

Credits

2

Course Objectives

The objectives of this course are to introduce field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition; methods for control of microbes and host microbe interactions.

Student Learning Outcomes

Students should be able to:

- Identify major categories of microorganisms and analyze their classification, diversity, and ubiquity;
- Identify and demonstrate structural, physiological, genetic similarities and differences of major categories of microorganisms; Identify and demonstrate how to control microbial growth; Demonstrate and evaluate interactions between microbes, hosts and environment.

SEMESTER-1					
Core	**Course code: 501104**	**MICROBIOLOGY**	**T**	**Credits: 2**	**Hours: 28**
Pre-requisite	Introduce field of microbiology with special emphasis on microbial diversity		Syllabus Revised		2022-23
Unit 1					
Objective 1	*Students will be able to learn the basics of microbiology and its taxonomical classifications*				
Introduction to microbiology and microbes, history & scope of microbiology, Domain and Kingdom concepts in classification of microorganisms, Classification of Bacteria according to Bergey's manual. Diversity of prokaryotic microorganisms.					
Outcome 1	*Detailed information about the basics of microbiology and the historical perspectives will be gained by the students*				**K1**
Unit 2					
Objective 2	To understand the detailed concept of sterilization along with the importance of antimicrobials				
Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.					
Outcome 2	*The basic concept and the importance of sterilization in microbiology and the knowledge of using antimicrobials to control the diseases.*				***K3***
Unit 3					
Objective 3	To briefly learn about the structure and genetics of microorganisms				
Bacterial morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods. Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions					
Outcome 3	*Understands the genetics of microorganism which in turn helps in terms of research.*				***K2***

Unit 4		
Objective 4	Ability to know about the emerging microbial diseases and its mode of action.	
Microbial Diseases and Host Pathogen Interaction: Normal microbiota; Ecological impact of microbes; Source/Reservoir of infection; Pathogen transmission & interaction, Infectious dose, Growth rate; Nosocomial infection, Emerging microbial diseases mechanism of microbial pathogenicity. Virulence: Pathogenicity islands, Resisting host defenses, Invasion & Colonization, Toxins. Mechanisms of drug resistance.		
Outcome 4	*Ability to know the importance of the microbial threats and will be able to develop some treatment strategies*	***K1***
Unit 5		
Objective 5	To understand about the nature of microbes and its significances in terms of medical and industrial aspects.	
Microbes from extreme environment. Industrial microbiology: Use of microbes in fermentation, production of antibiotics, enzymes, organic acids, wine, beer, cheese, yogurt and vitamins. Role of Microorganism on the earth - Symbiosis, mutalism, commensalism and parasitism, Probiotics and Prebiotics, Biological Control Agents (BCA).Quorum sensing and its inhibition mechanism		
Outcome 5	*Students will be able to gain the knowledge of useful microbes and can able to apply in the field of industrial research.*	***K2***
K1-Remembering/ Knowledge,**K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). *Microbiology* (5th ed.). New York: McGraw-Hill.
- Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011).
- *Prescott's Microbiology*. New York: McGraw-Hill.
- Matthai, W., Berg, C. Y., & Black, J. G. (2005). *Microbiology, Principles and Explorations*. Boston, MA: John Wiley & Sons.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M (2)	L (1)	S (3)	L (1)	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)
CO2	M (2)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.6**	**2.2**	**3**	**2.6**	**3**	**2.6**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Genetics

Credits

2

Course Objectives

The objectives of this course are to take students through basics of genetics and classical genetics covering prokaryotic/ phage genetics to yeast and higher eukaryotic domains. On covering all classical concepts of Mendelian genetics across these life-forms, students will be exposed to concepts of population genetics, quantitative genetics encompassing complex traits, clinical genetics and genetics of evolution.

Student Learning Outcomes

On successful completion of this course, student will be able:

- Describe fundamental molecular principles of genetics;
- Understand relationship between phenotype and genotype inhuman genetic traits;
- Describe the basics of genetic mapping;
- Understand how gene expression is regulated.

SEMESTER I					
Core	**Course code: 501105**	**GENETICS**	**T**	**Credits: 2**	**Hours:**
Pre-requisite	Concepts of Genetics		Syllabus Revised		2022-23
Unit I					
Objective 1	To understand the basic concepts of genetics and genome mappings				
Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of gene.					
Outcome 1	Gain knowledge on DNA structure and genome mapping				**K1 & K2**
Unit II					
Objective 2	To get familiarized with all classical concepts of Mendalian genetics across these life-forms and yeast genetics.				
Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.					
Outcome 2	Understanding concepts of Mendalian, non-mammalian genetics				**K2**
Unit III					
Objective 3	To acquire knowledge in importance phenotype and genetype in Drosophila, a classical genetics				
Monohybrid & dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in context of developmental mechanism.					
Outcome 3	Understanding relationship between phenotype and genotype in genetic traits				**K2 & K5**
Unit IV					
Objective 4	To acquire knowledge in basics of population genetics and evolution				
Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy- Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.					

Outcome 4	Learn the concepts of population genetics	**K3 & K5**
	Unit V	
Objective 5	To understand the concepts of QTLs	
Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs.		
Outcome 5	Learn to understand the QTLs application	**K4**
	Unit VI	
Objective 6	To understand the theoretical concepts of plant genetics	
Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding.		
Outcome 6	Learn the concepts of classical genetics and plant breeding	**K3 & K5**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Hartl, D. L., & Jones, E. W. (1998). Genetics: Principles and Analysis. Sudbury, MA: Jones and Bartlett.
- Pierce, B. A. (2005). Genetics: a Conceptual Approach. New York: W.H. Freeman.
- Tamarin, R. H., & Leavitt, R. W. (1991). Principles of Genetics. Dubuque, IA: Wm. C. Brown.
- Smith, J. M. (1998). Evolutionary Genetics. Oxford: Oxford University Press.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	M (2)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO6	M (2)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.7**	**2.5**	**2**	**3**	**2**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)
CO6	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Basics of Mathematics and Statistics

Credits

2

Course Objectives

The objective of this course is to give conceptual exposure of essential contents of mathematics and statistics to students.

Student Learning Outcomes On completion of this course, students should be able to:

- Gain broad understanding in mathematics and statistics;
- Recognize importance and value of mathematical and statistical thinking, training, and approach to problem solving, on a diverse variety of disciplines.

SEMESTER I					
Core	**Course code: 501106**	**BASICS OF MATHEMATICS AND STATISTICS**	**T**	**Credits: 2**	**Hours: 19**
Pre-requisite	Conceptual exposure of essential contents of mathematics and statistics		Syllabus Revised		2022-23
Unit I					
Objective 1	To understand the concepts of algebra and its applications				
Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; constructing linear models in biological systems; quadratic equations (solving, graphing, features of, interpreting quadratic models etc.), introduction to polynomials, graphs of binomials and polynomials; Symmetry of polynomial functions, basics of trigonometric functions, Pythagorean theory, graphing and constructing sinusoidal functions. Introduction to matrices.					
Outcome 1	Gain broad understanding of concepts and its application in biology				**K1, K2**
Unit II					
Objective 2	To describe the basics of differential and integral calculus and its advantages				
Differential calculus (limits, derivatives), integral calculus (integrals).					
Outcome 2	Gain the knowledge of Differential and integral calculus				**K1, K2**
Unit III					
Objective 3	To acquire knowledge on the application of mathematical concepts by applying biology				
Population dynamics; oscillations, circadian rhythms, developmental patterns, symmetry in biological systems, fractal geometries, size-limits & scaling in biology, modeling chemical reaction networks and metabolic networks.					
Outcome 3	Learn to understand the application of mathematics in biology				**K2, K4**
Unit IV					
Objective 4	To acquire knowledge of using statistical concepts in scientific research				
Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, linear regression, correlation, analysis of variance					
Outcome 4	*Learn the concepts of population genetics*				**K3, K4**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create					

Suggested Readings:

- Stroud, K. A., & Booth, D. J. (2009). Foundation Mathematics. New York, NY: Palgrave Macmillan
- Aitken, M., Broadhursts, B., & Haldky, S. (2009) Mathematics for Biological Scientists. Garland Science.
- Billingsley, P. (1986). Probability and Measure. New York: Wiley.
- Rosner, B. (2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press
- Daniel, W. W. (1987). Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**2.5**	**2**	**3**	**2**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Basics of Chemistry and Physics

Credits

2

Course Objectives

The objectives of this course are to cover all essentials required to appreciate physico-chemical principles underlying biological processes.

Student Learning Outcomes Students should be able to have a firm foundation in fundamentals and application of current chemical and physical scientific theories.

SEMESTER I					
Core	**Course code: 501107**	**BASICS OF CHEMISTRY AND PHYSICS**	**T**	**Credits: 2**	**Hours: 24**
Pre-requisite	Concepts of physio-chemical principles underlying biological processes		Syllabus Revised		2022-23
Unit I					
Objective 1	To gain a basis knowledge into physical sciences and its importance in biological research				
Physical quantities and their dynamics: definitions, units and dimensions; vectors & scalars, displacement, velocity, acceleration, kinematic formulas, angular momentum, torque force, power, work, energy (kinetic & potential/electric charge separation, electromagnetic spectrum, photons etc.); springs & Hookes laws; elastic and inelastic collisions; Newton's law of motions and conservation principles; simple harmonic motions, mechanical waves, Doppler effect, wave interference, amplitude, period, frequency & wavelength; diffusion, Fick's law, dissipation, random walks, and directed motions in biological systems; low Reynolds number - world of Biology, buoyant forces, Bernoulli's equation, viscosity, turbulence, surface tension, adhesion; laws of thermodynamics: Thermodynamics in Biological Systems, conduction, convection and radiation, internal energy, entropy, temperature and free energy, Maxwell's demon (entropic forces at work in biology, chemical assemblies, self-assembled systems, role of ATP); Coulomb's law, conductors and insulators, electric potential energy of charges, nerve impulses, Ohms law (basic electrical quantities: current, voltage & power), electrolyte conductivity, capacitors and capacitance, dielectrics; various machines in biology i.e. enzymes, allostery and molecular motors (molecules to cells and organisms).				
Outcome 1	Learn the concepts of energy, Newton law, Thermodynamics, enzyme dynamics and biological sciences				**K2, K4**
Unit II					
Objective 2	To acquire knowledge into basic concepts of chemistry used for biological sciences				
Basic constituents of matter - elements, atoms, isotopes, atomic weights, atomic numbers, basics of mass spectrometry, molecules, Avogadro number, molarity, gas constant, molecular weights, structural and molecular formulae, ions and polyatomic. ions; chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, Arrhenious equation, Maxwell Boltzmann distributions, rate- determining steps, catalysis, free-energy, entropy and enthalpy changes during reactions; kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant); light and matter interactions (optical spectroscopy, fluorescence, bioluminescence, paramagnetism and diamagnetism, photoelectron spectroscopy; chemical bonds (ionic, covalent, Van der Walls forces); electronegativity, polarity; VSEPR theory and molecular				

geometry, dipole moment, orbital hybridizations; states of matter - vapor pressure, phase diagrams, surface tension, boiling and melting points, solubility, capillary action, suspensions, colloids and solutions; acids, bases and pH - Arrhenious theory, pH, ionic product of water, weak acids and bases, conjugate acid-base pairs, buffers and buffering action etc; chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology; redox reactions and electrochemistry - oxidation-reduction reactions, standard cell potentials, Nernst equation, resting membrane potentials, electron transport chains (ETC) in biology, coupling of oxidative phosphorylations to ETC; theories of ATP production and dissipation across biological membranes; bond rotations and molecular conformations - Newman projections, conformational analysis of alkanes, alkenes and alkynes; functional groups, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot).

Outcome 2	Learn concepts of chemicals constituents applicable for biological sciences	**K2, K4, K5**

K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create

Suggested Readings:

- Baaquie, B. E. (2000). Laws of Physics: a Primer. Singapore: National University of Singapore.
- Matthews, C. P., & Shearer, J. S. (1897). Problems and Questions in Physics. New York: Macmillan Company.
- Halliday, D., Resnick, R., & Walker, J. (1993). Fundamentals of Physics. New York: Wiley.
- Ebbing, D. D., & Wrighton, M. S. (1990). General Chemistry. Boston: Houghton Mifflin.
- Averill, B., & Eldredge, P. (2007). Chemistry: Principles, Patterns, and Applications. San Francisco: Benjamin Cummings.
- Mahan, B. H. (1965). University Chemistry. Reading, MA: Addison-Wesley Pub.
- 7. Cantor, C. R., & Schimmel, P. R. (2004). Biophysical Chemistry. San Francisco: W.H. Freeman.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	S (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (2)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.5**	**2.5**	**2**	**3**	**2**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Laboratory I: Biochemistry & Analytical Techniques

Credits

4

Course Objectives

Introducing students to experiments in biochemistry and to teach students the experimental methods in biochemistry in a problem oriented manner.

Student Learning Outcomes

On completion of this course, students should be able to:

- To elaborate concepts of biochemistry with easy to run experiments;
- To familiarize with basic laboratory instruments and understand the principle of measurements using those instruments with experiments.

SEMESTER I					
Core	**Course code: 501108**	**LAB I: BIOCHEMISTRY AND ANALYTICAL TECHNIQUES**	**P**	**Credits: 4**	**Hours:**
Pre-requisite	Hands on experience in analyzing the biochemical parameters		Syllabus Revised		2022-23
Unit I					
Objective 1	To introduce the students to experiments in biochemistry				
- Introduction to measurements – Weighing Balance and Pipetting, Morality, Normality, Morality. - Preparing various stock solutions and working solutions that will be needed for the course - Preparation of buffers of pH range 2 to 11 (Tris buffer, PBS buffer, citrate buffer, sodium phosphate buffer, potassium phosphate buffer, phosphate citrate buffer).					
Outcome 1	Elaborate the concepts of biochemistry with easy to run experiments				**K6**
Unit II					
Objective 2	To teach students the experimental methods in biochemistry in a problem oriented manner				
- To prepare Acetic-Na Acetate buffer and validate the Henderson Hasselbach equation. - Estimation of Pka values in Acid-Base titration. - Estimation of PI values of Amino acids					
Outcome 2	Familiarize with basic laboratory instruments and understand the principle of measurements using those instruments with experiments				**K2**
Unit III					
Objective 3	To develop skills with the students to perform the basic analytical methods				
- Basic concepts and applications of the instruments used in biochemical analysis (Colorimetry, spectrophotometry and spectroflorimetry) - To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.					
Outcome 3	Distinguish between chromatography, spectroscopy and colorimetry techniques				**K4**

Unit IV		
Objective 4	To familiarize the students with various clinically applicable analytical techniques	
- Separation and identification of amino acids by TLC method - Separation of plant pigments by TLC method. - Separation of amino acids by paper chromatography - Electrophoresis techniques: separation of proteins by Native and SDS PAGE. - Identification of proteins by 2D gels-Demonstration		
Outcome 4	Exhibit a knowledge base in the fundamentals of electrophoresis and its practical application	**K6**
Unit V		
Objective 5	To expose the students to the principles of separation techniques	
- Derivation of Michaelis- Menten equation and determination of Vmax, Km. Determination of optimum pH, optimum temperature and substrate concentration of enzymes - Demonstration of HPLC, GC-MS, Fluorescence spectrophotometer.		
Outcome 5	Obtain hands-on experience in basic separation techniques, instrumentation, and concept of buffer preparation.	**K5, K6**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	M (2)	M (2)	M (2)	M (2)	M (2)	S (3)	S (3)	M (2)	S (3)	S (3)
CO 2	M (2)	M (2)	M (2)	M (2)	M (2)	S (3)	S (3)	M (2)	S (3)	S (3)
CO 3	M (2)	M (2)	M (2)	M (2)	M (2)	S (3)	S (3)	M (2)	S (3)	S (3)
CO 4	M (2)	M (2)	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)
W.AV:	**2**	**2**	**2**	**2**	**2.4**	**3**	**3**	**2**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	S (3)	S (3)	S (3)	S (3)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)
CO 3	S (3)	S (3)	S (3)	S (3)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	S (3)
CO 5	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Laboratory II: Microbiology

Credits

Course Objectives

The objective of this laboratory course is to provide practical skills on basic microbiological techniques.

Student Learning Outcomes

Students should be able to:

- Isolate, characterize and identify common bacterial organisms;
- Determine bacterial load of different samples;
- Perform antimicrobial sensitivity tests;
- Preserve bacterial cultures.

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Core	Course code: 501109	Lab in Microbiology	T	Credits: 2	Hours:
Pre-requisite	To provide practical skills on basic microbiological techniques.		Syllabus Revised		2022-23
Unit 1					
Objective 1	To develop the basic knowledge about the sterilization, cultivation and storage of microorganisms				
1. Sterilization, disinfection and safety in microbiological laboratory 2. Preparation of media for cultivation of bacteria 3. Maintenance of stock cultures: slants, stabs and glycerol stock cultures					
Outcome 1	*Ability to know about the importance of sterilization, the methods to cultivation and storage of microbes*				***K3***
Unit 2					
Objective 2	To make the students understand the methods to isolate and analyse the bacterial strains				
1. Isolation of bacteria in pure culture by streak plate method. 2. Enumeration of bacteria: standard plate count. 3. Study of colony and growth characteristics of some common bacteria: Bacillus, E. coli, Staphylococcus, Streptococcus, etc. 4. Preparation of bacterial smear and Gram's staining. 5. Isolation and identification of bacteria from soil/water samples – Biochemical and Molecular characterizations.					
Outcome 2	*Gains the knowledge about the isolation and methods to analyze the bacterial culture in terms of its physical and chemical properties..*				***K5***
Unit 3					
Objective 3	To develop the knowledge about the drug resistance and its importance for the current scenario.				
1. Antimicrobial sensitivity test and demonstration of drug resistance. 2. Determination of phenol co-efficient of antimicrobial agents. 3. Bacterial cell – cell communication system. 4. Determination of Minimum Inhibitory Concentration (MIC)					
Outcome 3	*Knowledge about the methods involved in the detection and analyzing of drug resistance with its mode of action*				***K4***
K1-Remembering/ Knowledge,**K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create					

Suggested Readings:

- Cappuccino, J. G., & Welsh, C. (2016). *Microbiology: a Laboratory Manual*. Benjamin-Cummings Publishing Company.
- Collins, C. H., Lyne, P. M., Grange, J. M., &Falkinham III, J. (2004). *Collins and Lyne's Microbiological Methods* (8th ed.). Arnolds.
- Tille, P. M., & Forbes, B. A. *Bailey & Scott's Diagnostic Microbiology.*

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**2.4**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Laboratory III: Plant and Animal Biotechnology

Course Objectives

The objectives of this course are to provide hands-on training in basic experiments of plant and animal biotechnology.

Student Learning Outcomes

On completion of course, students should be able to gain basic skills in plant and animal biotechnology.

SEMESTER I					
Core	**Course code: 501110**	**LABORATORY III: PLANT AND ANIMAL BIOTECHNOLOGY**	**P**	**Credits: 2**	**Hours:**
Pre-requisite			Syllabus Revised		2022-23
Unit I					
Objective 1	To gain knowledge in preparing diverse cell culture media with understanding of their compositions, applications and to obtain practical skills in basic plat tissue culture				
1. Preparation of stock solution (MS and B5 media). 2. Preparation of culture media with various supplements for plant tissue culture experiments. 3. Sterilization and inoculation of various explants for callus induction and direct regeneration. 4. Micropropagation of important medicinal plants 5. Synthetic seed development and plant regrowth in a representative plant **6.** Demonstration of cryopreservation in endangered plant germplasm.					
Outcome 1	Students will be able to establish and optimize media accordingly to the species of interest and learn to employ tissue culture techniques for the large-scale production of food crops and medicinal plants.				**K3**
Unit II					
Objective 2	To gain hands-on experience in genetic engineering techniques				
1. *Agrobacterium tumefaciens* mediated transformation of important food crops. 2. RAPD & ISSR profile of wild type and *in vitro* conserved plants and observation of genetic fingerprinting profiles. 3. Plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometric methods. **4.** Hairy root induction in medicinal plants with commercial importance					
Outcome 2	Students familiar with DNA extraction and isolation of particular genes. Students will be able apply knowledge of molecular markers for the identification of traits various genomes.				**K4**

Unit III		
Objective 3	To learn basic handling techniques in animal cell culture laboratory	
1. Animal cell culture laboratory: Sterilization techniques and Safety protocols. Equipment used in cell culture laboratory: Autoclave, Laminar flow hood/biosafety cabinet, CO2 incubator, storage (Refrigerator, freezer and cryostorage container), Inverted microscope, hemocytometer, centrifuge, water bath. 2. Different types of Cell culture media and preparation. 3. Preparation of Primary cell cultures from different sources using mechanical and enzymatic disaggregation. 4. Established cell lines- Culture condition, maintenance and passaging. 5. Detection and prevention of contamination in cell culture. 6. Preservation and revival of cells.		
Outcome 3	Students will learn to establish, handle, maintain and store different cell lines.	**K3**
Unit IV		
Objective 4	To have hands on training in basic cytotoxicity assays	
1. Cell counting by hemocytometer. 2. Checking cell viability by MTT and Trypan blue assay. **3.** Measurement of apoptosis by Acridine orange/Ethidium bromide staining.		
Outcome 4	Students will be able to screen drugs or any toxic compounds in *in vitro* conditions on different cell types.	**K4, K5**
Unit V		
Objective 5	To gain experience in handling and conducting experiments in live animal model systems	
1. *In vivo* animal models and route of administration – *C. elegans* and mice 2. Animal handling and dissection – Mice, *C. elegans* –Demonstration. 3. Preparation of single cell suspension from mice spleen/ mice thymus/chicken liver (Primary cell culture) 4. Isolation of DNA from animal tissue. 5. Isolation of RNA from model system **6.** Chromosome staining from animal cells using giemsa stain.		
Outcome 5	Gaining knowledge in route of drug administration, collecting tissue/cell samples and isolation of their genetic materials will help the students to plan and execute experiments on their own.	**K3**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
- Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science.
- Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International.
- Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols.

	Totowa, NJ: Humana Press • Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: an Introduction to Genetic Engineering. Oxford: Oxford University Press. • Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). Biochemistry & Molecular Biology of Plants. Chichester, West Sussex: John Wiley & Sons. **Online Resources:** • World Wide Web Service and Open AI

Course Outcome VS Programme Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L(1)	L(1)	S(3)	S(3)	S(3)	S(3)	S(3)	M(2)	M(2)	S(3)
CO2	L(1)	S(3)	S(3)	S(3)	S(3)	S(3)	S(3)	M(2)	S(3)	S(3)
CO3	L(1)	L(1)	S(3)	S(3)	S(3)	S(3)	S(3)	M(2)	M(2)	S(3)
CO4	L(1)	S(3)	S(3)	S(3)	S(3)	S(3)	S(3)	M(2)	S(3)	S(3)
CO5	L(1)	S(3)	S(3)	S(3)	S(3)	S(3)	S(3)	M(2)	S(3)	S(3)
W.AV	**1**	**2.2**	**3**	**3**	**3**	**3**	**3**	2	2.6	**3**

S–Strong(3),M-Medium(2),L-Low(1)

Course Outcome VS Programme Specific Outcomes

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	M(2)	L(1)	L(1)	S(3)	S(3)
CO2	M(2)	L(1)	S(3)	S(3)	S(3)
CO3	M(2)	L(1)	L(1)	S(3)	S(3)
CO4	M(2)	L(1)	L(1)	S(3)	S(3)
CO5	M(2)	L(1)	S(3)	S(3)	S(3)
W.AV	**2**	**1**	**1.8**	**3**	**3**

S–Strong (3),M-Medium(2),L-Low(1)

Semester Two

Genetic Engineering

Credits

3

Course Objectives

The objectives of this course are to teach students with various approaches to conducting genetic engineering and their applications in biological research as well as in biotechnology industries. Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course.

Student Learning Outcomes

Given the impact of genetic engineering in modern society, the students should be endowed with strong theoretical knowledge of this technology. In conjunction with the practical in molecular biology & genetic engineering, the students should be able to take up biological research as well as placement in the relevant biotech industry

SEMESTER II					
Core	**Course code: 501201**	**GENETIC ENGINEERING**	**T**	**Credits: 3**	**Hours:40**
Pre-requisite	Concepts of Genetic Engineering		Syllabus Revised		2022-23
Unit I					
Objective 1	To obtain the basic concepts of genetic engineering				
Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labellingof DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization.					
Outcome 1	Gain knowledge on genetic engineering				**K1, K2**
Unit II					
Objective 2	To understand the various expression system in genetic engineering				
Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, hagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, yeast vectors, shuttle vectors.					
Outcome 2	Understanding concepts and application of expression system				**K1, K2**
Unit III					
Objective 3	To gain knowledge on types of PCR, sequence synthesis method and Applications				
Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.					
Outcome 3	Understanding the concepts and application of molecular techniques used in diagnostic and mutation detection				**K2, K3**
Unit IV					
Objective 4	To acquire knowledge in gene manipulation technique, protein-DNA interaction and DNA sequencing				
Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation;					
Outcome 4	Learn the concepts and application of molecular techniques				**K2, K3**

Unit V		
Objective 5	To educate the application of genetic engineering	
Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems e.g. fruit flies (Drosophila), worms (*C. elegans*), frogs (Xenopus), fish (zebra fish) and chick; Transgenics- gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS.		
Outcome 5	Learn to understand the application of genetic engineering	**K3, K4**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
- Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
- Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
- Selected papers from scientific journals, particularly Nature & Science.
- Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	M (2)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	M (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	M (2)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.8**	**2.6**	**2.4**	**3**	**2**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Immunology

Credits

3

Course Objectives

The objectives of this course are to learn about structural features of components of immune system as well as their function. The major emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.

Student Learning Outcomes On completion of this course, students should be able to:

- Evaluate usefulness of immunology In different pharmaceutical companies;
- Identify proper research lab working in area of their own interests;
- Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in the setting of infection (viral or bacterial).

SEMESTER II					
Core	**Course code: 501202**	**IMMUNOLOGY**	**T**	**Credits: 3**	**Hours:40**
Pre-requisite			Syllabus Revised		2022-23
Unit I					
Objective 1	Learn about the basics and the structural features of components of immune system				
Elements of immune system: Components of innate and acquired immunity. Organs (primary and secondary) and cells of the immune system. Lymphatic system. Mucosal, Cutaneous and Gut associated Lymphoid tissue (MALT, CALT, GALT). Antigens - immunogens, haptens, adjuvants and epitope. Phagocytosis: steps involved, pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP)					
Outcome 1	Acquire knowledge in the basics of immune system and its components				**K1**
Unit II					
Objective 2	Acquire knowledge in development of immune system				
Immunoglobulins- basic structure, classes & subclasses. Immunoglobulin superfamily. Antibody genes and generation of diversity. Maturation, activation and differentiation of B and T cells. B and T cell receptors. ; Humoral and cell-mediated immune responses. ADCC. Mechanisms of antigen processing and presentation-cytosolic and endocytic pathways. Antibody engineering.					
Outcome 2	Students will understand how the body's immune system work on immune stimulation.				**K2**
Unit III					
Objective 3	Learn the role of functional components of immune system				
Major histocompatibility complex- structure and its interaction with peptide. Cytokines- properties, receptors and therapeutic uses. The complement systems: mode of activation, classical, alternate and lectin pathway. Immunization- active and passive. Immune response to infectious diseases – bacterial (tuberculosis), viral (HIV), protozoan and helminths.					
Outcome 3	Apply knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and determine the type of immune responses to an infection (viral or bacterial).				**K3**

Unit IV		
Objective 4	Understand the mechanisms by which our body elicits immune response by external and internal factors.	
Transplantation immunity - Organ transplantation and HLA tissue typing, immunological basis of graft rejection, transplantation and immunosuppressive therapy. Hypersensitivity-Type I-IV. Autoimmunity- organ specific (Type 1 Diabetes Mellitus, Myasthenia Gravis) and systemic (Multiple sclerosis, Rheumatoid Arthritis). Tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy.		
Outcome 4	Analyze the mechanism behind the disorders of immune system	**K4**
Unit V		
Objective 5	Learn about the different immunization techniques and immune-based therapy for diseases.	
Vaccinology: Active and passive immunization. Vaccines- live, killed, attenuated, subunit, recombinant DNA, protein based, peptide, plant-based and conjugate. Immunotherapy; Humanized antibody, Monoclonal antibodies- production and uses for cancer treatment. Applications of catalytic antibodies for the treatment of diseases.		
Outcome 5	Gain knowledge in the application sectors like vaccinology and may evoke their research interest leading to the development of new products for human welfare	**K6**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman.
- Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub.
- Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science.
- Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.
- Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press.
- Parham, P. (2005). The Immune System. New York: Garland Science.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome VS Programme Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S(3)	S(3)	S(3)	S(3)	L(1)	L(1)	M(2)	S(3)	M(2)	S(3)
CO2	S(3)	S(3)	S(3)	S(3)	L(1)	L(1)	M(2)	S(3)	M(2)	S(3)
CO3	S(3)	S(3)	S(3)	M(2)	S(3)	S(3)	M(2)	S(3)	S(3)	S(3)
CO4	S(3)	S(3)	S(3)	M(2)	S(3)	S(3)	M(2)	S(3)	S(3)	S(3)
CO5	S(3)	S(3)	S(3)	M(2)	S(3)	M(2)	L(1)	M(2)	S(3)	S(3)
W.AV	3	3	**3**	**2.4**	**2.2**	2	1.8	2.8	2.6	3

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome VS Programme Specific Outcomes

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S(3)	M(2)	L(1)	S(3)	L(1)
CO2	S(3)	M(2)	L(1)	S(3)	L(1)
CO3	S(3)	S(3)	L(1)	S(3)	L(1)
CO4	S(3)	S(3)	L(1)	S(3)	L(1)
CO5	S(3)	S(3)	L(1)	S(3)	L(1)
W.AV	**3**	**2.6**	**1**	**3**	**1**

S –Strong (3), M-Medium (2), L- Low (1)

Bioinformatics

Credits

3

Course Objectives

The objectives of this course are to provide theory and practical experience of the use of common computational tools and databases, which facilitate investigation of molecular biology and evolution-related concepts.

Student Learning Outcomes

Student should be able to:

- Develop an understanding of basic theory of these computational tools;
- Gain working knowledge of these computational tools and methods;
- Appreciate their relevance for investigating specific contemporary biological questions;
- Critically analyse and interpret results of their study.

SEMESTER II					
Core	**Course code: 501203**	**BIOINFORMATICS**	**T**	**Credits: 3**	**Hours:26**
Pre-requisite	The objectives of this course are to provide theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.		Syllabus Revised		2022-23
Unit I					
Objective 1	To provide introduction and understanding of the field of bioinformatics and information regarding various biological databases.				
Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.					
Outcome 1	*Helps to better understand and comprehend the principles of bioinformatics and provide practical knowledge on the biological databases.*				**K1, K2**
Unit II					
Objective 2	To make the students understand and perform analyses of DNA sequences.				
DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pair-wise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.					
Outcome 2	*Understand the essential DNA sequence analyses and to gain theoretical and practical knowledge on DNA sequencing technology.*				**K1, K2**

Unit III		
Objective 3	To understand the principle and purpose of Multiple sequence analysis and to equip students with its practical knowledge.	
Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.		
Outcome 3	Enable students to perform multiple sequence analysis in order to understand the phylogenetic distance between the DNA sequences.	**K1, K2 & K3**
Unit IV		
Objective 4	To attain theoretical and practical knowledge on protein modelling and the softwares used for protein modelling.	
Protein modeling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing.		
Outcome 4	Analyze and understand various protein structures and provide practical insights related to protein structure modelling and its analysis.	**K1, K2, K3 & K4**
Unit V		
Objective 5	To gain both theoretical and practical knowledge on protein structure prediction, the techniques related to the understanding of protein structures and to understand the process of scientific journals, grants and funding.	
Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; threading techniques; topology fingerprint approach for prediction; evaluation of alternate models; structure prediction on a mystery sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; significance analysis, scoring techniques, sequence-sequence scoring; protein function prediction; elements of in silico drug design;Virtual library: Searching PubMed, current content, science citation index and current awareness services, electronic journals, grants and funding information.		
Outcome 5	Learn about the practical techniques related to protein structure prediction and analysis along with an understanding of scientific citation index ,journals and information related to grants and funding.	**K1, K2, K3, K4 & K5**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		
	**Suggested Readings:** • Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press. • 2.Mount, D. W. (2001). Bioinformatics: Sequence and Genome	

	Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. • 3.Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience. • 4.Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell. • 5.Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss. • 6.Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press. **Online Resources:** • World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	S (3)	M (2)	M (2)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	M (2)	M (2)	M (2)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	M (2)	M (2)	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**2.4**	**2**	**2.6**	**1.6**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong; 2 – Medium; 1 – Low**

.

Genomics and Proteomics

Credits

2

Course Objectives

The objectives of this course is to provide introductory knowledge concerning genomics, proteomics and their applications.

Student Learning Outcomes Students should be able to acquire knowledge and understanding of Fundamentals of genomics and proteomics, transcriptomics and metabolomics and their applications in various applied areas of biology.

SEMESTER II					
Core	**Course code: 501204**	**GENOMICS AND PROTEOMICS**	**T**	**Credits: 2**	**Hours:28**
Pre-requisite	Basic Knowledge in Genomics and Proteomics		Syllabus Revised		2022-23
Unit I					
Objective 1	To build upon knowledge of genome organization of Prokaryotic and eukaryotic organisms				
Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast					
Outcome 1	Gain fundamental knowledge on genome organization				**K1**
Unit II					
Objective 2	To understand of various techniques available for genetic and physical mapping.				
Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, cytogenetic techniques, FISH technique in gene mapping, radiation hybrid maps, in situ hybridization, comparative gene mapping.					
Outcome 2	Understand the molecular techniques for mapping genetic and physical variations in an organism.				**K3**
Unit III					
Objective 3	To aware of genome projects developed for most studied model organisms and their comparison with human genome.				
Human Genome Project, genome-sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.					
Outcome 3	Acquire knowledge Genome projects for various organisms				**K2**
Unit IV					
Objective 4	To acquire knowledge on comparative genome using sequencing methods				
Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence.					
Outcome 4	Analyze and understand the relationship between genome arrangement of various organisms and gaining knowledge on variations with in a group of species.				**K5**

Unit V		
Objective 5	To gain knowledge on protein techniques	
Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases. protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics		
Outcome 5	Learn the techniques available to study the protein modifications, expression and their interactions	**K3**
Unit VI		
Objective 6	To acquire knowledge on functional analysis of macromolecules and its application	
Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function- forward and reverse genetics, gene ethics; introduction to metabolomics, lipidomics, metagenomics and systems biology.		
Outcome 6	Learn and explore the way of analyzing genes, proteins and their interactions with other small molecules.	**K4**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006).*Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
- Liebler, D. C. (2002). *Introduction to Proteomics: Tools for the New Biology*.Totowa, NJ: Humana Press.
- Campbell, A. M., & Heyer, L. J. (2003). *Discovering Genomics, Proteomics, and Bioinformatics*. San Francisco: Benjamin Cummings.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)
CO2	S (3)	M (2)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	M (2)
CO3	M (2)	M (2)	M (2)	S (3)	L (1)	S (3)	M (2)	S (3)	M (2)	S (3)
CO4	S (3)	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	M (2)
CO5	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.8**	**2.6**	**2.2**	**2.8**	**2**	**2.6**	**2.8**	**2.6**	**2.8**	**2.6**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	M (2)
CO4	S (3)	M (2)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**2.8**	**3**	**3**	**2.8**

***3 – Strong 2 – Medium 1 – Low**

Molecular Diagnostics

Credits

2

Course Objectives

The objectives of this course are to sensitize students about recent advances in molecular biology and various facets of molecular medicine, which has potential to profoundly alter many aspects of modern medicine including pre- or post- natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

Student Learning Outcomes Students should be able to understand various facets of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in early diagnosis and prognosis of human diseases.

SEMESTER II					
Core	**Course code: 501205**	**MOLECULAR DIGNOSTICS**	**T**	**Credits: 2**	**Hours:25**
Pre-requisite	Fundamental knowledge in molecular biology		Syllabus Revised		2022-23
Unit I					
Objective 1	To describe fundamental molecular principles of chromosomal level changes in human				
DNA, RNA, Protein: An overview; chromosomal structure & mutations; DNA polymorphism: human identity; clinical variability and genetically determined adverse reactions to drugs.					
Outcome 1	Gain fundamental knowledge in basics of genomics.				**K2**
Unit II					
Objective 2	To facilitate them to understand the advanced technical concepts of Biotechnology				
PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF-MS; Bioinformatics data acquisition & analysis. Metabolite profile for biomarker detection the body fluids/tissues in various metabolic disorders by making using LCMS & NMR technological platforms.					
Outcome 2	Learning the fundamentals of modern biology and advanced technologies improve student's capacity to apply their knowledge of a subject to solve current issues on both a local and global scale is a function of their critical thinking abilities.				**K2**
Unit III					
Objective 3	Understanding the microbial community, molecular changes and importance of antibiotic resistance in human disease.				
Direct detection and identification of pathogenic-organisms that are slow growing or currently lacking a system of *in vitro* cultivation as well as genotypic markers of microbial resistance to specific antibiotics.					
Outcome 3	Improve the skills of investigation, designing and conduct experiments, analyzing and interpreting data, and apply the laboratory skills to solve problems hypothesis.				**K3**

Unit IV		
Objective 4	To differentiate and understand immune responses in relation to infection and to understand importance of inherited diseases.	
Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: Fragile X Syndrome: Paradigm of new mutational mechanism of unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in growing number of familial cancer syndromes.		
Outcome 4	Appreciate their relevance for investigating specific contemporary biological questions.	**K2**
Unit V		
Objective 5	Understand the basic concepts of human diseases and learn matching therapies for infected patients.	
Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies. Quality oversight; regulations and approved testing.		
Outcome 5	Understanding genetics genetic aberrations in clinical level will provide disease progression and hereditary importance. Find employment opportunities in R&D of Biotech/Pharma industry, Medical or hospital related organizations, Regulatory Agencies, & Academia.	**K1**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.
- Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw-Hill.
- Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press.
- Coleman, W. B., & Tsongalis, G. J. (2010). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	M (2)	M (2)	M (2)	M (2)	M (2)	S (3)	S (3)	M (2)	S (3)
CO2	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	M (2)	S (3)	M (2)	M (2)
CO3	S (3)	S (3)	M (2)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	M (2)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	M (2)
CO5	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	S (3)
W.AV:	**3**	**2.6**	**2**	**2.8**	**2.6**	**2.4**	**2.6**	**3**	**2.4**	**2.6**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	M (2)	S (3)	M (2)
CO3	S (3)	M (2)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	M (2)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**2.8**	**2.8**	**2.8**	**2.8**

***3 – Strong 2 – Medium 1 – Low**

Research Methodology and Scientific Communication Skills

Credits

2

Course Objectives

The objectives of this course are to give background on history of science, emphasizing methodologies used to do research, use frame work of these methodologies for understanding effective lab practices and scientific communication and appreciate scientific ethics

Student Learning Outcomes

Students should be able to:

- Understand history and methodologies of scientific research, applying these to recent published papers;
- Understand and practice scientific reading, writing and presentations;
- Appreciate scientific ethics through case studies.

SEMESTER II					
Core	**Course code: 501206**	**RESEARCH METHODOLOGY & SCIENTIFIC COMMUNICATION SKILLS**	**T**	**Credits: 2**	**Hours:24**
Pre-requisite			Syllabus Revised		2022-23
Unit I					
Objective 1	To give background information on history of science, and methodologies to do research.				
History of science and science methodologies: Empirical science – Introduction and methods; Scientific method; Importance of manipulative experiments and controls in biological experiments; Deductive and Inductive reasoning; Descriptive science.					
Outcome 1	Graduates will acquire a solid understanding of science's historical evolution and methodologies, applying empirical methods, experimentation, and deductive/inductive reasoning in scientific investigations.				**K1**
Unit II					
Objective 2	To learn the art of choosing ideal mentor for research and how to develop the skills for asking research questions.				
Preparation for research: Choosing an ideal research mentor, Qualities, and values of a good mentor; laboratory and research questions; Criteria's and types of good research question; Steps for developing research question; Laboratory Note Book – Its importance and guidelines for maintenance.					
Outcome 2	Students get enough knowledge about the qualities of good mentor, familiarize about framing of research questions and maintaining laboratory note book.				**K2**

Unit III		
Objective 3	To provide framework for scientific communication and appreciate scientific ethics.	
Process of communication: Concept and elements of effective communication; Steps for clear and effective communication; Verbal and non-verbal; Avoiding breakdowns while communicating; Importance of body language; Power of effective listening; Recognizing cultural differences; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; Scientific poster preparation & presentation; Participating in group discussions; Computing skills for scientific research - web browsing for information search; Effective email strategy.		
Outcome 3	Get advanced knowledge on the elements of communication and computing knowledge.	**K4**
Unit IV		
Objective 4	To impart knowledge on the elements of effective scientific communication.	
Scientific communication: Technical writing skills - types of reports; layout of a formal report; scientific writing skills; Importance of communicating science; Plagiarism, software for plagiarism; Scientific publication writing: Elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; Drafting titles and framing abstracts; Publishing scientific papers ; peer review process and problems; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.		
Outcome 4	Students understand the art of technical writing, plagiarism, and scientific misconduct	**K4**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.
- On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.
- Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558.
- Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India.
- 5. Movie: Naturally Obsessed, The Making of a Scientist.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome VS Programme Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L (1)	M (2)	L (1)	M (2)	L (1)	M (2)	L (1)	M (2)	M (2)	L (1)
CO2	L (1)	L (1)	M (2)	L (1)	M (2)	M (2)	M (2)	M (2)	M (2)	M (2)
CO3	M (2)	M (2)	M (2)	L (1)	M (2)	L (1)	M (2)	M (2)	L (1)	L (1)
CO4	M (2)	L (1)	M (2)	M (2)	M (2)	L (1)	S (3)	S (3)	M (2)	M (2)
CO5	M (2)	M (2)	M (2)	M (2)	M (2)	M (2)	S (3)	M (2)	L (1)	M (2)
W. AV	**1.6**	**1.6**	**1.8**	**1.6**	**1.8**	**1.6**	**2.2**	**2.2**	**1.6**	**1.6**

Course Outcome VS Programme Specific Outcomes

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	L (1)	L (1)	M (2)	M (2)	M (2)
CO2	M (2)	M (2)	M (2)	L (1)	M (2)
CO3	M (2)	L (1)	M (2)	L (1)	M (2)
CO4	L (1)	M (2)	M (2)	M (2)	L (1)
CO5	M (2)	M (2)	L (1)	S (3)	M (2)
W. AV	**1.6**	**1.6**	**1.8**	**1.8**	**1.8**

S –Strong (3), M-Medium (2), L- Low (1)

Laboratory IV: Molecular Biology and Genetic Engineering

Credits

Course Objectives

The objectives of this course are to provide students with experimental knowledge of molecular biology and genetic engineering.

Student Learning Outcomes Students should be able to gain hands- on experience in gene cloning, protein expression and purification. This experience would enable them to begin a career in industry that engages in genetic engineering as well as in research laboratories conducting fundamental research.

SEMESTER II					
Core	**Course code: 501208**	**LBORATORY IV MOLECULAR BIOLOGY & GENETIC ENGINEERING**	**P**	**Credits: 4**	**Hours:**
Pre-requisite	The objectives of this course are to provide students with experimental knowledge of molecular biology and genetic engineering.		Syllabus Revised		2022-23
Unit I					
Objective 1	To provide introductory information along with the practical knowledge on lac-operon, isolation of auxotrophs, titration of phages and gene transfer methods.				
1.Concept of lac-operon: a)Lactose induction of B-galactosidase. b)Glucose Repression. c)Diauxic growth curve of *E. coli* 2.UV mutagenesis to isolate amino acid auxotroph 3.Phage titre with epsilon phage/M13 4.Genetic Transfer-Conjugation, gene mapping					
Outcome 1	Equip students to understand, comprehend and perform experiments related to gene regulation and gene transfer mechanism in a prokaryotic system.				**K3&K4**
Unit II					
Objective 2	To learn about and perform techniques related to molecular cloning and its confirmation.				
1. Plasmid DNA isolation and DNA quantitation 2. Restriction Enzyme digestion of plasmid DNA 3. Agarose gel electrophoresis 4. Polymerase Chain Reaction and analysis by agarose gel electrophoresis 5. Vector and Insert Ligation 6. Preparation of competent cells 7. Transformation of *E. coli* with standard plasmids, Calculation of transformation efficiency **8.** Confirmation of the insert by Colony PCR and Restriction mapping.					

Outcome 2	Enable students to get hands-on experience in techniques of molecular cloning and the confirmation techniques to ensure positive cloning.	***K4&K5***
Unit III		
Objective 3	To understand the principle and attain practical knowledge on techniques related to recombinant protein purification such as His-tagged protein purification using Ni-NTA columns and other techniques such as SDS-PAGE and Southern hybridization.	
1. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E. coli,* SDS-PAGE analysis 2. Purification of His-Tagged protein on Ni-NTA columns a)Random Primer labeling b)Southern hybridization.		
Outcome 3	Helps students to understand and perform experiments related to purification of recombinant proteins, specifically His-tagged proteins and give insights in techniques such as SDS-PAGE and provides complete knowledge on the way to overcome the challenges faced during protein purification.	***K4 & K5***
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		
	**Suggested Readings:** Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. **Online Resources:** • World Wide Web Service and Open AI	

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	M (2)	M (2)	M (2)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	M (2)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**2.6**	**2.3**	**2.3**	**1.3**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Laboratory V: Immunology

Credits

Course Objectives

The objectives of this laboratory course are to develop an understanding about practical aspects of components of immune system as well as their function. Basic as well as advanced methods will be taught to detect different antigen and antibody interactions, isolation of different lymphocyte cells *etc.* and how they can be used in respective research work.

Student Learning Outcomes

Students should be able to:

- Identify proper research lab working in area of their own interests;
- Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic lymphocyte responses and figure out kind of immune responses in setting of infection (viral or bacterial) by looking at cytokine profile.

SEMESTER II					
Core	**Course code: 501209**	**LABORATORY V: IMMUNOLOGY**	**P**	**Credits: 3**	**Hours:**
Pre-requisite	Immunology practical		Syllabus Revised		2022-23
Unit I					
Objective 1	To gain the knowledge of experiments related to Blood samples including counting and staining				
1. Selection of animals, preparation of antigens, immunization and methods of blood collection, serum separation and storage. 2. Immunohematology: Blood cell counts (Total RBC, WBC and differential count of WBC) 3. Blood grouping (ABO system and Rh grouping). 4. Separation of mononuclear cells by Ficoll-Hypaque and their cyropreservation. 5. Blood smear identification of leucocytes by Giemsa stain					
Outcome 1	*Gain knowledge on Blood related experiments*				**K3, K4**
Unit II					
Objective 2	To acquire knowledge on antigen-antibody reaction based experiments				
1. Immunodiagnostic technique: Antibody titre by ELISA method-Demonstration. 2. Detection of Antigen and Antibody: Double diffusion, Immuno- electrophoresis and Radial immuno diffusion. **3.** SDS-PAGE, Immunoblotting, Dot blot assays.					
Outcome 2	Apply their knowledge on designing experiments with the principle antigen-antibody reaction				**K3, K4**
Unit III					
Objective 3	To acquire knowledge on Phagocytosis separation, antigen antibody reactions, isolation and purification of antibodies.				
1. Demonstration of Phagocytosis of latex beads and their cryopreservation. 2. Demonstration of Complement fixation test. 3. Demonstration of Isolation and purification of IgG from serum or IgY from chicken egg. 4. Demonstration of ELISPOT. **5.** Demonstration of FACS.					
Outcome 3	Apply and design the immunological experiments for proper research				**K2**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create					

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	M (2)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.7**	**2.5**	**2**	**3**	**2**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Semester Three

Bioprocess Engineering & Technology

Credits

Course Objectives

The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

Student Learning Outcomes

Students should be able to:

- Appreciate relevance of microorganisms from industrial context;
- Give an account of design and operations of various fermenters;
- Present unit operations together with the fundamental principles for basic methods in production technique for bio-based products;
- Critically analyze any bioprocess from market point of view;
- Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

SEMESTER III					
Core	**Course code: 501301**	**BIOPROCESS ENGINEERING AND TECHNOLOGY**	**T**	**Credits: 3**	**Hours:36**
Pre-requisite	Fundamental concepts of bioprocess technology and its related applications.		Syllabus Revised		2022-23
Unit I					
Objective 1	To make students to learn the importance and application of microorganism in industry.				
Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.					
Outcome 1	*Understand the fundamentals of microbiology in industrial level.*				**K2**
Unit II					
Objective 2	To impart knowledge of upstream processing and other bioprocess techniques in industrial scale.				
Upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.					
Outcome 2	*Understand the optimization and process of Upstream processing.*				**K4**
Unit III					
Objective 3	To understand the significance of downstream processing in product recovery				
Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.					
Outcome 3	*Student would be able to select the best methods to obtain the products in industrial scale.*				*K4*

Unit IV		
Objective 4	To acquire knowledge in the basics of potential bioprocess technique and their effective management in marketing the products	
Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.		
Outcome 4	*Analyze and understand the correlation between the manufacturing and marketing the industrial products.*	*K3*
Unit V		
Objective 5	Students will able to learn the different methods of food and beverage fermentation and their application in food industry	
Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery.		
Outcome 5	*Learn how different fermented foods products been processed and commercialized.*	*K3*
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Ramkrishna, D., Sengupta, S., Bandyopadhyay, S.D. and Ghosh, A. eds. (2021). Advances in Bioprocess Engineering and Technology: Select Proceedings ICABET 2020. Springer Singapore.
- Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts.
- Upper Saddle River, NJ: Prentice Hall.
- Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.El-Mansi, M., & Bryce, C. F. (2007). Fermentation.
- Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M (2)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	L (1)
CO2	S (3)	S (3)	S (3))	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	L (1)	S (3)	M (2)
CO4	S (3)	M (2)	S (3)	L (1)	S (3)	S (3)	L (1)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	M (2)	S (3)	M (2)
W.AV:	**2.8**	**2.4**	**2.6**	**2.6**	**2.2**	**3**	**2.6**	**2.4**	**2.8**	**2.2**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	L (1)
CO2	S (3)	S (3)	L (1)	S (3)	S (3)
CO3	L (1)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	L (1)	M (2)	S (3)	M (2)
CO5	S (3)	M (2)	S (3)	L (1)	S (3)
W.AV:	**2.6**	**2.4**	**2.4**	**2.6**	**2.4**

***3 – Strong 2 – Medium 1 – Low**

Emerging Technologies

Credits

2

Course Objectives

This course is broad-based in nature encompassing several new technologies that current experimental researchers are employing to probe complex system biology questions in life-sciences. The Objectives of this course are to teach basics of the new principles to students so as to appreciate current-day research tool-kit bette

Student Learning Outcomes

Students should be to learn history, theoretical basis and basic understanding of latest technologies in area of biotechnology. They should also be able to learn about various applications of these technologies. The students may also learn one application in depth through an assignment and/or seminar.

SEMESTER III					
Core	**Course code: 501302**	**EMERGING TECHNOLOGIES**	**T**	**Credits: 2**	**Hours:28**
Pre-requisite	Concepts of Emerging Technologies		Syllabus Revised	2022-23	
Unit I					
Objective 1	To obtain knowledge on advancement and function of different microscopic technique and its various applications				
Basic Microscopy: Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy: what is fluorescence, what makes a molecule fluorescent, fluorescence microscope; optical arrangement, light source; filter sets: excitation filter, dichroic mirror, and barrier, optical layout for image capture; CCD cameras; back illumination, binning; recording color; three CCD elements with dichroic beamsplitters, boosting the signal. **Advanced Microscopy:** Confocal microscope: scanning optical microscope, confocal principle, resolution and point spread function, light source: gas lasers & solid-state, primary beamsplitter; beam scanning, pinhole and signal channel configurations, detectors; pixels and voxels; contrast, spatial sampling: temporal sampling: signal-to- noise ratio, multichannel images. Advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Near-Field and Evanescent Waves, Total Internal Reflection Microscopy; Near-Field Microscopy;					
Outcome 1	*Gain knowledge on microscopic techniques and their applications in various research field.*			**K2, K4, K5**	
Unit II					
Objective 2	To gain knowledge about mass spectroscopy methods and its applications				
Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.					
Outcome 2	*Understading concepts and application of spectroscopy*			**K2, K5**	

Unit III		
Objective 3	To understand the basic concepts of high throughput analysis using systems biology approach	
High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modeling and designing testable predictions.		
Outcome 3	*Understanding the concepts and application systems biology*	**K2, K4**
Unit IV		
Objective 4	To acquire knowledge on advanced methods	
X-ray diffraction methods, solution & solid-state NMR, cryo-electron microscopy, small- angle X-ray scattering, Atomic force microscopy.		
Outcome 4	*Learn the concepts and application of structural application*	**K3, K4**
Unit V		
Objective 5	To educate the application of CRISPR-CAS	
History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for in vivo genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.		
Outcome 5	*Learn to understand the application of CRISPR-CAS*	**K2, K3**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
- Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
- Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
- Selected papers from scientific journals, particularly Nature & Science.
- Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	M (2)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	M (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	M (2)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.8**	**2.6**	**2.4**	**3**	**2**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Critical Analysis of Classical Papers

Credits

2 SEMINAR ONLY; Course Code: 501303

Course Objectives

The objectives of this course are to familiarize students with classic literature to make them appreciate how groundbreaking discoveries were made without, necessarily, use of high-end technologies.

Student Learning Outcomes

Students should be able to train in the exercise of hypothesis building and methods of addressing the hypothesis with readily available technology.

How does the Course Module work? Students may be divided in groups and each group may be responsible for one classical paper. Each week there may be a 1.5 hour presentation cum discussion for each of the papers. At the end of the semester each student will be asked to write a mini-review (2-3pages long)on anyone classical paper, other than the one he/she presented/discussed.

A list of sixteen classic papers and some suggested reference materials:

Syllabus

Molecular Biology

1. Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a deoxy ribonucleic acid fraction isolated from *Pneumococcus* type III.
   Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944Feb1;79(2):137-58.
   Note: This paper demonstrates that DNA is the transforming Principle originally described by Fredrick Griffith.
2. Independentfunctionsofviralproteinandnucleicacidingrowthofbacteriophage
   Hershey AD and Chase M.; J Gen Physiol. 1952 May;36(1):39-56.
   Note: Note: This paper demonstrates that DNA, and not protein, component of phages enter bacterial cells.
3. Molecular structure of nucleic acids; a structure for deoxy ribosenucleic acid Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8
   Note: In this one page paper Watson and Crick first described the structure of DNA double helix
   Studyhelp-Watson_Crick_Nature_1953_annotated
4. Transposable mating type genes in *Saccharomyces cerevisiae*
   James Hicks, Jeffrey N. Strathern & AmarJ.S.Klar;Nature282,478-483,1979
   Note: Thispaperprovidedevidencefor‘cassettehypothesis’ofyeastmatingtype switches *i.e.* inter conversion of mating types in yeast *(S. cerevisiae)* occurs by DNA rearrange ment.
5. Messelson & Stahl experiment demonstrating semi-conservative replication of DNA. Meselson Mand Stahl FW.; Proc Natl Acad Sci USA. 1958Jul15;44(7):671-82 **Note:** The experiment demonstrating semi-conservative mode of DNA replication is referred to as "the most beautiful experiment in biology"
6. *In vivo* alteration of telomerese quences and senescence caused by mutated *Tetrahymena* telomerase RNAs
   Guo-Liang Yu, John D. Bradley, Laura D. Attardi & Elizabeth H. Blackburn; Nature 344, 126-132, 1990
   Note: This paper demonstrates that the telomerase contain the template for telomere synthesis

Syllabus

Cell Biology

1. A protein-conducting channel in the endoplasmic reticulum
   SimonSMANDBlobelG.;Cell.1991May3;65(3):371-80
   Note: This paper demonstrates the existence of a protein conducting channel
   Study help - A brief history of Signal Hypothesis

2. Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway
   Novick P, Field C, Schekman R.; Cell.1980 Aug;21(1):205-15
   Note: In this groundbreaking paper Randy Schekman's group used a mutagenesis screenforfastsedimentingyeastmutantstoidentifygenesinvolvedincellsecretion
3. Ayeastmutantdefectiveatanearlystageinimportofsecretoryproteinprecursors into the endoplasmic reticulum
   Deshaies RJ and Schekman R.;J CellBiol.1987Aug;105(2):633-45
   Note: Using another yeast mutation screen Schekman lab identifiesSec 61,a component of ER protein Conducting Channel (PCC)
   Suggested reference paper- A bio chemical assay for identification of PCC.
4. Reconstitution of the Transport of Protein between Successive Compartments of the Golgi
   Balch WE, Dunphy WG, BraellWA, Rothman JE.;Cell.1984Dec;39(2Pt1):405-16
   Note: This paper describes setting up of an *in vitro* reconstituted system for transport between golgi stacks which eventually paved the way for identification of most of the molecular players involved in these steps including NSF, SNAP *etc.*
5. A complete immunoglobulin gene is created by somatic recombination
   Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1-14
   Note: This study demonstrates DNA level molecular details of somatic rearrangement of immunoglobulin gene sequences leading to the generation of functionally competent antibody generating gene following recombination.
6. Anovelmultigenefamilymayencodeodorantreceptors:amolecularbasisfor odor recognition
   Buck L and Axel R; Cell.1991Apr 5; 65(1):175-87
   Note: This paper suggests that different chemical odorants associate with different cell-specific expression of a trans-membrane receptor in *Drosophila* olfactory epithelium where a large family of odorat receptors is expressed.
7. Kinesin walks hand-over-hand
   Yildiz A, Tomishige M, Vale RD, Selvin PR.;Science.2004Jan30;303(5658):676-8
   Note: This paper shows that kinesin motor works as a two-headed dimeric motor walking hand-over-hand rather than like an inchworm on microtubule tract using the energy of ATP hydrolysis.

Syllabus

Developmental Biology/Genetics

1. Mutations affecting egment number and polarity in *Drosophila*
   Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, 1980
   Note: This single mutagenesis screen identified majority of the developmentally important genes not only in flies but in other metazoans as well.
2. Information for the dorsal—ventral pattern of the *Drosophila* embryois stored as maternal mRNA
   Anderson KV and Nüsslein-Volhard C;Nature.1984Sep20-26;311(5983):223-7
   Note: This landmark paper demonstrated that early dorsal-ventral pattern information is stored as maternal mRNA in flies and devised the method of identifying genes encoding such genes
3. Hedgehogsignallinginthemouserequiresintraflagellartransportproteins
   Huangfu D, Liu A, Rakeman A S, Murcia N S, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7
   Note: One of the architects of original fly mutagenesis screens conducted a mouse mutagenes screen which identified a gene Kif3 a as a major component of hedgehog signaling pathway. Eventually this discovery revolutionizes our understanding of mechanisms of action of signaling pathways by demonstrating central role of Cilia in it.
   Suggested Reference paper-Design and execution of a embryonic lethal mutation screen in mouse.

Bioentrepre - neurship

Credits

2

Course Objectives

Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with the understanding of science & technology. Bio-entrepreneurship, an interdisciplinary course, revolves around The central theme of how to manage and develop life science companies and projects. The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

Student Learning Outcomes

Students should be able to gain entrepreneurial skills, understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centres and various agencies. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.

SEMESTER III					
Core	**Course code: 501304**	**BIO-ENTREPRENEURSHIP**	**T**	**Credits: 2**	**Hours:32**
Pre-requisite	Basic knowledge in fundamental concepts of bio-entrepreneurship.		Syllabus Revised		2022-23
Unit I					
Objective 1	To introduce the concept of Bio-entrepreneurship and its business opportunities.				
Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities.					
Outcome 1	*Get introduced to the concept, fundamentals and types of of bio-industries in bio-sector.*				**K2& K4**
Unit II					
Objective 2	To impart the knowledge of relevant strategies in commercializing and patenting.				
Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.					
Outcome 2	*Obtain a comprehensive knowledge about Entrepreneurship development programs and patenting & commercialization strategies.*				**K4**
Unit III					
Objective 3	To enrich the students' knowledge with the strategies and process of negotiation and basic concepts of agreements.				
Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs). Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.					
Outcome 3	*Student would be able to select the best strategies to market products.*				**K3&K4**

Unit IV		
Objective 4	To acquire knowledge in the basics of business plan and partnership	
Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.		
Outcome 4	*Analyze and understand the business feasibility and financial management.*	**K3**
Unit V		
Objective 5	Students will able to learn the different technologies to assess and upgrade the business status.	
Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).		
Outcome 5	*Learn to assess the technologies and regulatory process in upgrading the business.*	**K2&K3**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Adams, D. J., & Sparrow, J. C. (2008). Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion.
- Shimasaki, C. D. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading
- Onetti, A., & Zucchella, A. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.
- Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.
- Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M (2)	M (2)	S (3)	S (3)	S (3)	S (3)	M (2)	S (3)	M (2)	L (1)
CO2	S (3)	S (3)	S (3)	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	M (2)	L (1)	M (2)	M (2)
CO4	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	L (1)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	M (2)	S (3)	M (2)
W.AV:	**2.8**	**2.4**	**2.6**	**2.8**	**2.2**	**3**	**2.2**	**2.4**	**2.6**	**2.2**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	M (2)
CO2	L (1)	S (3)	S (3)	S (3)	S (3)
CO3	M (2)	S (3)	S (3)	L (1)	S (3)
CO4	S (3)	S (3)	L (1)	S (3)	S (3)
CO5	M (2)	S (3)	S (3)	M (2)	S (3)
W.AV:	**2.2**	**3**	**2.6**	**2.4**	**2.8**

***3 – Strong 2 – Medium 1 – Low**

Intellectual Property Rights, Biosafety and Bioethics

Credits

2

Course Objectives

The objectives of this course are:

- To provide basic knowledge on intellectual property rights and their implications in biological research and product development;
- To become familiar with India's IPR Policy;
- To learn Biosafety of products derived from biotechnology and regulation of such products;
- To become familiar with ethical issues in biological research..

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Student Learning Outcomes On completion of this course, students should be able to:

- Understand the rationale for and against IPR and especially patents;
- Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations;
- Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents;
- Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms,

national and international regulations;
Understand ethical aspects related to biological, biomedical, healthcare and biotechnology research

SEMESTER III					
Core	**Course code: 501305**	**IPR, BIOSAFETY & BIOETHICS**	**T**	**Credits: 2**	**Hours:25**
Pre-requisite			Syllabus Revised		2022-23
Unit I					
Objective 1	To provide basic knowledge on International organizations for protecting intellectual properties, and to understand the implications of intellectual property rights in biological research and product development.				
Introduction to IPR: General Agreement on Trade and Tariff (GATT) & World Trade Organization (WTO); Establishment and functions of GATT, WTO & WIPO; Physical & Intellectual Property; Various types of IP (Patent, TM, TS, GI, TK, and ID); Concept of 'prior art'; Plant variety protection and Farmers rights act; TRIPS.					
Outcome 1	Students will understand the importance of establishment and functions of international organizations such as WTO and WIPO and the various types of intellectual property.				**K1**
Unit II					
Objective 2	To become familiar with IPR policy in India and to understand the technique of filing patents				
Patenting: Different types of intellectual property rights (IPR) - Patents, Trade mark, Trade secret, Copy right & GI; Basics & types of patents; Biotechnological examples of Patents, Trade mark, Trade secret & Copy right; Indian Patent Act 1970 and its recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and its filing; Patent application filing; Types of patent application: Provisional and complete specifications; Disclosure/non-disclosure; Biopiracy and Case studies on patents (Basmati rice, Neem); Traditional Knowledge.					
Outcome 2	Students will get both basic and advanced knowledge about IPR, patent filing, and specifications.				**K2**

Unit III		
Objective 3	To learn the importance of biosafety cabinets and biosafety levels.	
Biosafety: Biosafety - introduction; Different Levels of Biosafety; Biological Safety Cabinets; GRAS organisms; Biosafety levels of specific microorganisms; Guidelines for rDNA research activities; General guidelines for research in transgenic plants; Good Laboratory Practices (GLP); Concepts of familiarity and substantial equivalence; GMOs & LMOs; Risk analysis of transgenic plants.		
Outcome 3	Students will get advance knowledge on the functions of biosafety cabinets and guidelines for recombinant DNA research activities.	**K4**
Unit IV		
Objective 4	To educate the functioning of international regulations, treaties, and frame work to carryout biotechnology research.	
National and international regulations: International regulations – Cartagena Biosafety protocol (CAB), OECD consensus documents and Codex Alimentarius; Role of regulatory framework – RCGM, GEAC, IBSC; Draft bill of Biotechnology Regulatory Authority of India; Standard Operating Procedures; GM labeling – Food Safety and Standards Authority of India (FSSAI).		
Outcome 4	Students will understand the role of various regulations and safety aspects of biotechnology products.	**K4**
Unit V		
Objective 5	To become familiar with ethical issues related to animals, plants, and microorganisms.	
Bioethics: Bioethics - Introduction. Animal Rights, General issues related to environmental release of transgenic plants, animals, and microorganisms. Ethical issues related to research in embryonic stem cell cloning.		
Outcome 5	Students acquire advance knowledge on the role of bioethics in animal research. Also critically analyse the ethical issues related to plant and animal research.	**K5**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- 1.Rupinder Tiwari and Mamta Bharadwaj (2021) Intellectual property A prime for academia, Publication Bureau, Panjab University Jatinder Moudgil Manager Press Panjab University, Chandigarh-160014, India. ISBN: 81-85322-92-9
- WIPO Intellectual Property Hand Book (2008). WIPO Publication No.489 (E) ISBN 978-92-805-1291-5
- Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy.*
- New Delhi: Tata McGraw-Hill Pub.
- *National IPR Policy*, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
- Kuhse, H. (2010). *Bioethics: an Anthology*. Malden, MA: Blackwell.
- World Trade Organisation. http://www.wto.org
- Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/ divisions/csurv/geac/annex-5.pdf
- Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu,

- F. (2009). *Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants*. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9
- Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.
- Guidelines and Standard Operating Procedures for Confined Field Trials of Regulated Genetically Engineered Plants. 2008. Retrieved from http://www.igmoris.nic.in/guidelines1.asp
- Alonso, G. M. (2013). *Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation to Ensure "Fit for Purpose" Risk Assessments*.
- Retrieved from http://biosafety.icgeb.org/inhousepublicationscollectionbiosafetyreviews.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L (1)	M (2)	L (1)	M (2)	L (1)	M (2)	L (1)	S (3)	M (2)	S (3)
CO2	M (2)	L (1)	M (2)	L (1)	M (2)	M (2)	M (2)	M (2)	S (3)	S (3)
CO3	M (2)	M (2)	L (1)	L (1)	M (2)	L (1)	M (2)	M (2)	M (2)	L (1)
CO4	M (2)	L (1)	M (2)	M (2)	M (2)	L (1)	M (2)	S (3)	M (2)	M (2)
CO5	M (2)	M (2)	M (2)	M (2)	M (2)	M (2)	S (3)	M (2)	S (3)	M (2)
W.AV:	**1.8**	**1.6**	**1.6**	**1.6**	**1.8**	**1.6**	**2.0**	**2.4**	**2.4**	**2.2**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	M (2)	M (2)	L (1)	M (2)	M (2)
CO2	M (2)	M (2)	L (1)	M (2)	M (2)
CO3	S (3)	L (1)	M (2)	L (1)	S (3)
CO4	L (1)	M (2)	M (2)	M (2)	L (1)
CO5	L (1)	M (2)	M (2)	S (3)	M (2)
W. AV	**1.8**	**1.8**	**1.6**	**2.0**	**2.0**

***3 – Strong 2 – Medium 1 – Low**

Project Proposal Preparation & Presentation

Credits

2

CODE: 501306

Course Objectives

The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

Student Learning Outcomes Students should be able to demonstrate the following abilities:

- Formulate a scientific question;
- Present scientific approach to solve the problem;
- Interpret, discuss and communicate scientific results in written form;
- Gain experience in writing a scientific proposal;
- Learn how to present and explain their research findings to the audience effectively.

Laboratory VI: Bioprocess Engineering & Technology

Credits

Course Objectives

The objectives of this laboratory course are to provide hands-on training to students in upstream and downstream unit operations.

Student Learning Outcomes

Students should be able to:

- Investigate, design and conduct experiments, analyze and interpret data, and apply the laboratory skills to solve complex bioprocess engineering problems;
- Apply skills and knowledge gained will be useful in solving problems typical of bio industries and research.

SEMESTER III					
Core	**Course code: 501308**	**LABORATORY VI: BIOPROCESS ENGINEERING & TECHNOLOGY**	**P**	**Credits: 4**	**Hours:**
Pre-requisite	Technical and hands-on skills will be applicable to help in industries.		Syllabus Revised		2022-23
Unit I					
Objective 1	Understanding the importance of basic microbiology techniques.				
Basic Microbiology techniques a) Scale up from frozen vial to agar plate to shake flask culture. b) Instrumentation: Microplate reader, spectrophotometer, microscopy. c) Isolation of microorganisms from soil samples.					
Outcome 1	*Gain fundamental knowledge in basic microbiology techniques*				***K4***
Unit II					
Objective 2	To make the students aware of importance of bioreactor techniques				
Experimental set-up a) Assembly of bioreactor and sterilization. b) Growth kinetics. a) Development of enzyme assays and quantification of enzyme activity and specific activity. Enzyme kinetics. Effect of pH and temperature on enzyme activity.					
Outcome 2	*Understand the basis of various enzyme assay conditions from the perspective of biochemical reactions.*				*K4*
Unit III					
Objective 3	To enable the students to acquire knowledge on the fundamental aspects of Biotechnology such as Biochemistry, Cell Biology, Microbiology, Environmental Biotechnology and Molecular Biology				
Fermentation a) Batch. b) Fed-batch. c) Continuous.					
Outcome 3	*Acquire knowledge in the basic enzymatic reactions that play a vital role in day to day life*				*K2*

Unit IV		
Objective 4	To acquire knowledge in basic techniques separation techniques.	
Unit operations a) Microfiltrations: Separation of cells from broth. b) Bioseparations: Various chromatographic techniques and extractions.		
Outcome 4	*Understand the applications of fundamental sciences for various field of biology in the context of Biotechnology.*	*K3*
Unit V		
Objective 5	To facilitate them to understand the advanced concepts of Biotechnology so that the students can take up any challenging career in this field	
Bioanalytics a) Bioseparations: Various chromatographic techniques and extractions, Bioanalytics: Fraction analytical techniques such as HPLC, FPLC, GC-MS, for measurement of amounts of products/substrates.		
Outcome 5	*Learning the fundamentals of modern biology and advanced technologies improve student's capacity to apply their knowledge of a subject to solve current issues on both a local and global scale is a function of their critical thinking abilities.*	*K2*
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- 1. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.
- 2. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.
- 3. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York:
- M. Dekker.
- 4. Bailey, J. E., & Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.
- 5. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	M (2)	S (3)	S (3)
CO2	M (2)	M (2)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	M (2)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	M (2)
CO4	S (3)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	M (2)	S (3)
CO5	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.8**	**2.4**	**2.6**	**2.6**	**2.4**	**2.8**	**3**	**2.8**	**2.8**	**2.8**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	M (2)	S (3)	M (2)	S (3)
CO3	S (3)	S (3)	M (2)	S (3)	S (3)
CO4	M (2)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.8**	**2.8**	**2.8**	**2.8**	**2.8**

***3 – Strong 2 – Medium 1 – Low**

Laboratory VII: Bioinformatics

Credits

Course Objectives

The aim of this course is to provide practical training in bioinformatic methods including accessing major public sequence databases, use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages.

Student Learning Outcomes On completion of this course, students should be able to:

- Describe contents and properties of most important bioinformatics databases;
- Perform text- and sequence-based searches and analyze and discuss results in light of molecular biological knowledge;
- Explain major steps in pairwise and multiple sequence alignment, explain principle and execute pairwise sequence alignment by dynamic programming;
- Predict secondary and tertiary structures of protein sequences.

SEMESTER III					
Core	**Course code: 501309**	**LABORATORY VII BIOINFORMATICS**	**P**	**Credits: 2**	**Hours:**
Pre-requisite	The aim of this course is to provide practical training in bioinformatics methods including accessing major public sequence databases, use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages.		Syllabus Revised		2022-23
Unit I					
Objective 1	To provide introduction, practical knowledge and helps students to understand bioinformatics and information regarding various biological databases.				
1. Using NCBI and Uniprot web resources. 2. Introduction and use of various genome databases. 3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt. 4. Similarity searches using tools like BLAST and interpretation of results.					
Outcome 1	*Enables students to understand and perform database search in various biological databases and BLAST analysis.*				*K1&K2*
Unit II					
Objective 2	To understand and provide practical knowledge on Multiple sequence analysis and to equip students with practical knowledge on how to perform phylogenetic analysis of various DNA and protein sequences.				
5. Multiple sequence alignment using ClustalW. 6. Phylogenetic analysis of protein and nucleotide sequences.					
Outcome 2	*Understand the essential DNA sequence analyses and to gain therotical and practical knowledge on DNA sequencing technology.*				*K1, K2& K3.*

Unit III		
Objective 3	To learn about and perform prediction of gene and RNA structures and also to design primers for PCR techniques and prediction of restriction sites in a gene sequence.	
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer). 8. Using RNA structure prediction tools. 9. Use of various primer designing and restriction site prediction tools.		
Outcome 3	*Facilitates students to perform gene, RNA structure prediction and designing of primers to best suit their PCR protocol and to predict restriction sites of a gene or DNA sequence.*	*K1, K2 & K3*
Unit IV		
Objective 4	To gain practical knowledge on protein modelling, the softwares used for protein modelling. Also helps to attain practical experience on *in silico* mutation of protein and prediction of miRNA.	
10. Use of different protein structure prediction databases (PDB, SCOP, CATH). 11. Construction and study of protein structures using Deepview/PyMol. 12. Homology modelling of proteins. 13. Use of tools for mutation and analysis of the energy minimization of protein structures. 14. Use of miRNA prediction, designing and target prediction tools.		
Outcome 4	*Will aid students to practically analyze and understand various protein structures and provide practical insights related to protein structure modelling and to perform analyses related to mutations and miRNA design and prediction .*	*K1, K2, K3 & K4.*
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- 1.Ashok Kumar Sharma (2012). Practical Bioinformatics. Oxford UniversityPress.
- 2.Cynthia Gibas, Per Jambeck (2001). Developing Bioinformatics Computer Skills, O'Reilly Media,Inc.,
- 3.David Edwards, Jason Eric Stajich, David Hansen, (2009). Bioinformatics: Tools and Applications, Springer.
- 4.David W Mount (2004). Bioinformatics: Sequence and genome analysis, Cold spring harbor laboratory press, 2nd edition,
- 5.Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.
- 6.Practical Bioinformatic (2013) by Michael J Agostino,Garland Science, Taylor & Francis Group, LLC

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	S (3)	M (2)	M (2)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	M (2)	M (2)	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	M (2)	M (2)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**2.25**	**2**	**2.5**	**2**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Semester Four

Dissertation

Credits

20 *(SemesterIV:20Credits)*

CODE: 501410

Course Objectives

The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.

Student Learning Outcomes

Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:

- In-depth knowledge of the chosen area of research.
- Capability to critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis.
- Capabilitytocreate,analyseandcriticallyevaluatedifferenttechnicalsolutions
- Ability to conduct research independently
- Project management skills
- Problem solving skills
- Competence in research design and planning
- Communication and inter personal skills

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Syllabus

Planning &performing experiments

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosenresearchtopicrelevanttobiologicalsciencesandsociety.Theyshouldbeableto systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

Syllabus

Thesis writing

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If there search findings have application-oriented outcomes, the students may file patent application.

Recommended Electives

Biological Imaging

Credits

2

Course Objectives

The objectives of this course are to provide complete over view of state-of-art live-cell imaging techniques using microscopes currently available in literature. Live-cell imaging techniques allow real-time examination of almost every aspect of cellular function under normal and experimental conditions. With live-cell imaging experiments, main challenges are to keep cells alive and healthy over a period of time. The growing number of live-cell imaging techniques means one can obtain greater amounts of information without stressing out cells.

Student Learning Outcomes

On completion of this course, students shall be able to gain a complete overview of super-resolution field from fundamentals to state-of-art methods and applications in biomedical research. The students shall learn the comparative advantages and disadvantages of each technique, covers all key techniques in field of biomedical science. The students shall also learn how to use new tools to increase resolution in sub-nanometer-scale images of living cells and tissue, which leads to new information about molecules, pathways and dynamics and state-of-the-art examples of applications using microscopes.

ELECTIVE					
DSE	**Course code:**	**BIOLOGICAL IMAGING**	**P**	**Credits: 2**	**Hours:22**
Pre-requisite	Overview of super-resolution Microscopy		Syllabus Revised		2022-23
Unit I					
Objective 1	**To provide a complete overview of state-of-art live-cell imaging techniques**				
One of the most basic techniques for live-cell imaging is widefield fluorescent microscopy. Standard inverted research grade microscopes can yield valuable results if you are imaging adherent cells, large regions of interest (such as organelles) or very thin tissue sections (less than 5 micrometer). In widefield, a CCD camera is usually used to capture images and the epi-fluorescence illumination source can be a mercury lamp, xenon lamp, LED's, etc. Each of light sources requires carefully matched interference filters for specific excitation and emission wavelengths of your fluorophore of interest. With widefield microscopy, your specimen is only exposed to excitation light for relatively short time periods as the full aperture of emission light is collected by the objectives. Widefield					

fluorescence microscopy can be used in combination with other common contrast techniques such as phase contrast and differential interference contract (DIC) microscopy. This combination is useful when performing live-cell imaging to examine general cell morphology or viability while also imaging regions of interest within cells.		
Outcome 1	*Overview on fundamentals of microscopy and its biomedical applications.*	*K1*
Unit II		
Objective 2	**To teach students the background and experimental methods in handling CLSM**	
CLSM has ability to eliminate out-of-focus light and information. It is also possible to obtain optical serial sections from thicker specimens. A conjugate pinhole in optical path of confocal microscope prevents fluorescence from outside of focal plane from being collected by photomultiplier detector or imaged by camera. In CLSM, a single pinhole (and single focused laser spot) is scanned across specimen by scanning system. This spot forms a reflected epi-fluorescence image back on original pinhole. When specimen is in focus, fluorescent light from it passes through pinhole to detector. Any out-of-focus light is defocused at pinhole and very little of this signal passes through to detector meaning that background fluorescence is greatly reduced. The pinhole acts as a spatial filter for emission light from the specimen.		
Outcome 2	*Familiarize with basic laboratory instruments and understand the working principle of CLSM*	*K2*
Unit III		
Objective 3	**To develop skills of the students to perform spinning disc confocal microscopy**	
This method utilises a 'Nipkow Disc' which is a mechanical opaque disc which has a series of thousands of drilled or etched pinholes arranged in a spiral pattern. Each illuminated pinhole on disc is imaged by microscope objective to a diffraction-limited spot on region of interest on specimen. The emission from fluorophores passes back though Nipkow disc pinholes and can be observed and captured by a CCD camera. The effect of spinning disc is that many thousands of points on specimen are simultaneously illuminated. Using SDCM to examine a specimen means that real-time imaging (30-frames-per-second or faster) can be achieved, which is extremely useful if you are looking at dynamic changes within living cells over a wide spectrum of time-scales.		
Outcome 3	*Distinguish the analysis of specimens in SDCM*	*K4*
Unit IV		
Objective 4	**To familiarize the students with light-sheet fluorescence microscopy**	
This method enables one to perform live-cell imaging on whole embryos, tissues and cell spheroids in vivo in a gentle manner with high temporal resolution and in three dimensions. One is able to track cell movement over extended periods of time and follow development of organs and tissues on a cellular level. The next evolution of light-sheet fluorescence microscopy, termed lattice light-sheet microscopy as developed by Eric Betzig (Nobel Prize Laureate 2014 for PALM super-resolution microscopy) will even allow live-cell imaging with super-resolved in vivo cellular localization capabilities.		
Outcome 4	*Exhibit a knowledge base in the fundamentals light-sheet fluorescence microscopy and its practical application*	*K6*

Unit V		
Objective 5	**To expose the students to mechanism of super-resolved fluorescence microscopy and its applications**	
Super-Resolution in a Standard Microscope: From Fast Fluorescence Imaging to Molecular Diffusion Laws in Live Cells; Photoswitching Fluorophores in Super- Resolution Fluorescence Microscopy; Image Analysis for Single-Molecule Localization Microscopy Deconvolution of Nanoscopic Images; Super-Resolution Fluorescence Microscopy of the Nanoscale Organization in cells; Correlative Live-Cell and Super- Resolution Microscopy and Its Biological Applications; SAX Microscopy and Its Application to Imaging of 3D-Cultured Cells; Quantitative Super-Resolution Microscopy for Cancer Biology and Medicine.		
Outcome 5	*Obtain knowledge in the components of super resolved fluorescence microscopy and its application in 3D cultured and cancer biology.*	*K5* *K6*
Unit VI		
Objective 6	**To Understand the basics of re-scan confocal microscopy**	
Structured Illumination Microscopy; Correlative Nanoscopy: AFM Super-Resolution (STED/STORM) ; Stochastic Optical Fluctuation Imaging.		
Outcome 6	*Understanding the functioning of different super resolution imaging microscopes, advantages and disadvantages of each techniques.*	*K2*
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Rajagopal Vadivambal, Digvir S. Jayas. (2015). Bio-Imaging: Principles, Techniques,
- and Applications. ISBN 9781466593671 - CAT# K20618.
- Alberto Diaspro, Marc A. M. J. van Zandvoort. (2016). Super-Resolution Imaging in
- Biomedicine. ISBN 9781482244342 - CAT# K23483.
- Taatjes, Douglas, Roth, Jürgen (Eds.). (2012). Cell Imaging Techniques Methods and
- Protocols. ISBN 978-1-62703-056-4.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	L (1)	L (1)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO 2	L (1)	L (1)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO 3	L (1)	L (1)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO 4	L (1)	L (1)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO 5	L (1)	L (1)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**1**	**1**	**3**	**2**	**3**	**3**	**3**	**2**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	POS1	POS2	POS3	POS4	POS5
CO 1	S (3)	S (3)	S (3)	S (3)	S (3)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)
CO 3	S (3)	S (3)	S (3)	S (3)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	S (3)
CO 5	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Computational Biology

Credits

2

Course Objectives

The objective of this course is to provide students with theory and practical experience of essentials to aid for genomic, proteomic and metabolomics courses and drug design program.

Student Learning Outcomes On completion of this course, the students are expected to:

- Develop an understanding of the basic theory of these computational tools;
- Develop required database extraction, integration, coding for computational tools and methods necessary for All Omics;
- Create hypothesis for investigating specific contemporary biological questions, provide help to experiment with or develop appropriate tools;
- Critically analyze and interpret results of their study with respect to whole systems.

ELECTIVE					
Core	**Course code:**	**Computational Biology**	**T & P**	**Credits: 4**	**ours:36**
Pre-requisite			Syllabus Revised		2022-23
Unit I					
Objective 1	To enable students gain a undergraduate level knowledge of bioinformatics with specific emphasis on different databases and its applications.				
Computers in biology and medicine; Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases.					
Outcome 1	*Gain fundamental knowledge on databases and their applications*				*K1*
Unit II					
Objective 2	To provide comprehensive insights on algorithm programming and functioning				
Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification.					
Outcome 2	*Learn the applications of algorithm in local and global alignment and explore BLAST options available in NCBI platform*				*K3*
Unit III					
Objective 3	To understand the various sequencing platforms, post sequencing analytical tools and their applications				
Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, Human genome project, Genomics and crop improvement. Study available GWAS, ENCODE, HUGO projects, extract and build sub databases; Visualization tools including Artemis and Vista for genome comparison; Functional genomics case studies.					
Outcome 3	*Acquire knowledge on various sequencing platforms and to derive valid conclusion from existing datasets*				*K2*

Unit IV		
Objective 4	To attain basic knowledge on various types of protein structure, illustrate ligand structure and evaluate their interactions	
Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD.		
Outcome 4	*Execute protein preparation, structure validation using Ramachandran plot, SAVES server and draw ligands for docking*	*K4*
Unit V		
Objective 5	Model, analyze and validate protein structure using various online and offline tools	
Significance and need, force field methods, energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; RMS fit of conformers and protein chains, assigning secondary structures; sequence alignment: methods, evaluation, scoring; protein curation: backbone construction and side chain addition; different types of protein chain modelling: ab initio, homology, hybrid, loop; Template recognition and alignments; Modelling parameters and considerations; Model analysis and validation; Model optimization; Substructure manipulations, annealing, protein folding and model generation; loop generating methods; loop analysis; Analysis of active sites using different methods in studying protein–protein interactions.		
Outcome 5	*Understanding modelling parameters to generate model of proteins and identify active sites of proteins responsible for its activity*	*K4*
Unit VI		
Objective 6	Implement molecular docking for drug discovery	
Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Ligand conformations, Clustering, Analysis of docking results and validation with known information. Extra- precision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high throughput screenings.		
Outcome 6	*Help explore different docking methods that will aid in drug discovery*	*K5*
Unit VII		
Objective 7	Aid in quantitatively predict both thermodynamic- and kinetic-based binding parameters of small molecules	
Quantitative structure activity relationships; Introduction to chemical descriptors like2D, 3D and Group-based; Radar plots and contribution plots and Activity predictions, Pharmacophore modeling, Pharmacophore-based screenings of compound library, analysis and experimental validation.		
Outcome 7	*Familarize with quantitative structure-activity relationship methods that are important for prediction of biological effect of chemical compounds based on mathematical and statistical relations.*	*K6*
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		
	• **Suggested Readings:** • Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. • Bourne, P. E., &Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss. • Lesk, A. M. (2004). Introduction to Protein Science: Architecture,	

Function and Genomics. Oxford: Oxford University Press.
- Campbell, M &Heyer, L. J. (2006), Discovering Genomics, Proteomics and
- Bioinformatics, Pearson Education.
- Oprea, T. (2005). Chemoinformatics in Drug Discovery, Volume 23. Wiley Online Library.
- 6. Gasteiger, J. &Engel,T. (2003), Chemoinformatics: a Textbook, Wiley Online Library.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	M (2)	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	M (2)	S (3)
CO2	L (1)	L (1)	S (3)	L (1)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)
CO3	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO6	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO7	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.7**	**2.57**	**2.85**	**2.42**	**3**	**3**	**3**	**2.85**	**2.57**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcomes Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Drug Discovery and Development

Credits

2

Course Objectives

This course will give a broad overview of research hand development carried out in industrial setup towards drug discovery.

Student Learning Outcomes

On completion of this course, students should be able to understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry.

ELECTIVE					
Core	**Course code:**	**Drug Discovery and Development**	**T**	**Credits: 2**	**Hours:29**
Pre-requisite	Knowledge in Biochemistry& Basics of Human Anatomy		Syllabus Revised		2022-23
Unit I					
Objective 1	To enable students to identify target or drug proficiently leads related to a specific disease through a comprehensive understanding and application of various techniques.				
Identification of target or drug leads associated with a particular disease by a number of different techniques including combinations of molecular modeling, combinatorial libraries and high-throughput screening (HTS); Conceptualizing the automation of the HTS process and the importance of bioinformatics and data processing in the identification of lead compounds; Rational drug design, based on understanding the three-dimensional structures and physicochemical properties of drugs and receptors; Modelling drug/ receptor interactions with the emphasis on molecular mechanisms, molecular dynamics simulations and homology modelling; Conformational sampling, macromolecular folding, structural bioinformatics, receptor-based and ligand-based design and docking methods, in silico screening of libraries, semi-empirical and ab-initio methods, QSAR methods, molecular diversity, design of combinatorial libraries of drug-like molecules, macromolecular and chemical databases.				
Outcome 1	Comprehensive understanding of lead compound identification for various diseases				*K2*
Unit II					
Objective 2	To develop a comprehensive understanding of molecular interactions, structure-activity relationships, and quantitative drug design principles				
Identification of relevant groups on a molecule that interact with a receptor and are responsible for biological activity; Understanding structure activity relationship; Structure modification to increase potency and therapeutic index; Concept of quantitative drug design using Quantitative structure–activity relationship models (QSAR models) based on the fact that the biological properties of a compound are a function of its physicochemical parameters such as solubility, lipophilicity, electronic effects, ionization, stereochemistry, etc.; Bioanalytical assay development in support of in vitro and in vivo studies (LC/MS/MS, GC/MS and ELISA).					
Outcome 2	Understanding of critical concepts in medicinal chemistry and drug design. Attain skills to develop robust bioanalytical assays using techniques				*K4*

Unit III		
Objective 3	To develop a comprehensive understanding of essential concepts in pharmacokinetics, pharmacodynamics, toxicology, and regulatory compliance, enabling proficient design and execution of preclinical and clinical studies for drug development.	
Principles of drug absorption, drug metabolism and distribution - intestinal absorption, metabolic stability, drug-drug interactions, plasma protein binding assays, metabolite profile studies, Principles of toxicology, Experimental design for preclinical and clinical PK/PD/TK studies, Selection of animal model; Regulatory guidelines for preclinical PK/ PD/TK studies; Scope of GLP, SOP for conduct of clinical & non clinical testing, control on animal house, report preparation and documentation Integration of non-clinical and preclinical data to aid design of clinical studies.		
Outcome 3	Acquire knowledge in key concepts in pharmacokinetics, pharmacodynamics, and toxicology.	*K2*
Unit IV		
Objective 4	To provide students with a comprehensive understanding of Good Manufacturing Practices (GMP) principles and implementation, encompassing documentation, quality control, quality assurance, regulatory compliance	
Requirements of GMP implementation, Documentation of GMP practices, CoA, Regulatory certification of GMP, Quality control and Quality assurance, concept and philosophy of TQM, ICH and ISO 9000; ICH guidelines for Manufacturing, Understanding Impurity Qualification Data, Stability Studies.		
Outcome 4	Students will proficiently grasp GMP implementation, adeptly document GMP practices, analyze CoA, navigate regulatory GMP certification, excel in Quality Control and Assurance, comprehend TQM concepts, evaluate ICH and ISO 9000 principles, interpret ICH guidelines for Manufacturing, expertly assess Impurity Qualification Data, and demonstrate competence in designing Stability Studies.	*K1*
Unit V		
Objective 5	To provide fundamental principles and practical applications of Phase I-IV clinical study design andAddress clinical safety through an in-depth exploration of adverse events and drug reactions.	
Objectives of Phase I, II, III and IV clinical studies, Clinical study design, enrollment, sites and documentation, Clinical safety studies: Adverse events and adverse drug reactions, Clinical PK, pharmacology, drug-drug interaction studies, Statistical analysis and documentation.		
Outcome 5	Understand the objectives and designs of Phase I-IV trials. Grasp safety assessment through adverse events and drug reactions and dive into clinical PK, pharmacology, and drug interactions. Develop proficiency in statistical analysis and meticulous documentation for robust clinical study execution.	*K4*

Unit VI		
Objective6	Understanding of Global Regulatory Affairs and addressing ethical considerations within current guidelines, including Ethical Committee setup and Animal Ethical issues.	
Global Regulatory Affairs and different steps involved, Regulatory Objectives, Regulatory Agencies; FDA guidelines on IND and NDA submissions, Studies required for IND and NDA submissions for oncology, HIV, cardiovascular indications, On-label vs. off-label drug use GCP and Requirements of GCP Compliance, Ethical issues and Compliance to current ethical guidelines, Ethical Committees and their set up, Animal Ethical issues and compliance.		
Outcome 6	Gained knowledge on Global Regulatory Affairs, FDA guidelines for IND and NDA submissions, required studies for oncology, HIV, and cardiovascular indications, on-label vs. off-label drug use, GCP compliance, ethical considerations, Ethical Committee setup, and Animal Ethics compliance.	*K1*
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Atkinson AJ Jr, Daniels CE, Dedrick RL. **Principles of Drug Action: The Basis of Pharmacology**. John Wiley & Sons; 2012.
- Hill RG. **Drug Discovery and Development: Technology in Transition**. Academic Press; 2013.
- Stevens EDC, Matthews K. **Medicinal Chemistry: The Modern Drug Discovery Process**. Pearson; 2013.
- Cairns D. **Pharmaceutical Chemistry**. Churchill Livingstone; 2006.
- Embrechts MJ, Chong S. **Drug Discovery: A Casebook and Analysis**. CRC Press; 2016.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	S (3)	M (2)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	M (2)	S (3)
CO4	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	L (1)	M (2)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**2.4**	**2.2**	**2.6**	**3**	**2.8**	**3**	**3**	**2.8**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	M (2)	S (3)	S (3)
CO3	M (2)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	M (2)	S (3)	S (3)
W.AV:	**2.8**	**3**	**2.6**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Environmental Biotechnology

Credits

2

Course Objectives

This course aims to introduce fundamentals of Environmental Biotechnology. The course will introduce major groups of microorganisms- tools in biotechnology and their most important environmental applications. The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.

Student Learning Outcomes

On completion of course, students will be able to understand use of basic microbiological, molecular and analytical methods, which are extensively used in environmental biotechnology.

ELECTIVE					
Core	**Course code: 501504**	**Environmental Biotechnology**	**P**	**Credits: 4**	**Hours:**
Pre-requisite	**Basic Knowledge about the fundamentals of Environmental Biotechnology**		Syllabus Revised		2022-23
Unit I					
Objective 1	To develop the basic knowledge about the pollution in the environment and the mechanism involved to eliminate the pollution using microorganisms				
Introduction to environment; pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology					
Outcome 1	*Ability to know about the environmental threats and the strategies to prevent it*				***K1***
Unit II					
Objective 2	To make the students understand the fundamentals of microbes involved in Bioremediation.				
Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.), technological aspects of bioremediation (in situ, ex situ).					
Outcome 2	*Gains the knowledge about the importance of microbial involvement in accordance to the environmental threats.*				***K2***
Unit III					
Objective 3	To develop the knowledge about the applications of microorganisms in bioremediation				
Application of bacteria and fungi in bioremediation: White rot fungi vs specialized degrading bacteria: examples, uses and advantages vs disadvantages; Phyto remediation: Fundamentals and description of major methods of application (phyto accumulation, phyto volatilization, rhizo filtration phyto stabilization).					
Outcome 3	*Knowledge about the methods involved and the applications of bioremediation*				***K3***
Unit IV					
Objective 4	To understand the mechanism and the mode of action of bioinsecticides with its safety measures.				
Bioinsecticides: Bacillus thuringiensis, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (e.g. Trichoderma, Pseudomonas fluorescens); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.					
Outcome 4	*Acquires knowledge about different microorganisms involved in environmental applications*				***K2***

Unit V		
Objective 5	To develop the knowledge about the importance and the need of biofuels along with the fundamental knowledge about eco-friendly industrial products.	
Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.		
Outcome 5	*Learn the production, manufacturing of environmentally friendly materials which is most economical and important.*	***K3***
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- G. M. Evans and J. C. Furlong (2003), *Environmental Biotechnology: Theory and Applications*, Wiley Publishers.
- B. Ritmann and P. L. McCarty, (2000), *Environmental Biotechnology: Principle & Applications*, 2nd Ed., McGraw Hill Science.
- Scragg A., (2005) *Environmental Biotechnology*. Pearson Education Limited.
- J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), *Biofiltration for Air Pollution Control*, CRC Press.
- H. J. Rehm and G. Reed, (2001), *Biotechnology – A Multi-volume Comprehensive Treatise*, Vol. 11, 2nd Ed., VCH Publishers Inc.
- 6. H. S. Peavy, D. R. Rowe and G. Tchobanoglous, (2013), *Environmental Engineering*, McGraw-Hill Inc.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M (2)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	L (1)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	L (1)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	L (1)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**1.6**	**2.2**	**3**	**3**	**2.4**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Microbial Technology

Credits

2

Course Objectives

The objectives of this course are to introduce students to developments/ advances made in field of microbial technology for use in human welfare and solving problems of the society.

Student Learning Outcomes

On completion of this course, students would develop deeper understanding of the microbial technology and its applications.

ELECTIVE					
Core	**Course code:**	**Microbial Technology**	**T**	**Credits: 2**	**Hours:**
Pre-requisite			Syllabus Revised		2022-23
Unit I					
Objective 1	This is a foundational course that aims to provide students with a comprehensive understanding of the basic principles and applications of microbial technology.				
Introduction to microbial technology: Microbial technology in human welfare; Isolation and screening of microbes important for industry – advances in methodology and its application; Advanced genome and epigenome editing tools (e.g., engineered zinc finger proteins, TALEs/TALENs, and the CRISPR/Cas9 system as nucleases for genome editing, transcription factors for epigenome editing, and other emerging tools) for manipulation of useful microbes/ strains and their applications; Strain improvement to increase yield of selected molecules, e.g., antibiotics, enzymes, biofuels.					
Outcome1	This study aids students in acquiring a solid foundation in microbiology, including the fundamental concepts and terminology used in the field. This also helps to understand the practical applications of microbial technology and its significance in solving real-world problems while developing the ability to analyse and evaluate the potential benefits and risks associated with the use of microorganisms in various technological applications.				**K2**
Unit II					
Objective 2	Studying the environmental applications of microbial technology is essential for understanding how microorganisms can be harnessed to address various environmental challenges. It also gives insights into the roles of microorganisms in ecosystems, nutrient cycling, their impact on the environment, and how they contribute to managing a sustainable environment.				
Environmental applications of microbial technology: Environmental application of microbes; Ore leaching; Biodegradation - biomass recycle and removal; Bioremediation - toxic waste removal and soil remediation; Global Biogeochemical cycles; Environment sensing (sensor organisms/ biological sensors); International and National guidelines regarding use of genetically modified organisms in environment, food and pharmaceuticals.					
Outcome2	This study provides an advantage in developing a deeper understanding of environmental issues and the potential of microbial technology in mitigating environmental degradation problems. It assists in gaining knowledge of practical microbial-based solutions for environmental challenges, which can be applied in industry, agriculture, and conservation efforts.				**K2**

Unit III		
Objective 3	By learning pharmaceutical applications of microbial technology, it prepares individuals to engage in the dynamic field of pharmaceuticals, where they can contribute to the development of new drugs, innovative treatment methods, and the advancement of medical science, all while considering the potential benefits and ethical considerations associated with the applications.	
Pharmaceutical applications of microbial technology: Recombinant protein and pharmaceuticals production in microbes – common bottlenecks and issues (technical/operational, commercial and ethical); Attributes required in industrial microbes (Streptomyces sp., Yeast) to be used as efficient cloning and expression hosts (biologicals production); Generating diversity and introduction of desirable properties in industrially important microbes (Streptomyces/Yeast); Microbial cell factories; Downstream processing approaches used in industrial production process (Streptomyces sp., Yeast).		
Outcome3	Upon completing the study of pharmaceutical applications of microbial technology, students will gain a comprehensive understanding of the intersection between microbiology and pharmaceutical science by understanding how microorganisms can be used in the synthesis of essential drugs, leading to more efficient and cost-effective pharmaceutical production. This study also gives a prospect for innovative techniques for targeted drug delivery, utilizing microbial systems to enhance the efficacy and specificity of pharmaceutical compounds.	**K3**
Unit IV		
Objective 4	In brief, studying food applications of microbial technology equips individuals with the knowledge and tools to contribute to the development of safe, high-quality, and innovative food products while promoting sustainable practices and addressing important issues related to food production and safety.	
Food applications of microbial technology: Application of microbes and microbial processes in food and healthcare industries - food processing and food preservation, antibiotics and enzymes production, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors); Non- recombinant ways of introducing desirable properties in Generally recognized as safe (GRAS) microbes to be used in food (e.g., Yeast) - exploiting the existing natural diversity or the artificially introduced diversity through conventional acceptable techniques (mutagenesis, protoplast fusion, breeding, genome shuffling, directed evolution etc.).		
Outcome4	This unit prepares the students to contribute to the development of new and innovative food products, such as probiotics, fortified foods, and plant-based alternatives, using microbial processes. It facilitates the knowledge and skills needed to identify, prevent, and control food-borne pathogens, ensuring that food products meet high safety standards and supporting environmentally friendly practices.	**K6**

<table>
<tr><th colspan="3">Unit V</th></tr>
<tr><td>Objective 5</td><td colspan="2">Studying advances in microbial technology advocates for us to be at the forefront of innovation, making meaningful contributions to the microbial technology field, improving existing practices, and leading the way in the application of microorganisms to solve pressing challenges.</td></tr>
<tr><td colspan="3">Advances in microbial technology– Microbial genomics for discovery of novel enzymes, drugs/ antibiotics; Limits of microbial genomics with respect to use in human welfare; Metagenomics and metatranscriptomics – their potential, methods to study and applications/use (animal and plant health, environmental clean-up, global nutrient cycles & global sustainability, understanding evolution), Global metagenomics initiative - surveys/projects and outcome, metagenomic library construction and functional screening in suitable hosts – tools and techniques for discovery/identification of novel enzymes, drugs (e.g., protease, antibiotic) etc.</td></tr>
<tr><td>Outcome 5</td><td>By course completion, students will have developed the skills to design and conduct advanced research projects in microbiology, contributing to the field's knowledge base. And they will also gain knowledge about the development of new technologies, products, and processes that utilise microorganisms in various industries, such as biotechnology, healthcare, and environmental management.</td><td>K5</td></tr>
<tr><td colspan="3">K1-Remembering/ Knowledge, K2-Understanding, K3-Applicant/Apply K4-Analysis/Analyze, K5-Evaluation/Evaluate, K6-Synthesis / Create</td></tr>
<tr><td></td><td colspan="2">Suggested Readings:
Lee, Y. K. (2013). Microbial Biotechnology: Principles and Applications. Hackensack, NJ: World Scientific.
Moo-Young, M. (2011). Comprehensive Biotechnology. Amsterdam: Elsevier.
Nelson, K. E. (2015). Encyclopedia of Metagenomics. Genes, Genomes and Metagenomes: Basics, Methods, Databases and Tools. Boston, MA: Springer US.
The New Science of Metagenomics Revealing the Secrets of Our Microbial Planet. (2007). Washington, D.C.: National Academies Press.
Journals: (a) Nature, (b) Nature Biotechnology, (c) Applied microbiology and biotechnology, (d) Trends in Biotechnology, (e) Trends in Microbiology, (f) Current opinion in Microbiology, (g) Biotechnology Advances,
(h) Genome Research)
Online Resources:
World Wide Web Service and Open AI
Websites: http://jgi.doe.gov/our-science/</td></tr>
</table>

Course Outcome VS Program me Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M (2)	S (3)	M (2)	L (1)	M (2)	M (2)	M (2)	L (1)	L (1)	L (1)
CO2	L (1)	L (1)	M (2)	S (3)	M (2)	L (1)	M (2)	L (1)	M (2)	M (2)
CO3	L (1)	L (1)	M (2)	L (1)	M (2)	L (1)	M (2)	L (1)	S (3)	L (1)
CO4	L (1)	L (1)	M (2)	L (1)	L (1)	M (2)	S (3)	L (1)	L (1)	L (1)
CO5	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)	M (2)	L (1)	L (1)	S (3)
W.AV	**1.2**	**1.6**	**1.8**	**1.6**	**1.8**	**1.6**	**2.2**	**1**	**1.6**	**1.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome VS Programme Specific Outcomes

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	L (1)	L (1)	M (2)	M (2)
CO2	M (2)	L (1)	L (1)	L (1)	M (2)
CO3	M (2)	M (2)	S (3)	S (3)	M (2)
CO4	M (2)	L (1)	M (2)	L (1)	L (1)
CO5	L (1)	L (1)	L (1)	M (2)	M (2)
W.AV	**2**	**1.2**	**1.6**	**1.8**	**1.8**

S –Strong (3), M-Medium (2), L- Low (1)

Protein Engineering

Credits

2

Course Objectives

The aim of this course is to introduce methods and strategies commonly used in protein engineering.

Student Learning Outcomes

On completion of this course, students should be able to:

- Analyze structure and construction of proteins by computer-based methods;
- Describe structure and classification of proteins;
- Analyze purity and stability of proteins and explain how to store them in best way;
- Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design.

ELECTIVE					
Core	**Course code:**	**PROTEIN ENGINEERING**	**T**	**Credits: 2**	**Hours:**
Pre-requisite	Basic Knowledge in Protein engineering		Syllabus Revised		2022-23
Unit I					
Objective 1	**To understand the basic methods and strategies commonly used in protein engineering**.				
Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study) – affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, *etc.* Protein engineering with unnatural amino acids and its applications.					
Outcome 1	**Examine the fundamental attributes of proteins and the strategies involved in the realm of protein engineering.**				*K1*
Unit II					
Objective 2	**To provide technical knowledge of protein stability, structure and classification of proteins.**				
Methods of measuring stability of a protein; Spectroscopic methods to study physicochemical properties of proteins: far-UV and near-UV CD; Fluorescence; UV absorbance; ORD; Hydrodynamic properties–viscosity, hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy – emphasis on parameters that can be measured/obtained from NMR and their interpretation.					
Outcome 2	**Students will understand the biochemical properties of protein structure**				*K3*
Unit III					
Objective 3	**To understand the significance of advanced high throughput screening of protein engineering applications**				
Applications: Forces stabilizing proteins – Van der waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Experimental methods of protein engineering: directed evolution like gene site saturation mutagenesis; Module shuffling; Guided protein recombination, *etc.*, Optimization and high throughput screening methodologies like GigaMetrix, High throughput microplate screens *etc.*, Application to devices with bacteriorhodopsin as an example; Engineering antibody affinity by yeast surface display; Applications to vaccines, Peptidomimetics and its use in drug discovery.					

Outcome 3	**Students will acquire knowledge in the experimental analysis of proteins and their applications in drug discovery.**	*K3*
Unit IV		
Objective 4	**To acquire knowledge in basic structure, function and mechanism of protein using computational applications.**	
Computational approaches: Protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles *vis-à-vis* those from mesophiles; Protein design, Directed evolution for protein engineering and its potential.		
Outcome 4	**Students learn to apply protein structure bioinformatics techniques.**	*K5*
Unit V		
Objective 5	**To understand the practical knowledge of commercial protein product engineered to enhance its application-relevant functionality**	
Case studies.		
Outcome 5	**Students will able to understand the theoretical concepts are underpinned by practical example.**	*K6*
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Edited by T E Creighton, (1997), *Protein Structure: a Practical Approach*, 2nd Edition, Oxford university press.
- Cleland and Craik, (2006), *Protein Engineering, Principles and Practice*, Vol 7, Springer Netherlands.
- Mueller and Arndt, *Protein Engineering Protocols*, 1st Edition, Humana Press.
- Ed. Robertson DE, Noel JP, (2004), *Protein Engineering Methods in Enzymology*, 388, Elsevier Academic Press.
- 5. J Kyte; (2006), *Structure in Protein Chemistry*, 2nd Edition, Garland publishers.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	L (1)	M (2)	M (2)	S (3)	S (3)	L (1)	S (3)	S (3)	S (3)
CO2	M (2)	S (3)	M (2)	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.8**	**2**	**2**	**2.8**	**2**	**3**	**2.6**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Nano-biotechnology

Credits

2

Course Objectives

The course aims at providing a general and broad introduction to multi-disciplinary field of nanotechnology. It will familiarize students with the combination of the top-down approach of microelectronics and micromechanics with the bottom-up approach of chemistry/biochemistry; a development that is creating new and exciting cross-disciplinary research fields and technologies. The course will also give an insight into complete systems where nanotechnology can be used to improve our everyday life.

Student Learning Outcomes

On successful completion of this course, students should be able to describe basic science behind the properties of materials at nanometre scale, and the principles behind advanced experimental and computational techniques for studying nanomaterials.

ELECTIVE					
Core	**Course code:**	**Nano- biotechnology**	**T**	**Credits: 2**	**Hours:**
Pre-requisite	Basic Knowledge in Biology, Chemistry and multi-disciplinary nanotechnology		Syllabus Revised		2022-23
Unit I					
Objective 1	To build upon basic knowledge of biology and chemistry to enable the students understand the science of nanobiotechnology. Understand the different methods of synthesis and characterization nanomaterial.				
Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.					
Outcome 1	Learn about the background on Nanobiotechnology, Understand the synthesis of nanomaterials and their application and impact in biotechnology.				K1, K2
Unit II					
Objective 2	To inculcate knowledge on thevarious forms of nanostructure, their morphology and architecture and the methods for their characterization				
Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation					
Outcome 2	Understand process thin film processing and methods for their characterization.				K2

Unit III		
Objective 3	To understand the role of nanoparticle in drug delivery, to utilize nanocarriers for drug delivery and strategies for enhanced permeation through various anatomical barriers.	
Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers		
Outcome 3	Understand nanocarriers for drug delivery employing suitable methods and distinguish the properties of various types of nanocarriers and routes of delivery, Explain the synthesis and applications of nanoparticles for drug delivery.	K2
Unit IV		
Objective 4	To acquire knowledge and understand unique optical and physic-chemical properties of nanomaterials that may potentiate their applications in biomedicine, particularly in diagnostics and bioimaging	
Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.		
Outcome 4	Analyze and understand types of bionanomaterials for analysis and sensing techniques.	K3
Unit V		
Objective 5	To understand the basic concepts of biocatalysis and to know their applications in drug development	
Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in synthesis, applications of nanobiocatalysis in the production of drugs and drug intermediates		
Outcome 5	Learn how to synthesize and characterize nanobiocatalysts, apply the role of enzymes in biocatalysis and how enzymes are incorporated into nanostructured materials and nanobiocatalytic approaches to enzyme immobilization and stabilization	K4, K6
Unit VI		
Objective 6	To understand the basic concepts nanotoxycity and its implications to the environment	
Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratus of environment; Ecotoxicity models and assays; Life Cycle Assessment, containment.		
Outcome 6	Learn model assays involve cell culture testing and tissue engineering	K3, K5
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- GeroDecher, Joseph B. Schlenoff, (2003); *Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials*, Wiley-VCH Verlag GmbH & Co. KGaA
- David S. Goodsell, (2004); *Bionanotechnology*: *Lessons from Nature*; Wiley-Liss

	• Neelina H. Malsch (2005), *Biomedical Nanotechnology*, CRC Press • Greg T. Hermanson, (2013); *Bioconjugate Techniques*, (3rd Edition); Elsevier • Recent review papers in the area of Nanomedicine. **Online Resources:** • World Wide Web Service and Open AI

Course Outcome Vs Programme Outcome:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L (1)	L (1)	S (3)	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
CO2	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	L (1)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO6	M (2)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**2.5**	**1.5**	**3**	**2.8**	**2.5**	**3**	**3**	**3**	**3**	**3**

***3 – Strong 2 – Medium 1 – Low**

Course Outcome Vs Programme Specific Outcome:

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	S (3)	S (3)	M (2)
CO2	S (3)	S (3)	S (3)	S (3)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)
CO6	S (3)	S (3)	S (3)	S (3)	S (3)
W.AV:	**3**	**3**	**3**	**3**	**2.8**

***3 – Strong 2 – Medium 1 – Low**

Vaccines

Credits

2

Course Objectives

This course will provide students with an overview of current developments in different areas of vaccines.

Student Learning Outcomes By the end of this course, students should be able to:

- Understand fundamental concepts of human immune system and basic immunology;
- Differentiate and understand immune responses in relation to infection And vaccination;
- Understand requirement and designing of different types of vaccines;
- Understand importance of conventional and new emerging vaccine technologies.

ELECTIVE					
Core	**Course code: 501508**	**Vaccines**	**P**	**Credits: 4**	**Hours:**
Pre-requisite			Syllabus Revised		2022-23
Unit I					
Objective 1	**To provide a comprehensive understanding of the human immune system and its components, including innate and adaptive immunity, T and B cells, and immune response to infection.**				
Fundamentals of immune system: Overview of Immune system; Human Immune system: Effectors of immune system; Innate & Adaptive Immunity; Activation of the Innate Immunity; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Correlates of protection.					
Outcome 1	Students will be able to comprehend the fundamental principles of the immune system, analyze its role in protecting against infections, and evaluate the importance of immune correlates in vaccination strategies.				K1
Unit II					
Objective 2	**To explore the diverse aspects of immune responses to bacterial, viral, and parasitic infections, including primary and secondary immune responses, antigen presentation, and the roles of immune cells in humoral and cell-mediated responses.**				
Immune response to infection: Protective immune response in bacterial; viral and parasitic infections; Primary and Secondary immune responses during infection; Antigen presentation and Role of Antigen presenting cells: Dendritic cells in immune response; Innate immune response; Humoral (antibody mediated) responses; Cell mediated responses: role of CD4+ and CD8+ T cells; Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.					
Outcome 2	**Students will gain a deep understanding of protective immune responses during infections, contributing to their knowledge of the body's defense mechanisms against various pathogens.**				**K2**

Unit III		
Objective 3	**To explore the immune responses elicited by vaccination, including the understanding of adjuvants, antigen delivery systems, modulation of Th1 and Th2 responses, and the role of chemokines, cytokines, and soluble mediators in vaccination.**	
Immune response to vaccination: Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.		
Outcome3	**Students will acquire a comprehensive understanding of how vaccinations induce immune responses, the importance of adjuvants and antigen delivery systems, as well as the significance of oral immunization and mucosal immunity in vaccination strategies.**	**K3**
Unit IV		
Objective 4	**To provide an overview of vaccine types and design, including the history of vaccines, conventional vaccines, bacterial and viral vaccines, and vaccines based on different routes of administration, such as parenteral, oral, and mucosal.**	
Vaccine types & design: History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine.		
Outcome4	**Students will gain a comprehensive understanding of various vaccine types and recognize their significance in modern vaccination strategies, enabling them to appreciate the historical context and advancements in vaccine development.**	**K2**
Unit V		
Objective 5	**Course Objective: To explore the latest vaccine technologies and advancements in vaccine development.**	
Vaccine technologies: New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for targeted delivery (Vaccine Delivery systems); Disease specificvaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika).		
Outcome5	**Students will gain an in-depth understanding of cutting-edge vaccine technologies, enabling them to appreciate the potential of rationally designed vaccines, DNA vaccination, and mucosal vaccination, as well as grasp the importance of new vaccine delivery approaches.**	**K4 & K5**
K1-Remembering/ Knowledge, **K2**-Understanding, **K3**-Applicant/Apply **K4**-Analysis/Analyze, **K5**-Evaluation/Evaluate, **K6**-Synthesis / Create		

Suggested Readings:

- Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). Immuno Biology:the Immune System in Health and Disease. USA: Garland Science Pub.
- Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). Kuby Immunology.New York: W.H. Freeman.
- Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH.
- **Online resources:**
- Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology,Expert review of vaccines.

Online Resources:

- World Wide Web Service and Open AI

Course Outcome VS Programme Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S (3)	M (2)	S (3)	S (3)	L (1)	S (3)	L (1)	L (1)	M (2)	S (3)
CO2	S (3)	S (3)	S (3)	S (3)	L (1)	S (3)	L (1)	L (1)	M (2)	S (3)
CO3	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	M (2)	S (3)
CO4	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	M (2)	M (2)
CO5	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)
W.AV	**3**	**2.8**	**3**	**3**	**2.2**	**3**	**1**	1	2.2	**2.8**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome VS Programme Specific Outcomes

CO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	S (3)	S (3)	L (1)	S (3)	L (1)
CO2	S (3)	S (3)	L (1)	S (3)	L (1)
CO3	S (3)	S (3)	L (1)	S (3)	L (1)
CO4	S (3)	S (3)	L (1)	S (3)	L (1)
CO5	S (3)	S (3)	L (1)	S (3)	L (1)
W.AV	**3**	**3**	**1**	**3**	**1**

S –Strong (3), M-Medium (2), L- Low (1)

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