

Curriculum for M. Sc Biotechnology MASTER OF SCIENCE

M. Sc SYLLABUS

[For the Candidates admitted on 2023-2024 onwards under Autonomous, CBCS & OBE pattern]
(I to IV SEMESTERS)



DEPARTMENT OF BIOTECHNOLOGY



VIVEKANANDHA COLLEGE OF ARTS AND SCIENCES FOR WOMEN [AUTONOMOUS]

An ISO 9001:2015 Certified Institution | Affiliated to Periyar University Approved by
AICTE | Re-accredited with "A" Grade by NAAC|
Recognized Under 2(f) and 12 (b) of UGC Act, 1956.
Elayampalayam, Tiruchengode-637 205, Namakkal Dt., Tamil Nadu, India

M.Sc BIOTECHNOLOGY

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

GRADE	OBJECTIVE
PEO: 1	Biotechnology graduate students shall attain professional/industrial expertise by developing competent, creative and ever ready personality to accept recent, innovative and challenging roles in Industry and Academic and Research sectors
PEO: 2	Students shall inculcate in the development of entrepreneurial traits in order to cuddle innovative opportunities by adapting emerging biotechnological concepts in terms of techniques with subsequent development of leadership in the course of start-up of small-medium scale biotech based industry
PEO: 3	Students shall progressively adapt, follow and learn the concepts of biotechnology continuously by aiding modern teaching tools
PEO: 4	Imparting the basic and outstanding knowledge in all terms of biotechnology
PEO: 5	Students shall acquire the concepts to disseminate the advanced biotechnological aspects and its cutting edge developments in specific and developing area in the field of Biotechnology

PROGRAMME OUTCOMES (POs)

GRADE	OUTCOME
PO: 1	To train and develop students with the much needed biotechnological education, so that they develop added competitive skill metrics (CSM) for industrial employment higher education and employment upon graduation
PO: 2	To comprehend the assorted knowledge of biotechnical concepts domains and their applicability in the development of value added products for the welfare of the society
PO: 3	To develop a broad range of biotechnological skills and knowledge, development of general and specific competences to meet-out current expectations and requirements of medical, pharmaceutical, bio-molecular and agricultural sectors
PO: 4	To understand and merge the knowledge and concepts of biochemical, biophysical and bio statistical domains
PO: 5	To clarify various challenges in health care by integrating different biological domains including clinical, immunological, pharmaceutical and cancer genomics

PROGRAMME SPECIFIC OUTCOMES (PSOs)

GRADE	SPECIFIC OUTCOME
PSO: 1	To provide solutions for the challenges faced by pharmaceutical and molecular diagnostic Sectors
PSO: 2	To provide technical products with high frequency of reproducibility to the society
PSO: 3	To gain vertical mobility in career that will make students more competent to face national/international qualifying exams with practical knowledge acquaintance and in modern biotechnology field
PSO: 4	To solve complex problems in the field of Biotechnology with an understanding of social, ethical, legal and cultural aspects of the society
PSO: 5	To understand the over-all theme/concepts of each specialization in biotechnology and analysing the frequency of its applicability in industry, research and for the goodness of Society

DEPARTMENT OF BIOTECHNOLOGY
M.Sc. DEGREE COURSE IN BIOTECHNOLOGY
Choice-Based Credit System
REVISED REGULATIONS AND SYLLABUS (w.e.f. 2023-2024)
(in compliance with TANSCHÉ)

The recent development in the field of biotechnology as rapid growth and the establishment of biotechnological industries. This has resulted in great demand for trained manpower in this field and has opened new career opportunities for the young generation of students to acquire skills, training and knowledge to enhance their thinking, comprehension and application abilities and prepare them to compete, succeed and excel globally. Sustained initiatives are required to reform the present higher education system for improving and upgrading the academic resources and learning environments by raising the quality of teaching and standards of achievements in learning outcomes. The academic research into innovations for practical use in society and economy, promoting efficient and transparent governance and management of the higher education system, enhancing the capacity of the higher education system to govern itself through coordinated regulatory reform and increasing both public and private sector investment in higher education, with special emphasis on targeted and effective equity-related initiatives.

Learning Outcomes based approach to Curriculum Planning:

The Learning Outcomes based approach to Curriculum planning aims to factor in on the aptitude, interests and strengths of the students during their progress through the coursework and at the same time focus on overall student attainment. The main objective of the learning outcomes based framework is to better equip the students in their pursuit of knowledge, with the required employability skills, innovation in research and entrepreneurship skills. The course is so designed with practical work that will help students to apply their theoretical knowledge in experimenting and exploring. The curriculum envisions that the student, once graduates as specialists in a discipline, have an important role to play in the newer developments and innovations in the future in the subject for the advancement of the discipline.

Graduate Attributes in Biotechnology:

Graduate attributes are the high-level qualities, skills and understandings that a student should gain as a result of the learning and experiences. They equip students and graduates for lifelong personal development, learning and to be successful in society. Students will be equipped to be active citizens both nationally and globally. The students graduating in biotechnology should also develop excellent communication skills both in the written as well as spoken language which are a must for them to pursue higher studies from some of the best and internationally acclaimed universities and research institutions spread across the globe. The graduate attributes reflect both disciplinary knowledge and understanding, generic skills, including global competitiveness all students in different academic fields of study should acquire/attain and demonstrate. Some of the characteristic attributes that a graduate should demonstrate are as follows

- Leadership Readiness
- Moral and ethical awareness/reasoning.

- Multicultural Competence.
- Life-long Learning.
- Communication Skills.
- Critical thinking.
- Problem-solvingng.
- Research-related skills.
- Scientific reasoning.
- Self-directed learning.
- Disciplinary knowledge.

Qualification Descriptors:

Upon successful completion of the course, the students receive an M.Sc. degree in Biotechnology. Biotechnology postgraduates of this department are expected to branch out into different paths of seeking advanced research-based knowledge, professional employment, or entrepreneurship that they find fulfilling. They will be able to demonstrate knowledge as well as skills in diverse fields of Biotechnology. This will provide a foundation, which shall help them to embark on research careers by attaining doctoral positions in coveted institutions, as well as securing employment in research projects in industry or institutes. Besides research, they can get suitable teaching positions in Colleges and Universities as Assistant professors after qualifying National Eligibility Test (NET). It is expected that besides the skills specific to the discipline, the wider life skills of analysis, logical reasoning, scientific aptitude, communication skills, research and life ethics, and moral values will be inculcated in the students. The list below provides a synoptic overview of possible career paths provided by postgraduate training in Biotechnology:

- Biotechnology entrepreneurship
- Patents and Law
- Scientific Writing and Editing
- Document preparation and publication
- Research
- Industry
- Teaching
- Administration and Policy Making
- Scientific Communication

Teaching-learning process

The Learning Outcomes-Based Approach to curriculum planning and transaction requires that the teaching- learning processes are oriented towards enabling students to attain the defined learning outcomes relating to the courses within a programme. The outcome-based approach, particularly in the context of undergraduate studies, requires a significant shift from teacher-centric to learner-centric pedagogies, and from passive to active/participatory pedagogies. Planning for teaching therein becomes critical. Every programme of study lends itself to a well-structured and sequenced acquisition of knowledge and skills. Practical skills, including an appreciation of the link between theory and experiment, will constitute an important aspect of the teaching- learning process. Teaching methods, guided by such a framework, may include:

- ✓ **Classroom Teaching** for intensely information-based topics. This is a very regular feature of all the courses in Biotechnology.
- ✓ **PowerPoint slides** for topics that involve information and use of PowerPoint presentations are also made whenever the lectures are to be summarized in a crisp and point-wise manner to highlight salient/important conclusions from the topics.
- ✓ **Classroom Discussions** are a regular feature while teaching. The students are drawn into impromptu discussions by the teacher during the process of teaching.
- ✓ **Video Displaying**, both real-time and animations, are used for topics that require 3D dimensional viewing of the biological mechanisms to drive the point home. These have proved to be very helpful while teaching concepts of molecular biology like DNA replication, transcription and translation.
- ✓ **Model Making** is also used especially for understanding and building a perception of the students.
- ✓ **Laboratory Practical** are an integral part of every course included in the PG programme in Biotechnology. This is also a daily affair for PG students of Biotechnology.
- ✓ **Problem Solving** is encouraged during the laboratory work.
- ✓ **Group Activity** as well as discussions with the laboratory supervisor/ among the students themselves/ Mentor is also encouraged during laboratory work.
- ✓ **Project Work** is included in the programme where students work individually or in groups to design experiments to solve/answer a problem suggested by the Mentor or identified by the students in consultation with the Mentor. The students are mentored regularly during the duration of the project.
- ✓ **Presentations by the Students** are regularly done. The students are mentored in the presentation of data, interpretation of data and articulation with the students/teachers/Research Scholars during their presentation.
- ✓ **Presentations by Experts** in different specialties of Biotechnology are arranged to broaden the horizons of the students.
- ✓ **Interaction with Experts** is also encouraged during/after presentations to satisfy/ignite the curiosities of the students related to developments in the different areas of Biotechnology.
- ✓ **Visit to Industries/Laboratories** related to Biotechnology like fermentation, food, pharmaceuticals; diagnostics etc. are organized to acquaint the students with real-life working environments of the professional biotechnologist with a view to broadening their perspective on the subject of Biotechnology.

Assessment methods

The students of PG Biotechnology program must achieve the desired results in terms of the learning outcomes to be professionally sound and competitive in a global society. Achieving the desired learning outcomes is also imperative in terms of job employment leading to a happy and prosperous individual further leading to a happy and prosperous family and thereby a happy and prosperous society or nation. The assessment tasks are pivotal to getting authentic feedback for the teaching-learning process and mid-course corrections and further improvements in the future. The assessment tasks are carried out at various stages of the duration of the PG Biotechnology programme like Mid-

term assessments, End-term assessments, Semester examinations, Regular assessments, viva-voce, etc. The assessment tasks are listed below:-

- ✓ **Short-Answer Questions** during term and semester examinations are used to assess the ability of the student to convey his thoughts in a coherent way where prioritization of the information in terms of their significance is tested.
- ✓ **Problem Solving questions** are generally given during the laboratory work.
- ✓ **Surprise Quizzes** are regularly used during continuous assessment while the teaching-learning process is continuing which prepares the student to quickly recall information or quickly analyze a problem and come up with proper solutions.
- ✓ **Impromptu Opinions** on biotechnological problems are sought from student during regular teaching- learning which help them to think quickly in a given context. This help build their ability to come up with solutions to problems that the students might not have confronted previously.
- ✓ **Data Interpretation** is also another assessment task that is used to develop the analytical skills of the students. This assessment is used during laboratory work as well as during project work.
- ✓ **Analytical Skills** are assessed during work related to several experiments like enzyme kinetics, growth of bacteria and Bacteriophages, and mutation frequencies.
- ✓ **Paper/ Project presentations** are used to assess the articulation skills of the student. These are carried out both during the duration of the teaching-learning processes as well as during end-Semester examinations.
- ✓ **Report Writing** is used to assess the keenness of the students for details related to Biotechnology while visiting laboratories/industries as students invariably are required to submit a report after such visits.
- ✓ **Assignment Writing** is used to assess the writing abilities of the students during midterm vacations.
- ✓ **Viva-voce** during the laboratory working hours and during laboratory, examinations are used to assess the overall knowledge and intelligence of the students.

Key Words:

Biotechnology, Teaching, Learning outcomes, Curriculum, Curriculum Framework, Programme outcomes, Course outcomes, PG Programme, Postgraduate programme, Teaching-learning processes, Assessment Tasks, Evaluation Tasks, Online Courses, MOOCS, SWAYAM, UGC, India, Higher Education Institutions.

1. CONDITIONS FOR ADMISSION:

A Candidate with a Bachelor's Degree in Science in the disciplines of Biotechnology, Biology, Botany, Zoology, Microbiology, Genetics, Chemistry, Biochemistry, Physics, Agriculture from this University or B.E/ B.TECH (Biotech), B.V.Sc, MBBS, BDS or any area of Biological Sciences / Agriculture and allied sciences; Veterinary and allied sciences or an examination of some other University accepted by the Syndicate as equivalent there to shall be for the M.Sc Degree Examination of this University after a course of two academic years in an Affiliated Colleges of this University.

2 DURATION OF THE COURSE:

The duration of the course is for two academic years consisting of four semesters.

3. STRUCTURE OF THE COURSE

The course is organized on semester basis with a total of four semesters. In the first, second and third semesters, there are three (core) theory papers (9 hrs per week), one Core Practical (15hrs per week) and Two elective/ optional papers(4hrs per week), per semester and in the fourth semester, there are only one core theory paper(Research Methodology) (4hrs per week), a core project/ dissertation work constituting a total of 20 hrs per week, two electives (4hrs per week), and a Soft skill program (2hrs perweek).

Elective paper: Each student shall opt for a comprehensive, interactive course with one of the faculty member. The topic of specialization and course content will be determined by the department/ course advisor.

Core Practical Laboratory: Independent practical shall be held under each component. It is recommended that the practical training be organized as an exercise rather than simple demonstration. The students must actually perform the experiments.

4. ELIGIBILITY FOR THE AWARD OF DEGREE:

A candidate shall be eligible for the award of the degree only if he/she has undergone the prescribed course of study in a college affiliated to the University for a period of not less than two academic years, passed the examination of all the four semesters prescribed earning minimum of 91 credits and fulfilled such conditions as have been prescribed therefore.

A candidate shall be eligible for the award of the degree only if he/she has undergone the prescribed courses on Soft Skills and internship in addition to the courses prescribed by the respective Board of Studies for the subject of the Masters Degree. For two years Master's Degree Programme, a candidate shall undergo a minimum of 4 courses (4 x 2=8 credits) from the courses on Soft skills.

A two year Master's Degree student shall undergo 4-6 weeks (2 credits internship during the summer vacation of the First year and submit a report in the beginning of third semester. The report will be evaluated in third semester and the marks forwarded to the University along with third semester internal assessment (CIA)marks.

5. EXAMINATIONS:

There shall be four semester examinations: first semester examination at the middle of the first academic year and the second semester examination at the end of the first academic year. Similarly, the third and fourth semester examinations shall be held at the middle and the end of the second academic year, respectively. Practical examination shall be conducted independently at the end of even semesters. For practical examination, a single comprehensive (covering different courses offered during that semester) practical examination (6hrs per day) shall be held for each component of the core practical at the end of even semesters.

Examinations for the courses on soft skills will be held along with the semester examinations of the core and elective courses. There is no written examination for internship. A student shall submit a report after completing the summer internship. The report will be evaluated by two examiners within the Department of the college/ institution.

6. COURSE OF STUDY AND SCHEME OF EXAMINATIONS:

FIRST SEMESTER

S.No.	Paper Code	Course Components	Name of Course	Semester	Inst. Hours	Credits	Exam HRS	Max. Marks	
								CIA	External
1	23P1BT01	Core Paper-1	Biochemistry	I	3	4	3	25	75
2	23P1BT02	Core Paper-2	Molecular Genetics	I	3	4	3	25	75
3	23P1BT03	Core Paper-3	Molecular Cell Biology	I	3	4	3	25	75
4	23P1BTP01	Core Paper-4 Practical-I	Practical – I (A) Biochemistry (B) Molecular Genetics (C) Molecular Cellbiology	I	12	4	6	40	60
5	23P1BTE01	Elective Paper-1*	Bioinstrumentation	I	2	3	3	25	75
6	23P1BTE02	Elective Paper-2 *	Biostatistics	I	2	3	3	25	75
7	23P1BTE03	Paper-3 * Elective	Enzymology	I	2	3	3	25	75
8	23P1BTSSP01	Soft Skill - I	Statistics using R Program	I	2	2	3	40	60
Total Credits : 24									

*Candidates can opt for any two Electives (Practical examination shall be conducted independently at the end of even semesters.)

SECOND SEMESTER

S. No.	Paper Code	Course Components	Name of Course	Semester	Inst. Hours	Credits	Exam HRS	Max. Marks	
								CIA	External
9	23P2BT04	Core Paper-5	Microbiology	II	3	4	3	25	75
10	23P2BT05	Core Paper-6	Plant and Animal Biotechnology	II	3	4	3	25	75
11	23P2BT06	Core Paper-7	Genetic Engineering	II	3	4	3	25	75
12	23P2BTP02	Core Paper-8 Practical-II	Practical – II (A) Microbiology (B) Plant and Animal Biotechnology (C) Genetic Engineering	II	12	4	6	40	60
13	23P2BTE04	Elective Paper-4*	Regulatory affairs and Industrial standards	II	2	3	3	25	75
14	23P2BTE05	Elective Paper-5*	Pharmaceutical Biotechnology	II	2	3	3	25	75
15	23P2BTE06	Elective Paper-6*	Environmental Biotechnology	II	2	3	3	25	75
16	-	Extra* disciplinary elective	Any Elective offered by other Depts.	II	2	3	3	25	75
17	23P2BTSS02	Soft skill - II	Genomics and proteomics	II	2	2	3	25	75
18	23P2BTED01	Elective offered to other Dept.	Extra disciplinary Tissue engineering	II	2	2	3	25	75
Total credits: 24									

* Candidates can opt for any one Elective and one extra disciplinary elective

THIRD SEMESTER

S. No.	Paper Code	Course Components	Name of Course	Semester	Inst. Hours	Credits	Exam HRS	Max. Marks	
								CIA	External
19	23P3BT07	Core Paper-9	Bioinformatics	III	3	4	3	25	75
20	23P3BT08	Core Paper-10	Immunology	III	3	4	3	25	75
21	23P3BT09	Core Paper-11	Bioprocess Technology	III	3	4	3	25	75
22	23P3BTP03	Core Paper-12 Practical-III	Practical – III (A) Bioinformatics (B) Immunology (C) Bioprocess Technology	III	12	4	6	40	60
23	23P3BTE07	Elective Paper-7*	Nano Biotechnology	III	2	3	3	25	75
24	23P3BTE08	Elective Paper-8*	Molecular Developmental Biology	III	2	3	3	25	75
25	-	Extra* disciplinary Elective	Any Elective offered by other Depts.	III	2	3	3	25	75
26	23P3BTSSP03	Soft skill – III	Omics Data analysis	III	2	2	3	40	60
27	23P3BTINT01	**Internship	Internship in Industries to Biotechnology Field (food / clinical trial/ dairy/ aquasciences, pharmaceutical) CSIR/DBT/DST research laboratories	III	-	2	-	-	100
28	23P3BTED02	Elective offered to other Dept.	Principles of Gene Manipulation Technology	III	2	2	3	25	75
Total credits: 26									

(Practical examination shall be conducted independently at the end of even semesters.)

*Candidates can opt for any one Elective and one extra disciplinary elective

** Internship will be carried out during the summer vacation of II Semester and the report will be evaluated by two examiners within the Department of the college/ institution. The marks should be sent to the University by the College and the same will be included in the Third Semester Marks Statement.

FOURTH SEMESTER

S. No.	Paper Code	Course Components	Name of Course	Semester	Inst. Hour	Credits	Exam HRS	Max. Marks	
								CIA	External
29	23P4BT10	Core Paper-13	Research Methodology	IV	4	4	3	25	75
30	23P4BTE09	Elective Paper-9*	Stem Cell Biology	IV	2	3	3	25	75
31	23P4BTE10	Elective Paper-10*	Bioethics, Human Rights and Social Issues	IV	2	3	3	25	75
32	23P4BTTPR01	Core Paper-14	Dissertation	IV	20	8		40	60
33	23P4BTSSP04	Soft skill – IV	Artificial intelligence/ML	IV	2	2	3	40	60
Total credits: 17									

*Candidates can opt for any one of the two Electives and the additional 2 hours shall be used for Dissertation work. However, additional elective paper can be opted for earning extra credits.

The following procedure is followed for Internal Marks:

Theory Papers: Internal Marks:**25 marks**

Best Two tests out of 3

10 marks

Attendance

5 marks

Seminar

5 marks

Assignment

5 marks

Practical: Internal Marks:**25 marks****40**

Attendance

5 marks

Practical Best Test 2 out of 3

25 marks

Record

5 marks

Viva

5 marks

Break-up Details for Attendance

Below 60% - No marks

60% to 75% - 3 marks

76% to 90% - 4 marks

91% to 100% - 5 marks

7. DISSERTATION EVALUATION:

Dissertation Work should be carried out as an individual Dissertation and actual bench work. The Dissertation work will begin from IIIrd Semester, and will continue through the IVth Semester. The Dissertation report (also work book shall be presented at the time of presentation and viva voce) will be submitted at the end of the IVth Semester and evaluated. For the conduct of the End Semester Examination and evaluation of Dissertation Work, the University will appoint External Examiners.

Since the dissertation is by research, dissertation work carries a total of 300 marks and evaluation will be carried out by both internal and external evaluators. The average marks awarded by them will be considered. Project work book consisting of daily research activities, methods adopted, results recorded and maintained by the candidate shall also be submitted along with dissertation for evaluation. The viva-voce examination is part of dissertation which carries marks as specified below.

The assignment of marks for Project is as follows: Continuous Internal Assessment

Marks	Best 2 out of 3 presentations (Literature survey, Methodology and Results of the project work) - 60 marks	Project work book - 40 marks
Dissertation/ -		150marks
Viva-voce -		50marks

8. REQUIREMENTS FOR PROCEEDING TO SUBSEQUENT SEMESTERS:

- (i) Candidates shall register their names for the First semester examination after the admission in the PG courses.
- (ii) Candidates shall be permitted to proceed from the First Semester up to the Final Semester irrespective of their failure in any of the Semester Examination subject to the condition that the candidates should register for all the arrear subjects of earlier semesters along with current (subject) Semester subjects.
- (iii) Candidates shall be eligible to proceed to the subsequent semester, only if they earn sufficient attendance as prescribed therefore by the Syndicate from time to time.

Provided in case of candidate earning less than 50% of attendance in any one of the semester due to any extraordinary circumstance such as medical grounds, such candidates who shall produce Medical Certificate issued by the Authorised Medical Attendant (AMA), duly certified by the Principal of the College, shall be permitted to proceed to the next semester and to complete the course of study. Such candidate shall have to repeat the missed semester by rejoining after completion of final semester of the course, after paying the fee for the break of study as prescribed by the University from time to time.

9. PROCEDURE IN THE EVENT OF FAILURE

1. If a candidate fails in a particular subject (other than project work) he /she may appear for the University examination in that subject in the subsequent semester(s) and obtain pass marks.
2. In the event of failure in project work, the candidates will re-register for the project work and redo the project work in the subsequent semester and resubmit the dissertation a fresh for evaluation. The Continuous Internal Assessment marks will be allotted freshly in this case.

10. PASSING MINIMUM:

- a) There shall be no Passing Minimum for Internal.
- b) For External Examination, Passing Minimum shall be of 50 % (Fifty Percentage) of the maximum marks prescribed for the paper.
- c) In the aggregate (External+Internal) the passing minimum shall be of 50% for each Paper/Practical/Project and Viva-voce.
- d) Grading shall be based on over all marks obtained (internal + external).

11. CLASSIFICATION OF SUCCESSFUL CANDIDATES:

Candidates who secured not less than 60% of aggregate marks (Internal + External) in the whole examination shall be declared to have passed the examination in the First Class. All other successful candidates shall be declared to have passed in Second Class. Candidates who obtain 75% of the marks in the aggregate (Internal+External) shall be deemed to have passed the examination in First Class with Distinction, provided they pass all the examinations (theory papers, practicals, project and viva-voce) prescribed for the course in the First appearance.

12. GRADING SYSTEM:

As per the existing TANSCHÉ Grading followed by all Post-graduate degree Courses under CBCS (w.e.f. 2009-10).

13. RANKING:

Candidates who pass all the examinations prescribed for the course in the first appearance itself alone are eligible for Ranking/ Distinction.

Provided in the case of candidates who pass all the examinations prescribed for the course with a break in the First Appearance due to the reasons as furnished in the Regulations under "Requirements for Proceeding to subsequent Semester" are only eligible for Classification.

14. PATTERN OF QUESTION PAPER:

Question paper pattern for M.Sc Biotechnology degree course for each semester will be given as follows. For Theory Paper subjects

Part A

10 Objective questions or definitions of 2 marks covering all units of the syllabus (No choice will be given)

10 x 2 = 20 marks

Part B

5 Paragraph questions of 5 marks to be answered choosing one each from each unit following either/or pattern

5 x 5 = 25 marks

Part C

Two Essay type questions of 15 marks to be answered choosing one from each Unit following

either/or pattern 2 x 15 = 30 marks

15. APPEARANCE FORIMPROVEMENT:

Candidates who have passed in a theory paper / papers are allowed to appear again for theory paper / papers only once in order to improve his/her marks, by paying the fee prescribed from time to time. Such candidates are allowed to improve within a maximum period of 10 semesters counting from his/her first semester of his/her admission. If candidate improve his/her marks, then improved marks will be taken into consideration for the award of Classification only. Such improved marks will not be counted for the award of Prizes/ Medals, Rank and Distinction. If the candidate does not show improvement in the marks, his previous marks will be taken into consideration.

No candidate will be allowed to improve marks in the Practical, Project, Viva-voce, Field work.

16. TRANSITORY PROVISION:

Candidates who have undergone the course of study prior to the academic year 2022-2023 will be permitted to appear for the examinations under those Regulations for a period of three years i.e., up to and inclusive of April/May 2025 Examinations. Thereafter, they will be permitted to appear for the examination only under the Regulations then in force.

Core Paper-1
BIOCHEMISTRY

Paper – 1			
Title of the paper	BIOCHEMISTRY	Subject code: 23P1BT01	
Category of the course	Year	Semester	Credits
Core Paper	1 st	1 st	4

Learning Outcome:

The paper imparts a thorough knowledge on the basics of all the Biochemical concepts, Metabolic reactions and its regulation. The student will get to understand the core concepts of metabolism and physiological processes of the body in both healthy and disease state.

Course outcomes:

At the end of the Course, the Student will be able to:

CO-1	To understand the basics of pH and related principles and carbohydrate metabolism.	K1&K2
CO-2	To provide basic knowledge about lipid metabolism and related significance.	K1,K2 & K3
CO-3	To enlighten the students on Bio-energetics and Biological oxidation pathways.	K1,K2 & K3
CO-4	To update the knowledge on Amino acids and Protein.	K1,K2 & K3
CO-5	To assess and appraise the role of Nucleic acids.	K1,K2 & K3

SYLLABUS | Core Paper-1 | BIOCHEMISTRY

Unit	Content	Hours
I	pH, pK . acid, base .Buffers- Henderson- Haselbach equation, biological buffer system – Phosphate buffer system, protein buffer system, bicarbonate buffer system, amino acid buffer system and Hb buffer system. Water, Carbohydrates: Nomenclature, classification, structure, chemical and physical properties of carbohydrates. Metabolisms: glycogenesis, glycogenolysis, gluconeogenesis, pentose phosphate pathway.	10
II	Lipids: Nomenclature, classification, structure, chemical and physical properties of fatty acids. Metabolisms: biosynthesis of fatty acids, triglycerols, phospholipids, glycol lipids. Cholesterol biosynthesis, bile acids and salt formation. Eicosanoids, sphingolipids and steroid hormones.	10
III	Bioenergetics – Concept of energy, Principle of thermodynamics, Relationship between standard free energy and Equilibrium constant, ATP ads universal unit of free energy in Biological systems. Biological oxidation: Electron transport chain, oxidative phosphorylation, glycolysis, citric acid cycle, cori.s cycle, glyoxalate pathway. Oxidation of fatty acids- mitochondrial and peroxisomal β -oxidation, alpha and beta oxidation, oxidation of unsaturated and odd chainfatty acids, ketone bodies. Photosynthesis, urea cycle, hormonal regulation of fatty acids and carbohydrates metabolisms, Mineral metabolism	10

IV	Amino acids and Protein: Nomenclature, Classification, structure, chemical and physical properties of amino acids and proteins. Metabolisms: Biosynthesis of amino acids. Degradation of proteins, nitrogen metabolisms and carbon skeleton of amino acids. Over all in born error metabolisms	10
V	Nucleic acids: Nomenclature, Classification, structure, chemical and physical properties of purine and pyrimidines. In de novo and salvage synthesis of purines, pyrimidine bases, nucleosides and nucleotides. Catabolisms of purines and pyrimidines bases. Synthetic analogues of nitrogenous bases	10

Reference books:

- Philip Kuchel, Simon Easterbrook-Smith, Vanessa Gysbers, Jacqui M. Matthews, 2011. Schaum.s Outline of Biochemistry, Third Edition (Schaum.s Outline Series), McGraw-Hill.
- Sathyanarayana.U and U.Chakrapani., 2011. Biochemistry. Books and Allied private limited, Kolkata.
- Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, 2010. Biochemistry, Seventh Edition, W. H. Freeman.
- Albert Lehninger, David L. NelsonVoet Donald, Judith G.Voet and Charlotte W.Pratt., 2008. Principles of Biochemistry. John Wiley and sons, Inc., New Jersey.
- Michael M. Cox, 2008. Lehninger Principles of Biochemistry, Fifth Edition, W. H. Freeman publishers.

Useful web sites:

- mcdb-webarchive.mcdb.ucsb.edu/.../biochemistry/.../website-tourf.htm
- www.biochemweb.org/
- <http://golgi.harvard.edu/biopages.html>
- webarchive.mcdb.ucsb.edu/sears/biochemistry/info/website-

Core Paper-2

MOLECULAR GENETICS

Paper – 1			
Title of the paper	MOLECULAR GENETICS	Subject code: 23P1BT02	
Category of the course	Year	Semester	Credits
Core Paper	1 st	1 st	4

Learning outcome:

The paper imparts a thorough knowledge on the basics of all the Genetics concepts, molecules and its regulation. The student will get to understand the core concepts of molecules and genetics.

Course outcomes:

At the end of the Course, the Student will be able to:

CO-1	To acquire good knowledge about the molecular mechanisms of gene expression and understand the theories behind the organization and functions of genetic material in the living world.	K1, K2 & K3
CO-2	Identify and distinguish genetic regulatory mechanisms at different levels and explain the processes behind mutations and other genetic changes and study various chromosomal abnormalities.	K1, K2 & K3
CO-3-	Make the students understand different range of DNA damage and range of their tools for their detection an.	K1, K2 & K3
CO-4	Learn the concepts of the transposons and their applications.	K1 & K2
CO-5	Detects the Allele frequencies and genotype frequencies in populations and describe the concepts behind the theory of evolution	K1, K2 & K3

SYLLABUS | Core Paper-2 | MOLECULAR GENETICS

Unit	Content	Hours
I	Genes and chromosomes, Colinearity of Genes and Proteins, Genetic code, Identification of DNA as the genetic material. The complexity of eukaryotic genome (introns, exons, repetitive DNA sequence, gene duplication and pseudogenes). DNA markers -VNTR, STR, microsatellite, SNP and their detection Techniques.	10
II	Replication of DNA, Gene expression and regulation in prokaryotes and eukaryotes. Mutation: Spontaneous and virus induced mutation, Radiation induced mutation. Ionizing radiation, UV radiation. Chromosomal Abnormalities and associated genetic diseases, Techniques in the study of chromosomes and their applications, Recombination – models.	10
III	DNA Damage and Repair-Internal and external agents causing DNA damages 3.2. DNA damages (Oxidative damages, Depurinations, Depyrimidinations, O6-methylguanines, Cytosine deamination, single and double strand breaks) 3.3. Mechanisms of DNA damage (transition, transversion, frameshift, nonsense mutations) 3.4. Repair mechanisms (Photo reactivation, excision repair, mismatch repair, post replication repair, SOS repair) 3.5. Discovery: Early experiments of McClintock in maize. Insertion sequences in prokaryotes. Complex transposons (ex. Tn3, Tn5, Tn9 and Tn10). Mechanisms, control consequences and application of transposition by simple and complex elements.	10

IV	Allele frequencies and genotype frequencies, Random mating population, Hardy-Weinberg principle, complications of dominance, special cases of random mating – multiple alleles, different frequencies between sexes (autosomal and X-linked) inbreeding, genetics and evolution, random genetic drift, Karyotyping and usefulness of chromosomes in understanding Genetic variation, Genetics of eukaryotes gene linkage and chromosome mapping.	10
V	Extrachromosomal heredity: Biology of Plasmids, their discovery, types and structure of F.RTH. <i>col</i> factors and Ti – Replication and partitioning, Incompatibility and copy number control-natural and artificial plasmid transfer and their applications-Human Genome Project, Genomics and Modern methodologies in understanding genome.	10

References:

- Principles of Genetics- 8th Edition, Gardner, Simmons and Snustad, 2002.
- The Cell- A Molecular Approach. 3rd Edition. Geoffrey M. Cooper, Robert E. Hausman, 2003.
- Genetics- Kavitha B. Ahluwalia, New Age International Pvt Ltd and Publishers, New Delhi, 2010
- Genetics – P.S Verma and A.K Agarwal (Rack 3, Central Library)
- Robert Brooker.2011. Genetics- Analysis and Principles. 4th edition. McGraw Hill.
- Leland Hartwell, Leroy Hood, Michael Goldberg, Ann Reynolds, Lee Silver, 2010. Genetics: From Genes to Genomes, 4th Edition, McGraw Hill.
- Rastogi Smita and Neelam Pathak., 2010. Genetic Engineering, Oxford University Press, New Delhi. (Rack 3, Central Library)
- Watson, Hopkins, Roberts, Steitz, Weiner, 2004. Molecular Biology of Genes, 4th Edition.
- DNA markers Protocols, applications and overviews Anolles G. C. & Gresshoff P. M. Wiley-Liss
- Molecular markers in Plant Genetics and Biotechnology Vienne De. D. Science Publishers
- Genetics of Population Hedrick P.W. Jones & Bartlett 4 Principle of Population Genetics Hartl D. L. and Clark A. G. Sinauer Associates

Core Paper-3
MOLECULAR CELL BIOLOGY

Paper – 3			
Title of the paper	MOLECULAR CELL BIOLOGY	Subject code: 23P1BT03	
Category of the course	Year	Semester	Credits
Core Paper	1 st	1st	4

Learning Outcome:

The paper imparts a thorough knowledge on the basics of all the Cell biology concepts, molecules and its regulation. The student will get to understand the core concepts of molecules and cell biology.

Course outcomes:

CO-1	To understanding of the molecular machinery of living cells and the principles that govern the structures of macromolecules and their participation in molecular recognition.	K1,K2 &K3
CO-2	Identify the structures and purposes of basic components in prokaryotic and eukaryotic cells and their molecular mechanism	K1,K2 & K3
CO-3-	Demonstrate knowledge and understanding of the principles and basic mechanisms of nuclear envelope and its functions.	K1,K2 & K3
CO-4	Understand the metabolic pathways and the process of transmission of extracellular signals	K1,K2 & K3
CO-5	Demonstrate the operation of various microscopes and microtomy in the laboratory	K1,K2 & K3

SYLLABUS | Core Paper-3 | MOLECULAR CELL BIOLOGY

Unit	Content	Hours
I	Introduction to cell Biology- Basic properties of cells-Cellular dimension-Size of cells and their composition-Cell origin and Evolution (Endosymbiotic theory)– Microscopy- Light Microscopy, Electron Microscopy, Application of Electron Microscopy in cell biology, Phase Contrast Microscopy, Fluorescence Microscopy, Flow Cytometry and FRET .Organelles of the eukaryotic cell and its functions; Biomembranes - structural organization, transport across membrane (Passive, Active and Bulk transport); Cell-Cell adhesion- Cell junctions (Tight junctions, gap junctions, desmosomes, adherens); Extra cellular matrix (ECM)- components and role of ECM in growth.	10

II	Structure of Nucleic acids, Genome organization in Eukaryotes, DNA Replication, Transcription, Translation and post translational Modification. Synthesis, sorting and trafficking of proteins: site of synthesis of organelle and membrane proteins – transport of secretory and membrane proteins across ER – post-translational modification in RER – transport to mitochondria, nucleus, chloroplast and peroxisome - protein glycosylation – mechanism and regulation of vesicular transport – golgi and post-golgisorting and processing – receptor mediated endocytosis; Synthesis of membrane lipids.	10
III	Nucleus: Nuclear envelope – Nuclear pore complexes- nuclear matrix – organization of chromatin – supercoiling, linking number, twist - nucleosome and high order of folding and organization of chromosome(Solenoid and Zigzag model)-Global structure of chromosome –(Lamp brush and polytene chromosomes).	10
IV	Molecular basis of eukaryotic cell cycle, Regulation and cell cycle check points; Programmed cell death (Apoptosis); Cell-Cell signaling-signaling molecules, types of signaling, signal transduction pathways(GPCR-cAMP, IP3 , RTK, MAP Kinase, JAK-STAT, Wnt Pathway).	10
V	Cancer Biology: Multistage cancer development Mitogens, carcinogens, oncogenes and proto- oncogenes, tumor suppressor genes-Rb, p 53, Apoptosis and significance of apoptosis, Genome Editing – CRISPR/Cas 9.	10

References

- Karp, G., 2009, Cell and Molecular Biology, Sixth edition, John Wiley & Sons, New York.
- David E.Sadva., 2009. Cell biology organelles structure and function, CBS publishers and distributors, New Delhi.
- Prakash S. Lohar , 2009. Cell and Molecular Biology.
- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, 2007.,Molecular Biology of the Cell, Fifth edition. Garland Science.
- Lodish,H., Berk, A., Zipursky, S.L., Matsudaira, P., Kaiser, A., Krieger, Scott and Darnell, J. 2007. Molecular Cell Biology. Media Connected, sixth edition. W.H.Freeman and Company
- Geoffrey.M.Cooper, Robert.E.Hausman.2007.The Cell-A Molecular Approach, Fourth edition. Sinauer Associates. •
- Luiz Carlos Uchoa, Janqueira, Jose, Carneiro. 2005. Basic HistologyText and Atlas. McGraw-Hill Professional.
- Paul A, 2001, Text Book Of Cell And Molecular Biology 2edition Niyogi Books •
- T.Fleming. 2002. Cell interactions: A practical approach Second edition.
- Alberts B, Molecular Cell Biology. 8. Casimeris et al., Lewin's cells. Jones and Bartlett.
- Plopper, Principles of cell Biology. Jones and Bartlett.
- Gartner, Cell Biology and Histology. LWW.
- Pollard et al., Cell Biology. Saunders.
- Copper, The Cell a Molecular approach. Sinauer

Core Paper-4
PRACTICAL-I
(Biochemistry, Molecular Genetics & Molecular Cell biology)

Paper – 4			
Title of the paper	PRACTICAL-I (Biochemistry, Molecular Genetics & Molecular Cell biology)	Subject code: 23P1BTP01	
Category of the course	Year	Semester	Credits
Core Paper	1 st	1 st	4

Learning Outcome:

The practical will establish a basic study skills on the subject and will improve the student's ability to calculate and improve their practical skill and knowledge.

Course outcomes:

On successful completion of the course the students will be able to

CO 1	(K2) Illustrate basic biochemistry procedures	K3,K4 &K5
CO 2	(K3) study the methods of estimation of biomolecules	K3,K4 &K5
CO 3	(K4) isolate & Analyze DNA, RNA & protein	K3,K4 &K5
CO 4	(K5) critically analyze the isolated biomolecules	K3,K4 &K5
CO 5	(K5) evaluate the quality and purity of DNA, RNA & Protein	K3,K4 &K5

SYLLABUS Core Paper-4 PRACTICAL-I		
Unit	Content	Hours
A	<p>(A) Biochemistry – Practical</p> <ol style="list-style-type: none"> 1. Basic calculations in Biochemistry - Normality, Molarity, Molality percent solutions (v/v, w/v). 2. Calibration of pH meter 3. Transition interval of commonly used pH indicators 4. Preparation of biological buffer - phosphate buffer 5a. Extraction of Proteins from biological materials 5b Protein separation methods:-Ammonium sulphate Precipitation 5c. Membrane Dialysis, 5d. SDS PAGE 	15

	<p>6. Urea-SDS PAGE for separation of low molecularweight proteins</p> <p>7. Estimation of Proteins by Lowry's method</p> <p>8. Estimation of Proteins by Biuret method</p> <p>9. Estimation of Proteins by Bradford method</p> <p>10. Estimation of RNA by orcinol method</p> <p>11. Estimation of DNA by diphenylamine method</p> <p>12. Estimation of Carbohydrate by Anthrone method</p> <p>13 Purity check of DNA & RNA by UV Spectrophotometry - A260/280</p> <p>14. Separation of amino acids by PaperChromatography</p> <p>15. Separation of sugars by Paper Chromatography</p> <p>16. Separation of amino acids by Thin layerchromatography</p> <p>17. Separation of sugars by Thin layerchromatography</p> <p>18. Thermal Denaturation of DNA and UV absorptionstudies</p> <p>Demo Experiments</p> <p>1. Gel permeation chromatography,</p> <p>2. Affinity chromatography,</p> <p>3. Ion.exchange chromatography</p> <p>4. Western blotting</p> <p>5. PCR</p>	
<p>B</p>	<p>(B) Molecular Genetics - Practical</p> <p>1. Isolation of DNA from bacteria</p> <p>2. Isolation of DNA from plants</p> <p>3. Isolation of DNA from animal tissue</p> <p>4. Isolation of DNA from blood</p> <p>5. Plasmid DNA isolation.</p> <p>6. Agarose gel electrophoresis of DNA</p> <p>7. Transer of DNA from gel – Southern Blotting</p> <p>8. Isolation of RNA</p> <p>9. Glyoxal denatured Agarose gel electrophoresis ofRNA</p> <p>10. Formaldehyde denatured Agarose gelelectrophoresis of RNA</p> <p>11. Urea denatured Agarose gel electrophoresis ofRNA</p> <p>12. Transfer of RNA from gel – Northern Blotting</p> <p>13. Restriction digestion of DNA</p> <p>14. Radiation induced genetic damage assessment</p> <p>15. Chemical induced genetic damage assessment.</p> <p>16. Preparation of metaphase chromosomes form blood</p>	<p>15</p>

<p>C</p>	<p>(C) Molecular Cell Biology -Practical</p> <ol style="list-style-type: none"> 1. Introduction to Microtome and types 2. Microtomy-Fixation of tissue 3. Microtomy -Embedding 4. Microtomy-Sectioning of tissue 5. H&E Staining of tissues 6. Histochemical staining to localize proteins 7. Histochemical staining to localize carbohydrates 8. Histochemical staining to localize lipids. 9. Subcellular fractionation and marker enzyme detection (mitochondria). 10. Giant chromosome studies in Chironomid larvae 11. Meiotic study in flower bud and cockroach or grasshopper 12. Preparation of tissue culture medium and membrane filtration 13. Preparation of single cell suspension from spleen and thymus; 14. Cell counting and cell viability; 15. Embryonic development and stem cells (serpulid polychaete Hydroids elegans/chick/ frog) 	<p>15</p>
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Elective Paper-1
BIOINSTRUMENTATION

Paper – 1			
Title of the paper	BIOINSTRUMENTATION	Subject code: 23P1BTE01	
Category of the course	Year	Semester	Credits
Elective Paper	1 st	1 st	3

Learning Outcome:

The paper imparts a thorough knowledge on the basics of all the instrumentation concepts, in biology. The student will get to understand the core concepts of biological instruments and their principles.

Course outcomes:

At the end of the Course, the Student will be able to:

CO-1	Introduction and various types of Microscopic techniques	K1 & K2
CO-2	Impart understanding on centrifugation instruments and techniques	K1, K2, K3
CO-3-	Separation of Biomolecules	K1, K2 & K3
CO-4	Analytical methods on Spectroscopic Analysis	K1, K2 & K3
CO-5	Understand the application and Detection on Bioinstrumentation	K1, K2 & K3

SYLLABUS | Elective Paper-1 | BIOINSTRUMENTATION

Unit	Content	Hours
I	Microscopic Techniques: Principles and Applications: Compound, Light, Stereo, Phase Contrast, Fluorescent Microscopy, Scanning and Transmission Electron Microscopy, Scanning Electron Microscopy, Atomic Force Microscopy, Confocal Microscopy, FRET and Flow Cytometry.	7
II	Centrifugation: pH meter, Principle and Applications of various types of centrifugation, Sedimentation Coefficient, Svedberg unit, RCF, Density Gradient Centrifugation. Chromatography Techniques: Principle and Application of Paper Chromatography, TLC, Gel Filtration Chromatography, Ion Exchange Chromatography, Affinity Chromatography, GC & HPLC.	7
III	Electrophoretic Techniques: Principle and Application of Agarose Gel Electrophoresis, 2D-gel Electrophoresis, PAGE- NATIVE & SDS PAGE, Iso- electric Focusing, High resolution Electrophoresis, Immuno Electrophoresis (Immunofixation EP,), ELISA, RIA, Southern, Northern and Western Blotting. Electro blotting, PCR and RT-PCR, Microarray (DNA, Proteins)	7
IV	Spectroscopic Techniques: Theory and Application of UV and Visible Spectroscopy, Fluorescence Spectroscopy, Mass Spectroscopy, IR Spectroscopy NMR, ESR, Atomic Absorption Spectroscopy, X- ray Spectroscopy, Laser Spectroscopy and Raman Spectroscopy	7
V	Radio-isotopic Techniques: Introduction to Radioisotopes, Uses and their Biological Applications, Radioactive Decay – Types and Measurement , Principles and Applications of GM Counter, Solid and Liquid Scintillation Counter, Autoradiography, RIA, Radiation Dosimetry, Health effects of Radiations.	7

Reference books

- M.H. Fulekar and Bhawana Pandey Bioinstrumentation, Wiley
- Keith Wilson, John Walker, 2010. Principles and Techniques of Biochemistry and Molecular Biology (7th Edition), Cambridge University Press •
- David L. Nelson, Michael M. Cox. Menninger (2008). Principles of Biochemistry, Fifth edition W. H. Freeman, New York. •
- Experiments in Biochemistry: A Hands-On Approach by Shawn O. Farrell, Ryan T. Ranallo, Paperback: 324 pages, Publisher: Brooks Cole. 20 •
- Metzler D.E. 2001, the chemical reactions of living cells –Academic Press. 2nd edition.
- Stryer L, 1999, Biochemistry-W.H. Freeman & Company, New York. 1. • 4th edition
- L.Veerakumari (2006) Bioinstrumentation MJP Publisher Kindle edition
- Jeffrey. M., Backer et al., 1996. Biotechnology- A Laboratory Course. Academic Press, New York.
- Holcapek, M., Byrdwell, Wm. C. 2017. Handbook of Advanced Chromatography /Mass Spectrometry Techniques, Elsevier

Elective Paper-2
BIostatISTICS

Paper – 2			
Title of the paper	BIostatISTICS	Subject code: 23P1BTE02	
Category of the course	Year	Semester	Credits
Elective Paper	1 st	1 st	3

Learning Outcome:

The paper imparts a thorough knowledge on the basics of all the statistical concepts, in biology. The student will get to understand the core concepts of computation principles for the data analysis.

Course outcomes:

At the end of the Course, the Student will be able to:

CO-1	To understand the major Methods of collection & presentation of data	K1,K2,K3 & K4
CO-2	To provide basic knowledge about methods of analysis of variance	K1,K2,K3 & K4
CO-3	To enlighten the students about the methods of setting hypothesis and calculation of errors.	K1,K2,K3 & K4
CO-4	To update the knowledge on Tests of significance for large and small samples.	K1,K2,K3 & K4
CO-5	To assess and appraise the role of novel microbes in environment and integrate them in specific innovative approaches.	K1,K2,K3 & K4

SYLLABUS | Elective Paper-2 | BIostatISTICS

Unit	Content	Hours
I	Statistics – Scope –collection, classification, tabulation of Statistical Data – Diagrammatic representation – graphs – graph drawing – graph paper – plotted curve – Sampling method and standard errors –random sampling – use of random numbers –expectation of sample estimates – means – confidence limits – standard errors – variance. Measures of central tendency – measures of dispersion – skew ness,	7
II	Correlation and regression – correlation table – coefficient of correlation – Z transformation – regression – relation between regression and correlation. Probability – Markov chains applications – Probability distributions – Binomial (Gaussiandistribution) and negative binomial, compound and multinomial distributions – Poisson distribution	7
III	Normal distribution – graphic representation.– frequency curve and its characteristics –measures of central value, dispersion, coefficient of variation and methods of computation – Basis of Statistical Inference – Sampling Distribution – Standard error – Testing of hypothesis – Null Hypothesis –Type I and Type II errors	7

IV	Tests of significance for large and small samples based on Normal, t, z distributions with regard to mean, variance, proportions and correlation coefficient – chi-square test of goodness of fit – contingency tables – χ^2 test for independence of two attributes – Fisher and Behrens 'd' test – 2x2 table – testing heterogeneity – rX c table – chi-square test in genetic experiments – partition X 2 – Emerson's method	7
V	Tests of significance – t tests – F tests – Analysis of variance – one way classification – Two way classification, CRD, RBD, LSD. Spreadsheets – Data entry – mathematical functions – statistical function – Graphics display – printing spreadsheets – use as a database word processes – databases – statistical analysis packages graphics/presentation packages	7

References Books:

- Veer bala Rastogi. 2011. Fundamentals of Biostatistics. Ane books Pvt Ltd, Chennai.
- Rosner, B (2005), "Fundamentals of Biostatistics", Duxbury Press.
- Warren, J; Gregory, E; Grant, R (2004), "Statistical Methods in Bioinformatics", 1st edition, Springer
- Milton, J.S. (1992), "Statistical methods in the Biological and Health Sciences", 2nd edition, Mc Graw Hill,
- Sundar Rao P. S.S., Jesudian G. & Richard J. (1987), "An Introduction to Biostatistics", 2nd edition, Prestographik, Vellore, India,.
- Zar, J.H. (1984) "Bio Statistical Methods", Prentice Hall, International Edition

Useful Websites:

- www.statsoft.com/textbook/biosun1.harvard.edu/
- www.bettycjung.net/Statsites.htm
- www.ucl.ac.uk/statistics/biostatistics

Elective Paper-3
ENZYMOLOGY

Paper – 3			
Title of the paper	ENZYMOLOGY		Subject code: 23P1BTE03
Category of the course	Year	Semester	Credits
Elective Paper	1 st	1 st	3

Learning Outcome:

The subject imparts knowledge on the fundamentals of enzyme structure and its kinetics. The student will be provided with a basic knowledge and understanding about the functions of enzyme as well as the industrial application of enzymes.

Course outcomes:

CO-1	(K2) Explain the basics of enzyme nomenclature and properties	K3 & K5
CO-2	(K3) Classify and Cognize the native and immobilized enzyme	K3 & K5
CO-3	(K4) Examine the equations of steady state kinetics	K3 & K4
CO-4	(K5) Assess extraction and downstream processing of enzymes	K3, K4 & K6
CO-5	(K6) Compile the uses of enzymes and design enzymes for Industrial and Clinical application	K3, K4, K5 & K6

SYLLABUS | Elective Paper-3 | ENZYMOLOGY

Unit	Content	Hours
I	Introduction to enzymes, Classification, nomenclature and general properties like effects of pH, substrate and temperature on enzyme catalysed reactions. Extraction Isolation and purification of enzymes by precipitation, centrifugation, chromatography and electrophoresis and liquid-liquid extraction methods	7
II	Kinetics of catalysed reaction : Single substrate reactions, bisubstrate reactions, concept of Michaelis - Menten, Briggs Haldane relationship, Determination and significance of kinetic constants, Limitations of Michaelis-Menten Kinetics, line weaver burk plot, Hanes wolf equation, Eadie hoofstee equation ,Inhibition of enzyme activity	7
III	Enzyme catalysis: enzyme specificity and the concept of active site, determination of active site. Stereospecificity of enzymes. Mechanism of catalysis: Proximity and orientation effects, general acid-base catalysis, concerted acid - base catalysis, nucleophilic and electrophilic attacks, catalysis by distortion, metal ion catalysis	7
IV	Theories on mechanism of catalysis.-Mechanism of enzymes action: mechanism of action of lysozyme, chymotrypsin, carboxypeptidase and DNA polymerase. Multienzymes system, Mechanism of action and regulation of pyruvate dehydrogenase and fatty acid synthetase complex	7

V	Coenzyme action. Enzyme regulation: General mechanisms of enzyme regulation, Allosteric enzymes, sigmoidal kinetics and their physiological significance, Symmetric and sequential modes for action of allosteric enzymes. Reversible and irreversible covalent modification of enzymes, Immobilized enzymes and their industrial applications. Clinical and industrial applications of enzymes, Enzyme Engineering	7
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Reference Books

- Nicholas C. Price and Lewis Stevens., 2010. Fundamentals of Enzymology. Oxford University Press, New Delhi
- Lehninger, Nelson and Cox, 2005, Principles of Biochemistry - 4th edition, WH Freeman and Company, New York, USA
- Principles of Biochemistry with human focus - Garrett and Grisham, 2002, Harcourt College Publishers, Orlando, Florida, USA.
- Geoffrey L, Zubay, Biochemistry -, 1998, 4th edition. 23
- Donald Voet, Judith Voet and Pratt, 1995, Fundamentals of Biochemistry, 2nd edition.
- Harper.s Biochemistry - Murray et al, 2000, 25th edition, Appleton and Lange Publishers.
- Enzymes – Trevor Palmer 2002.

Useful Websites

- www.lsbu.ac.uk/biology/enztech/
- www.lsbu.ac.uk/biology/enzyme/
- <http://www.aetltd.com/tech/applications.html>

SOFT SKILL - I

STATISTICS USING R PROGRAM

Paper – 1			
Title of the paper	STATISTICS USING R PROGRAM	Subject code: 23P1BTSSP01	
Category of the course	Year	Semester	Credits
SOFT SKILL	1 st	1 st	2

Learning Outcome:

The subject imparts knowledge on the fundamentals of statistics. The student will be provided with a basic knowledge and understanding about the usage of R programming.

Course outcomes:

CO-1	To install the R and its packages and its basic applications	K3
CO-2	To understand the data import and manipulation	K3 & K5
CO-3	To impart the knowledge on presenting the data	K3 & K4
CO-4	To assess the data and implement the statistics	K3, K4 & K6
CO-5	To apply the statistics on the research data	K3, K4, K5 & K6

SYLLABUS | SOFT SKILL - I | STATISTICS USING R PROGRAM

Unit	Content	Hours
I	Introduction to R - Installing R and R studio – Getting R help – Installing R packages – R Built-in Datasets; R programming basics – Basic arithmetic operations – functions – Assigning values to variables – Data types – Vectors – Matrices – Factors – Data Frames – Lists	7
II	Importing data –from text/csv/excel files – Exporting data - from R to text/csv/excel files – saving data - RDATA – Reshaping and Manipulating the data	7
III	Data Visualization – creating and saving graphs – Density plots - histograms – Box plots – violin plots – scatter plots - Bar plots – Deviation graphs – line plots - Lollipop charts – Error bars – Pie charts – Heatmaps - Volcano plots	7
IV	Basic statistics - Measure of central tendency: mean, median, mode; Measure of variability - Range: minimum & maximum, Interquartile range, Variance and Standard deviation; Normality test	7
V	Research Statistics - Correlation test – Correlation matrix – Comparing means of two groups – Student’s t-test, Wilcoxon rank test; Comparing the means of more than two groups – ANOVA test, Kruskal-Wallis rank sum test; Comparing the variances- F-test, Bartlett’s test and Fligner-Killeen test; Comparing proportions - Chi-square goodness of fit - Chi-Square test of independence.	7

Reference Books:

- Andrie de Vries, R For Dummies (2nd Edition) John Wiley & Sons,
- Hadley Wickham, R for Data Science (1st Edition) O’Reilly

**Core Paper-5
MICROBIOLOGY**

Paper – 5			
Title of the paper	MICROBIOLOGY	Subject code: 23P2BT04	
Category of the course	Year	Semester	Credits
Core Paper	1 st	2 nd	4

Learning Outcome:

To provide a comprehensive knowledge on taxonomy and microbial diversity, growth, their harmful effects and beneficial role of microorganisms in agriculture and environment

Course outcomes:

CO-1	To understand the major discoveries of microbiology and describe microbial diversity, Microbial growth and metabolism.	K1, K2 & K3
CO-2	To provide basic knowledge about microbial culture, identification of microbes, principle and working of microscopes and sterilization techniques	K2, K3 & K5
CO-3	To enlighten the students on host microbe interaction and Epidemiology of microbial disease	K1, K2, K3
CO-4	To update the knowledge on epidemic and pandemic diseases.	K4 & K5
CO-5	To assess and appraise the role of novel microbes in environment and integrate them in specific innovative approaches.	K4 & K5

SYLLABUS | Core Paper-5 | MICROBIOLOGY

Unit	Content	Hours
I	History and microbial taxonomy: Major discoveries related to the field of microbiology: Antony Von Leeuwenhoek, Louis Pasteur, Robert Koch and Edward Jenner. Microbial taxonomy: Bacteria, viruses, fungi, algae and protozoa, Microbial diversity: Biovars, Serovars and Prions, Microbial growth and metabolism: Microbial growth: Growth curve, factors affecting growth, Microbial metabolism - Methanogenesis, acetogenesis and auxotrophs	10
II	Microbial culture, identification, and control: Nutritional requirements for growth - Growth media and types, Pure culture techniques: Serial dilution and plating methods, Staining methods - Principles and types of staining (simple and differential), Identification of bacteria – Biochemical – IMViC, 16s rRNA sequencing. Microscopy: principles and applications of Bright field, fluorescent and Scanning electron microscopes, Microbial growth control: Physical Methods – Heat, Filtration, Low Temperatures, High Pressure, Desiccation, Osmotic Pressure, Radiation; Chemical Methods	10

III	Host microbe interaction and Epidemiology: Human microbiome; Skin, Gastrointestinal tract, Oral cavity, Lung. Symbiotic relationship of microbes: Symbiosis, Mutualism, Parasitism, Commensalism and endophyte. Epidemiology of microbes: causes, types and transmission of epidemic, endemic and pandemic Diseases.	10
IV	Microbial Diseases: Microbial diseases - General characteristics, pathogenesis, laboratory diagnosis and control measures of Pandemic and Epidemic diseases: Tuberculosis, Leprosy, Cholera, Typhoid, COVID-19, Yellow Fever, Flu, AIDS, Ebola, Zika Virus, Small Pox, Dengue, Chickungunya, Malaria, filariasis, Candidiasis, superficial mycosis.	10
V	Agricultural and Environmental Microbiology: Biological nitrogen fixation, free living, symbiotic nitrogen fixation, mechanism of Nitrogen, Biofertilizers- types and applications; Rhizosphere effect. Biogeochemical cycles-Carbon, Nitrogen, Sulphur and Phosphorous; Methanogenic bacteria Extremophiles- Thermophiles Acidophiles, Halophiles and alkalophiles; Biotechnological application of Extremophiles.	10

References

- Joanne Willey, Linda Sherwood, Christopher J. Woolverton, (2017). Prescott's Microbiology, (10th edition), McGraw-Hill Education, ISBN: 978-1259281594.
- Maheshwari D K, Dubey R C 2013. A Textbook of Microbiology. 4th Edn S Chand Publishing India.
- Ananthanarayan and Paniker's (2017) Textbook of Microbiology, (10th edition), The Orient Blackswan, ISBN: 978-9386235251.
- Benson HJ. (1999). Microbiological Applications: A Laboratory manual in General Microbiology, 7th Edition, McGraw Hill. 5
- Managing epidemics- Key facts about major deadly diseases, World Health Organization (WHO) 2018. 9. O'Flaherty, Vincent & Collins, Gavin & Mahony, Thérèse. (2010). Environmental Microbiology, Second Edition. 10.1002/9780470495117.ch11.
- Agriculture Microbiology, 2016. E-Course Developed By TNAU (ICAR)

Web Sources

- <https://www.who.int/emergencies/diseases/managing-epidemics-interactive.pdf> ISBN 978-92-4-156553-0. <https://doi.org/10.3389/fmicb.2020.631736>
- <https://www.agrimoon.com/wp-content/uploads/AGRICULTURAL-Microbiology.pdf>.

Core Paper-6
PLANT AND ANIMAL BIOTECHNOLOGY

Paper – 6			
Title of the paper	PLANT AND ANIMAL BIOTECHNOLOGY	Subject code: 23P2BT05	
Category of the course	Year	Semester	Credits
Core Paper	1 st	2 nd	4

Learning Outcome:

The paper imparts a thorough knowledge on the basics of all the biotechnological application on plant and animals. The student will get to understand the core concepts of biotechnology.

Course outcomes:

CO-1	To impart theoretical knowledge on various techniques of plant biotechnology like tissue culture, plant genetic transformation and their application in industries.	K1, K2 & K3
CO-2	Importance of secondary metabolites and production in plants.	K1, K2 & K5
CO-3	To develop concepts, principles and processes in animal biotechnology.	K4 & K5
CO-4	Concept and different types in Animal Cell Culture and animal cell lines.	K2, K3, K4 & K5
CO-5	Use of molecular biology techniques genetically engineer the animals to improve sustainability, productivity and suitability for pharmaceutical and industrial applications.	K3, K4 & K6

SYLLABUS | Core Paper-6 | PLANT AND ANIMAL BIOTECHNOLOGY

Unit	Content	Hours
I	Introduction of plant tissue culture, composition of media, Micropropagation, organogenesis, somatic embryogenesis, haploid and triploid production, protoplast isolation and fusion, hybrid and cybrid, synthetic seed production. Secondary metabolites in plants - Phytochemicals- Glycosides and Flavonoids; Anthocyanins and Coumarins - Lignans, Terpenes, Volatile oils and Saponins; Carotenoids and Alkaloids: biogenesis, therapeutic applications.	10
II	Plant Transformation Direct transformation by electroporation and particle gun bombardment. Agrobacterium, Ti plasmid vector. Theory and techniques for the development of new genetic traits, conferring resistance to biotic and abiotic. Plant engineering towards the development of enriched food products, plant growth regulators; Molecular Marker aided breeding: RFLP maps, Linkage analysis, RAPD markers, STS Micro satellite, SCAR, SSCP, QTL, Map based cloning and Molecular marker assisted selection.	10
III	Animal health disease diagnosis, hybridoma technique, monoclonal antibodies, application of probes for disease diagnosis of existing and emerging animal diseases. Prophylaxis - Vaccines, Oral vaccines DNA Vaccines in animal disease. Cell culture: primary and established culture; organ culture; tissue culture	10

IV	Disaggregation of tissue and primary culture; cell separation, Slide and coverslip cultures, flask culture, test tube culture techniques, cell synchronization, cryo preservation. Scaling up of animal cell culture, cell line and cloning micromanipulation and cloning, somatic cell cloning. Karyotyping; measuring parameters for growth, measurement of cell death, apoptosis and its determination, cytotoxicity assays.	10
V	Nuclear magnetic resonance methods of monitoring cell metabolism culturing animal cells in fluidised bed reactors. Application of animal cell culture for in vitro testing of drugs, in production of human and animal viral vaccines and pharmaceutical proteins. Culture Scale up and mass production of biologically important compounds. Harvesting of products, purification and assays. Transgenic animals: Production and application; transgenic animals in livestock improvement, transgenic animals as model for human diseases; Stem Cells- Properties, Types, Therapy, Prospects and Ethics in stem cell research.	10
Reference Books		
<ul style="list-style-type: none"> • Razdan. M. K., 2011. Plant tissue culture. Oxford and IBH publishing Company Pvt. Ltd, NewDelhi. 		
<ul style="list-style-type: none"> • Chawla. H. S., 2010. Introduction to plant biotechnology. Oxford and IBH publishing company pvt. Ltd, New delhi. • Ian Freshney, 2010. Culture of animal cells. 6th edition, Wiley-Blackwell publishers. • Slater, 2008. Plant Biotechnology: The Genetic manipulation of plants, Second Edition, Oxford University Press, USA. • J.D.Watson, Gillman, J.Witknowski and M.Zoller, 2006. Recombinant DNA. 3rd ed. • W.H.Freeman. 26 K. Dass. 2005, Text book of Biotechnology, Second Edition, Wiley Dreamtech, India (P) Ltd. • H.Kreuzer & A.Massey. 2001. Recombinant DNA and Biotechnology: A guide for teachers Second Edition. ASM press, Washington. • M.Sudhir. 2000. Applied Biotechnology & Plant Genetics. Dominant publishers & Distributors. • Genetic Engineering of Animals by (Ed) A.Puhler, VCH Publishers, Weinheim, FRG, 1993. • Animal Cell culture Practical approach. Ed. John R.W.Masters, Oxford.2004. • Concepts in Biotechnology D. Balasubramaniam, Bryce, Dharmalingam, Green, Jayaraman Univ. Press, 1996 		

Core Paper-7
GENETIC ENGINEERING

Paper – 7			
Title of the paper	GENETIC ENGINEERING	Subject code: 23P2BT06	
Category of the course	Year	Semester	Credits
Core Paper	1 st	2 nd	4

Learning Outcome:

The paper imparts a thorough knowledge on the basics of all the biotechnological application on plant and animals. The student will get to understand the core concepts of biotechnology.

Course outcomes:

CO-1	Understanding the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.	K1, K2, K5
CO-2	Getting detailed knowledge of gene transfer methods and identifying suitable hosts for cloning.	K2, K3, K4
CO-3	Acquiring theoretical knowledge in the techniques, tools, and application and safety measures of genetic engineering.	K3, K4 & K6
CO-4	Describes the genome mapping and sequencing and methods for gene therapy.	K3, K4, K5 & K6
CO-5	Elucidate different techniques involved in genetic engineering	K3, K4, K5 & K6

SYLLABUS | Core Paper-7 | GENETIC ENGINEERING

Unit	Content	Hours
I	Gene cloning. Genetic engineering tools. Nucleic acid manipulating enzymes. Promoters, Selectable markers and reporters used in rDNA technology. Restriction digestion, Ligation, Transformation, Selection of Recombinants. Construction of gene libraries	10
II	E.Coli vectors - pBR322 and its derivatives; Cloning vectors for gram negative bacteria - ColE1, p15A, R1, IncPa, pSC101; Lambda bacteriophage vectors, filamentous phages, Cosmids, Phasmids, Phagemids. Cloning in gram-positive bacteria (<i>Bacillus subtilis</i>).	10
III	Cloning in yeast <i>Saccharomyces cerevisiae</i> . Life cycle and types of vectors; Eukaryotic vectors. SV40 (molecular genetics and expression); Specialized cloning vector for cDNA; Synthesis of specific RNA in vitro; Vectors for cloning promoters and terminators; vectors with adjustable copy number.	10
IV	Nucleic acid hybridization techniques; Molecular probes (Types of probes and its construction); probe labeling. Nick translation, End labeling and Random primer labeling. Polymerase chain reaction and its variants; DNA fingerprinting; DNA sequencing first generation sequencing methods (Maxam and Gilbert sequencing, Sangers Dideoxy sequencing, Pyrosequencing, PCR based sequencing and hybridization sequencing). Second generation sequencing methods.	10

V	Site directed mutagenesis; DNA microarray; chromosome walking and jumping. Proteomics – Protein-Protein Interaction, 2D gel and MALDI-TOF. Molecular techniques in prenatal diagnosis gene therapy, Transgenic animals (knockout mice) and plants (Flavr-savr tomato), Pharmaceutical products (Vaccine, Humulin, etc), Crop improvement. Pesticide resistance, herbicide resistance, transgenic animals and GM foods; Modern Concepts in Genetic Analysis.	10
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Reference Books:

- T.A. Brown, 2010. Gene cloning and DNA analysis: An introduction, 6th edition, Wiley-Blackwell.
- Sandy B.Primrose and Richard Twyman, 2006. Principles of Gene Manipulation and genomics, 7th edition, Wiley-Blackwell.
- Lewin, 2009. Genes X, 10th edition, Jones & Barlett Publishers
- Raymond Rodriguez and David T.Denhart 2003.Vectors, A survey of molecular cloning vectors and their uses
- Errst-L. Winnacker 1987.From genes to clones. Introduction to Gene Technology,
- Ed. David V. Geoddel 2002.Gene Expression technologies. Methods in enzymology (Vol.185)
- William Wu, Michael J.Welsh, Peter B.Kaufmar, Helen H.Zhang 2001. Methods in Gene Biotechnology

Core Paper-8

PRACTICAL-II

(Microbiology, Plant and Animal Biotechnology & Genetic Engineering)

Paper – 8			
Title of the paper	PRACTICAL-II (Microbiology, Plant and Animal Biotechnology & Genetic Engineering)	Subject code: 23P2BTP02	
Category of the course	Year	Semester	Credits
Core Paper	1 st	2 nd	4

Learning Outcome:

The practical will establish a basic study skill on the subject and will improve the student's ability to have a hands on experience on the above core subjects.

Course outcomes:

CO-1	(K2) Isolate and identify microbes from various sources.	K1,K2,K3,K4,K5 &K6
CO-2	(K3) Characterize microbes.	K3,K4 & K5
CO-3	(K4) Examine Plant and Animal cells and their functions	K3,K4 &K5
CO-4	(K5) Assess extracted DNA, RNA and protein for rDNA technology	K3,K4 &K5
CO-5	(K6) to study cloning tools	K3,K4 &K5

SYLLABUS | Core Paper-8 | PRACTICAL-II

Unit	Content	Hours
A	(A) Microbiology-Practical 1. Sterilization of glassware using dry heat- hot air oven 2. Sterilization of media using moist heat – autoclave 3. Filter sterilization 4. Liquid media preparation – nutrient broth 5. Solid media preparation – SDA plates 6. Preparation of Agar slants 7. Streak plate method 8. Pour plate method 9. Spread plate method 10. Enumeration of total count of the bacteria 10. 11. Isolation of microbes from soil	15

	<p>12. Isolation of microbes from water</p> <p>13. Isolation of microbes from air</p> <p>14. Isolation of microbes from plant surface.</p> <p>15. Isolation of pure culture of E.coli,</p> <p>16. Isolation of pure culture of Aspergillus niger,</p> <p>17. Isolation of pure culture of Streptomyces.</p> <p>18. Gram staining and morphological characterization of microbes.</p> <p>19. Negative staining of bacteria</p> <p>20. Determination of growth curve of bacteria – E.coli</p> <p>21. IMViC test of enteric bacteria</p> <p>Demonstration</p> <p>16srRNA sequencing</p>	
<p>B</p>	<p>(B) Plant and Animal Biotechnology - Practical:</p> <p>1. Plant tissue culture media preparation</p> <p>2. Plant tissue culture sterilization techniques.</p> <p>3. Generation of Callus from leaf</p> <p>4. Generation of Callus from root</p> <p>5. Generation of Callus from bud</p> <p>6. Generation of Callus from shoot apex</p> <p>7. Maintenance of callus culture.</p> <p>8. Cell suspension culture</p> <p>9. Anther culture</p> <p>10. Pollen culture</p> <p>11. Embryo culture.</p> <p>12. Isolation of plant protoplast</p> <p>13. Culture of plant protoplast.</p> <p>14. Protoplast viability test.</p> <p>15. Localization of nucleus using nuclear stain.</p> <p>16. Agrobacterium culture maintenance and isolation of plasmid DNA.</p> <p>17. Mass culture of Chlorella /Spirulina</p>	<p>15</p>

	<p>18. Introduction to Animal Cell culture: Procedure for handling cells and medium.</p> <p>19. Cleaning and sterilization of glassware and plastic tissue culture flasks</p> <p>20. Preparation of tissue culture media</p> <p>21. Preparation of sera for animal cell culture</p> <p>22. Preparation of single cell suspension from chicken liver (Primary cell culture).</p> <p>23. Trypsinization of established cell culture.</p> <p>24. Cell counting and viability - staining of cells (a) Vital Staining (Trypan blue, Erythrosin (b) Giemsa staining.</p> <p>25. MTT Assay</p>	
<p>C</p>	<p>(C) Genetic Engineering - Practical</p> <ol style="list-style-type: none"> 1. Preparation of plasmid DNA by alkaline lysis method. 2. Agarose gel electrophoresis 3. Silver staining of gels 4. Methylene blue DNA staining 5. Elution of DNA from agarose gel. 6. Restriction enzyme digestion. 7. Restriction mapping of plasmid DNA. 8. Ligation. 9. Competent cell preparation 10. Transformation and selection of recombinants. 11. Cloning of fragments in PBR322 12. Insertional inactivation/Blue white screening 13. RAPD 14. RFLP 15. Amplification of DNA - PCR 16. Determination of molecular weight of DNA <p>Demonstration: RT-PCR for COVID-19</p>	<p>15</p>

Elective Paper-4
REGULATORY AFFAIRS AND INDUSTRIAL STANDARDS

Paper – 4			
Title of the paper	REGULATORY AFFAIRS AND INDUSTRIAL STANDARDS	Subject code: 23P2BTE04	
Category of the course	Year	Semester	Credits
Elective Paper	1 st	2 nd	3

Learning Outcome:

The subject imparts knowledge on the fundamentals of regulatory requirement in industries. The student will be provided with a basic knowledge and understanding about the regulatory affairs based on biotechnological industry requirements.

Course outcomes:

CO-1	Elucidate the basic requirements of establish laboratory for testing samples as per the regulatory body's requirements	K2,K3,K4
CO-2	Describe the Scientific, technical knowledge about various food preservation techniques	K2 & K3
CO-3	Describe the basic concepts of packing of food materials, various parameters observed during packaging	K2,K3 & K4
CO-4	Describe the testing of food materials and identifying of microbial food contaminant	K2,K3,K4
CO-5	Explain the basic of food safety management system, good manufacturing practice and good hygienic practices	K2,K3 & K6

SYLLABUS Elective Paper-4 REGULATORY AFFAIRS AND INDUSTRIAL STANDARDS		
Unit	Content	Hours
I	<p>Planning, Organisation and setting of Food testing laboratory and laboratory safety</p> <p>Understand the requirements for setting up a laboratory for the legal defensibility of analytical data. The ideal structure design, environment, layout for microbiological testing and Air handling etc., Introduction about accreditation, Different accreditation bodies (NABL, APLAC, ILAC), Requirements for ISO/IEC 17025:2017, documentation, pre-requisites for accreditation, management requirements, technical requirements, measurement of traceability, Laboratory safety: Personnel and laboratory hygiene, emergency planning, general hazards in a food laboratory, safety equipment, storage of chemicals, acids, flammables etc, handling and biological spills and waste disposal.</p>	7

II	<p>Principles of Food Preservation technology</p> <p>Heat: Principles of Heat transfer, Blanching, Pasteurization, Heat sterilization, thermal extrusion, cooking. Water Removal: Forms of Water in Foods, Sorption of water in foods, Water activity, drying and evaporation technology. Temperature reduction: Chilling, Freezing, Radiation: Ionizing Radiation, Microwave, Use of chemicals: Class-I & Class-II preservatives, smoke other chemical additives, New non-thermal methods: High hydrostatic pressure, modified atmosphere, high intensity pulsed electric fields, intense pulsed light, oscillating magnetic fields, hurdle technology, ultrasonic and ohmic heating etc.</p>	10
III	<p>Principles of Food Packaging technology</p> <p>Effect of environment on food stability: light, oxygen, water, temperature, sensitivity to mechanical damage and attack by biological agents, Different packaging materials used for food packaging and their properties including barrier properties, strength properties, optical properties: Glass, metals, paper, plastics, biodegradable and edible films and coatings aseptic packaging and combinations, Selection of packaging material and design for various food commodities including fresh produce (Fruits and vegetables), milk and milk products (dairy), cereal, pulses, oil, meat, fish, poultry, water and processed foods, Evaluation of quality and safety of packaging materials- different testing procedures, Function of packaging: Protective packaging and active packaging smart and intelligent packaging, Newer packaging technologies-CAP/MAP packaging aseptic processing and packaging, irradiated packaging, retort pouch and microwaveable packaging.</p>	10
IV	<p>Food Microbiology and testing</p> <p>Introduction of Food microbiology: Classification and nomenclature of microorganisms. Morphology and structure of microorganisms in foods (yeast and Molds, Bacterial cells viruses), Important genera of mold, yeast, bacteria (Gram positive and Gram negative, facultative aerobic and anaerobic, endospore forming bacteria and non-sporulating bacteria), Bacterial groups (lactic acid, acetic acid, butyric acid etc.), thermophilic, proteolytic, saccharomytic etc, coliforms, faecal coliforms, enteric pathogens and emerging microbes, Sources of microorganisms in food chain (raw materials, water, air, equipment etc) and microbiological quality of foods, Microbial growth characteristics: Reproduction and growth (fission, generation time optimum growth, growth curve etc). Microbial growth in foods: intrinsic (pH, Moisture content, oxidation-reduction potential, nutrient content, antimicrobial constituents and extrinsic parameters (temperature of storage, relative humidity of environment, presence and concentration of gases in the environment, Thermal destruction of microorganisms: Thermal death time, D Value, Z- Value, F-Value, thermal death time curve, 12 D Concept, Microbial food spoilage and food borne diseases, food pathogens, <i>Bacillus cereus</i> and other <i>Bacillus</i> species, <i>Campylobacter</i>, <i>Clostridium</i> species, <i>Enterobacteriaceae</i>, <i>E. coli</i>, <i>Listeria monocytogenes</i>, <i>Salmonella</i>, <i>Shigella</i>, <i>Staphylococcus aureus</i>, <i>Vibrio</i> species, <i>Yersinia enterocolitica</i>, fungi, virus etc., Methods for the Microbiological examination of foods: Sampling activity and</p>	10

	sampling plan, pure culture isolation: streaking, serial dilution and plating, cultivation, maintenance and preservation/stocking of pure culture, Observation of Indicator organisms: Direct examination, enumeration methods, plate count,MPN, biochemical test, Rapid methods detection of specific organisms.	
V	HACCP and Food safety management systems: ISO 22000: Importance of implementing a HACCP system and how it can be applied to various products. Prerequisite programs, HACCP principles, some limitation of HACCP food safety objective (FSO).Foodsafety audits: Management review, audit certification and importance. Good manufacturing practices (GMP), Good hygienic practices (GHP),Food safety plan, food safety management riskanalysis.Traceability food products recal and sanitation.	7
References: <ul style="list-style-type: none"> • ISO 9001, Quality management systems – Requirements • ISO 17034 General requirements for the competence of reference material producers • ISO/IEC 17043 Conformity assessment – General requirements for proficiency testing. • Food safety standards authority regulation 2011. 		

Elective Paper-5

PHARMACEUTICAL BIOTECHNOLOGY

Paper – 5			
Title of the paper	PHARMACEUTICAL BIOTECHNOLOGY	Subject code: 23P2BTE05	
Category of the course	Year	Semester	Credits
Elective Paper	1 st	2 nd	3

Learning Outcome:

The subject imparts knowledge on the fundamentals of pharmaceutical biotechnology. The student will be provided with a basic knowledge and understanding about the pharmaceutical products produced based on biotechnological methods and its biomedical applications.

Course outcomes:

CO-1	Explain the basic components of pharmaceutical and biotechnology industry and methods and applications of biosensor	K1
CO-2	Describe the Scientific, technical and economic aspects of vaccine & rDNA technology	K3 & K4
CO-3	Describe the basic concepts of protein Engineering, therapeutic proteins and enzyme immobilization techniques	K2
CO-4	Describe the concepts of hybridoma technology, microbial biotransformation and microbial bio-transformed products	K2 & K4
CO-5	Explain the basic components of somatic gene therapy, Xeno-transplantation and fermenter and bio safety methods	K1,K2 &K5

SYLLABUS | Elective Paper-5 | PHARMACEUTICAL BIOTECHNOLOGY

Unit	Content	Hours
I	Introduction to concepts and technologies in pharmaceutical biotechnology and industrial applications, Biosensors- Working and applications of biosensors in pharmaceutical Industries; Pharmacology and Ethnopharmacology: Scope, applications and Importance.	7
II	Scientific, technical and economic aspects of vaccine research and development, Preparation of bacterial vaccines, toxoids, viral vaccine and antitoxins, Storage conditions and stability of vaccines, Recombinant DNA technology, Application of rDNA technology and genetic engineering in the production of: (i) Interferon (ii) Vaccines - hepatitis- B (iii) Hormones – Insulin, Brief introduction to Protein Engineering, Therapeutic proteins, Production of Enzymes- General consideration – Amylase, Catalase, Peroxidase, Lipase, Protease, Penicillinase, Methods of enzyme immobilization and applications	7

III	Hybridoma technology - Production, Purification and Applications, Formulation of biotech products - Rituximab, Introduction to Microbial biotransformation and applications, Study of the production of – penicillins, citric acid, Vitamin B12, Glutamic acid and Griseofulvin Somatic gene therapy, Xenotransplantation in pharmaceutical biotechnology, Large scale production fermenter design and its various controls, Bio safety in pharmaceutical industry.	7
IV	Pharmacological activity of Plant drugs, Plant Chemicals in modern pharmacology; biochemistry and pharmacology of atropine, caffeine, ephedrine, opioids, taxol, vinca alkaloids, synthetic substitutes for therapeutically active plant constituents; drug improvement by structure modification and bio- transformation. Criteria for pharmacological evaluation of drugs.	7
V	Clinical Pharmacology, Drug therapy, therapeutic situation, benefits and risk of use of drugs, Mechanism of drug action, Therapeutic efficacy, Therapeutic index, tolerance, dosage forms and routes of drug action , factors affecting drug action; Adverse Drug reactions and drug poisoning-classification and causes of ADR; principle clinical manifestations and treatment of ADR, General principles of management of drug poisoning; antidotes, classification of drugs.	7

Reference Books:

- Harbans Lal, 2011. Pharmaceuticals biochemistry. CBS Publishers and distributors Pvt. Ltd, Chennai.
- Carlos A. Guzmán and Giora Z. Feuerstein, 2009. Pharmaceutical Biotechnology, 1st edition, Springer.
- Daniel Figeys (Ed.). 2005. Industrial Proteomics: Applications for Biotechnology and Pharmaceuticals. Wiley, John & Sons, Incorporated.
- Kayser, O and Muller R.H.. 2004. Pharmaceutical Biotechnology Drug Discovery and Clinical Applications. WILEY-VCH
- Leon Shargel, Andrew B. C. Yu, Susanna Wu-Pong, and Yu Andrew B. C. 2004. Applied Biopharmaceutics & Pharmacokinetics. McGraw-Hill Companies
- Stefania Spada, Garywalsh. 2004. Directory of approved biopharmaceutical
- Gary Walsh. 2003. Biopharmaceutical, Biochemistry & Biotechnology.
- Heinrich Klefenz. 2002. Industrial pharmaceutical biotechnology.
- Thomas Lengauer (Ed.). 2002. Bioinformatics – from Genomes to Drugs. Volume I & II. Wiley-VCH.
- John F. Corpenner (editor), Mark C. Manning. 2002. Rational Design of stable formulation Theory and Practice (Pharmaceutical Biotechnology). Plenum, US. 1st edition.
- D.I.A. Crommelin, et al., 2002. Pharmaceutical Biology. Amazon prime publications.
- Werner Kalow, Urs A Meyer and Rachel F. Tyndale. 2001.
- Pharmacogenomics. CPL press.

Useful Websites:

- <https://tugasakhirsttifbogor.files.wordpress.com/2018/08/pharmaceutical-biotechnology.pdf>
- <http://library.nuft.edu.ua/ebook/file/Gad2007.pdf>
- <https://oasis.iik.ac.id:9443/library/repository/a932eb462c49885a2c72755977036b81.pdf>

Elective Paper-6
ENVIRONMENTAL BIOTECHNOLOGY

Paper – 6			
Title of the paper	ENVIRONMENTAL BIOTECHNOLOGY	Subject code: 23P2BTE06	
Category of the course	Year	Semester	Credits
Elective Paper	1 st	2 nd	3

Learning Outcome:

The subject imparts knowledge on the fundamentals of ecology and pollution. The student will be provided with a basic knowledge and understanding about the functions of ecosystem and reduction of pollution by biotechnological tools.

Course outcomes:

On successful completion of the course the students will be able to

CO-1	(K2) explain various waste management methods	K2
CO-2	(K3) classify potential methods of biodegrading organic pollutants.	K3
CO-3	(K4) examine the techniques involved in remediation of polluted environments	K4
CO-4	(K5) assess types of pollution & its control	K5
CO-5	(K6) compile biotechnological approaches to degrade xenobiotic compounds	K6

SYLLABUS | Elective Paper-6 | ENVIRONMENTAL BIOTECHNOLOGY

Unit	Content	Hours
I	Environment: Basic concepts and issues; Environmental management and Conservation, Environmental Laws & Agencies involved in conservation. Environmental Pollution: Types of pollution & its control strategies -Air pollution, Soil pollution, Water pollution, Oil pollution & Radioactive pollution.	7
II	Biofilm Kinetics: Completely mixed biofilm reactor- Soluble microbial products and inert biomass-Special- case biofilm solution. Reactor types:- batch reactor - continuous-flow stirred-tank reactor- Plug-flow reactor. Engineering design of reactors- Reactors in series.	7
III	Waste water management, source of waste water, Waste water treatment- physical, chemical and biological treatment. Microbiology of Waste water; Aerobic and anaerobic process, BOD and COD.	7
IV	Toxicity: Types and Test for evaluating Toxicity. Biosensors, Biomonitoring of toxic materials .Biomagnification, Biomining and Biofuels.	7
V	Bioremediation; <i>In-situ and Ex-situ</i> Bioremediation of contaminated soils and waste land; Microbiology of degradation of Xenobiotics in environment; Pesticides, Surfactants, Degradative plasmids. Solid waste: Composting, Vermiculture and methane production.	7

Reference Books:

- Gareth M. Evans, Gareth G. Evans, Judy Furlong 2011
- Environmental biotechnology: theory and application John Wiley & Sons, Ltd. West Sussex,UK
- M. Moo-Young, W.A. Anderson, A.M. Chakrabarty, 2010. Environmental Biotechnology:Principles and Applications. Springer.
- M. H. Fulekar, 2010 Environmental Biotechnology, by Science Publishers Department of LifeSciences, University of Mumbai, India,
- Stanley E. Manahan, 2009. Environmental Chemistry, Ninth Edition, CRC Press.
- Environmental chemistry 5th edition by A.K.De. 1997.
- Bruce E. Rittmann and Perry L. McCarty. 2001. Environmental Biotechnology :Principles and applications. McGraw Hill, Newyork.
- Ahmed N, Qureshi, F.M. and Khan, O.Y. 2001.Industrial and Environmental Biotechnology.Horizon Press.
- Ahmed N, Qureshi, F.M. and Khan, O.Y. 2001.Industrial and Environmental Biotechnology.Horizon Press.

Useful Websites:

- [lbewww.epfl.ch/LBE/Default_E.htm](http://www.epfl.ch/LBE/Default_E.htm)
- <http://lbe.epfl.ch>

SOFT SKILL - II
GENOMICS AND PROTEOMICS

Paper – 1			
Title of the paper	GENOMICS AND PROTEOMICS	Subject code: 23P2BTSS02	
Category of the course	Year	Semester	Credits
SOFT SKILL	1st	2nd	2

Learning Outcome:

To understand the basic concepts in genomics and proteomics of various techniques applied to enumerate genome sequences and its functions.

Course outcomes:

CO-1	To know about DNA manipulating enzymes and its role in rDNA Technology	K3 & K5
CO-2	To gain knowledge on different types of plasmid vectors and their Usage	K3 & K5
CO-3	To acquire knowledge on basic gene cloning strategies	K3 & K4
CO-4	To evaluate the usage and applications of gene cloning for the development of value added products	K3, K4 & K6
CO-5	To know-how on versatile techniques in recombinant DNA technology.	K3, K4, K5 & K6

SYLLABUS | SOFT SKILL – II | GENOMICS AND PROTEOMICS

Unit	Content	Hours
I	Genomics-Overview of Genome anatomies. Prokaryotic Genome Organization: operons. Eukaryotic Genomes, Nuclear Genomes and gene families, Organelle genomes: origin, Repetitive DNA contents, Tandem repeats, Transposons and transposable elements.	7
II	DNA sequencing methods: Shot gun sequencing – Contig assembly. Techniques for gene location: ORF findings, Northern Hybridization, RT- PCR, RACE, S1 nuclease mapping, exon trapping. Transcriptome analysis: SAGE and Microarray technology	7
III	Genome Mapping: Genetic Mapping: RFLP, SSLP, SNP-Physical Mapping, Restriction site Mapping: FISH, STS mapping. Human genome organization. Gene therapy for inherited disorders and infectious diseases and ethics.	7
IV	Tools of Proteomics: The proteome – the life cycle of protein-analytical techniques. Protein separation: 1D PAGE, 2D-PAGE, RPHPLC, Protein digestion techniques: peptide analysis- MALDI-TOF-ESI, Tandem Mass analyzers, Peptide Mass finger printing.	7
V	Applications of Proteomics: Protein mining, SALSA algorithm for mining specific features. Protein expression profiling. Identifying protein - protein interactions. Mapping of protein modifications.	7

Reference Books

- Joaquim Jaumot, Carmen Bedia, Roma Tauler, Data Analysis for Omic Sciences: Methods and Applications (1st Edition) Elsevier, 2018
- Azuaje, Francisco. Bioinformatics and biomarker discovery: "omic" data analysis for personalised medicine. Hoboken, NJ: John Wiley & Sons, 2010
- Tseng, George C., Debashis Ghosh, and Xianghong Jasmine Zhou. Integrating Omics Data. Cambridge University Press, 2015.

Extra disciplinary subject for other department students

TISSUE ENGINEERING

Paper			
Title of the paper	TISSUE ENGINEERING		Subject code: 23P2BTED01
Category of the course	Year	Semester	Credits
Extra disciplinary subject	2 nd	3 rd	3

Learning Outcome:

The subject imparts knowledge on the fundamentals of tissue and its function. The student will be provided with a basic knowledge and understanding about the functions of tissue and its biomedical applications.

Course Outcome:

CO-1	Understand the basics of Basics of Tissue Engineering	K4 & K5
CO-2	Apply the knowledge to create tissue culture methods	K3 & K5
CO-3	Acquire adequate knowledge in the use of tissue in medical application	K1,K2,K3 & K4
CO-4	Evaluate the benefits of Tissue Engineering & Pharmaceutical Products	K2,K3,K4,K5
CO-5	Analyze the importance of applications of tissue engineering	K2,K3,K4 & K6

SYLLABUS | Extra disciplinary subject | TISSUE ENGINEERING

Unit	Content	Hours
I	Basic biology of tissue engineering: The basis of growth and differentiation-morphogenesis and tissue engineering	7
II	In vitro control of tissue development-Growth factors-Tissue engineering bioreactors- In vitro synthesis of Tissue and organs- Organotypic and histotypic engineered tissues. 3D cell culture-Tissue assembly in microgravity	7
III	Biomaterials in tissue engineering-Scaffolds, extracellular matrix, polymers and nanocomposites. Approaches to transplanting engineered cells.	7
IV	Bioartificial pancreas, Hepatassit liver support system, Artificial Womb, Heamatopoietic system: Red blood cell substitutes, Renal replacement devices.	7
V	Structural tissue engineering-Bone regeneration through cellular engineering, Skin tissue engineering, Brain implants-Neural stem cells, Periodontal applications	7

Reference Books:

- Sylvia, S. Mader, 2011, Human Biology, Twelfth edition, Mc Graw Hill, USA.
- Robert P. Lanaza, Robert Langer and Joseph Vacanti, 2007. Principles of Tissue Engineering. Third edition Academic Press.
- Micklem.H.S., Loutit John.F., 2004, Tissue grafting and radiation, Academic Press, NewYork..
- Penso.G., Balducci.D., 2004. Tissue cultures in biological research, Elsevier, Amsterdam
- Cecie Starr, 1996, Biology, Third edition, Wordsworth, America.

Useful Websites:

- www.nuigalway.ie/anatomy/tissue_engineering.htm

Core Paper-9
BIOINFORMATICS

Paper – 9			
Title of the paper	BIOINFORMATICS		Subject code: 23P3BT07
Category of the course	Year	Semester	Credits
Core Paper	2 nd	3 rd	4

Learning Outcome:

The paper imparts a thorough knowledge of the basics of bioinformatics tools. The student will get to understand the core concepts of in Silico biological research.

Course outcomes:

CO-1	To get introduced to the basic concepts of Bioinformatics and its significance in Biological data analysis.	K1 & K2
CO-2	Describe the history, scope and importance of Bioinformatics and role of internet in Bioinformatics.	K2, K3 & K5
CO-3	Explain about the methods to characterize and manage the different types of Biological data.	K2 & K5
CO-4	Classify different types of Biological Databases.	K4 & K5
CO-5	Introduction to the basics of sequence alignment and analysis	K3, K4 & K6

SYLLABUS | Core Paper-9 | BIOINFORMATICS

Unit	Content	Hours
I	Database concepts, Introduction to internet and its application, Introduction to bioinformatics, Protein and nucleotide databases, Information retrieval from biological databases, Sequence alignment and database searching-similarity searches using BLAST and FASTA. Artificial Intelligence: Introduction to biological neural network, motivation for artificial neural network (ANN), Big data analysis - DNA/RNA/protein sequence or structure data, gene expression data, protein-protein interaction (PPI) data, pathway data and gene ontology (GO) data	10
II	Sequence alignment basics, match, mismatch, similarity, scoring an alignment, gap penalty, protein vs DNA alignments, Dot-matrix alignment, pairwise alignment. Global and local alignment algorithms, multiple sequence alignment-progressive alignment and iterative alignment algorithms, consensus sequence, patterns and profiles, Database searching: Pairwise alignment based rigorous algorithm (Smith and Waterman) and Heuristic algorithms (FASTA and Blast). Multiple sequence alignment based database searching. PSI- Blast, PAM and Blosum matrices	10

III	Bioinformatics for genome sequencing, EST Clustering and analyses, Finding genes in prokaryotic and eukaryotic genomes, Regulatory sequence analysis, Bioinformatics for Genome maps and markers, Bioinformatics for understanding Genomevariation, Protein structure-X-ray crystallography, Theprotein databank and the PDBSum-SCOP, CATH, DALI and HSSP ;Visualization of molecularstructures- RasMol and Pymol; Protein secondary structure prediction, Fold Recognition; Transmembrane topology prediction.	10
IV	Molecular visualization tools. Rasmol, Chime and Spdb viewer. Structure analysis tools. VAST and DALI, Structural biology - Homology modeling, Bioinformatics for micro array designing and transcriptional profiling, Bioinformatics for metabolic reconstruction, Bioinformatics for phylogenetic analysis.	10
V	Medical application of Bioinformatics. Disease genes, Drug Discovery. History. Steps in drug discovery. Target Identification. Target Validation. QSAR. Lead Identification. Preclinical pharmacology and toxicology. ADME. Drug designing. Rational drug design. Computer aided drug design. Ligand based approach. Target based approach.	10

Reference Books:

- DassanayakeS.Ranil, Y.I.N. Silva Gunawardene, 2011. Genomic and Proteomic Techniques, Narosa Publishing House Pvt. Ltd, New Delhi.
- Thiagarajan B, Rajalakshmi.P.A., 2009. Computational Biology, MJP publishers, Chennai.
- BosuOrpita, SimminderKaurThukral, 2007. Bioinformatics Databases, Tools and Algorithms, Oxford University press, New Delhi.
- Rastogi.S.C, Mendiratta.N, Rastogi.P, 2004. Bioinformatics methods and applications, Prentice-Hall of India private limited, New Delhi.
- Lohar s. Prakash, 2009. Bioinformatics, MJP Publishers, Chennai.
- Stephen misener and Stephen A. Krawetz., 2000. Bioinformatics methods and protocols, Humana press Inc, New Jersey.
- Durbin.R, S.Eddy, A.Krogh and G.Mitchison, 1998. Biological sequence analysis, Cambridge university press, Cambridge.

Core Paper-10
IMMUNOLOGY

Paper – 10			
Title of the paper	IMMUNOLOGY	Subject code: 23P3BT08	
Category of the course	Year	Semester	Credits
Core Paper	2 nd	3 rd	4

Learning Outcome:

The paper imparts a thorough knowledge on the basics of immunology. The student will get to understand the core concepts of immune systems and their non-specific and specific mechanisms, vaccine, etc.

Course outcomes:

At the end of the course the students will be able to

CO-1	(K2) Illustrate various mechanisms that regulate immune responses and maintain tolerance	K1 & K2
CO-2	(K3) describe key events and cellular players in antigen presentation, and how the nature of the antigen will shape resulting effector responses	K2, K3 & K5
CO-3	(K4) learn the concepts of cellular and molecular processes that represent the human immune system.	K2 & K5
CO-4	(K5) elucidate the role of immunological regulation and tolerance at a cellular and molecular level	K4 & K5
CO-5	(K6) compile concepts on immunological principles and diagnosis	K3, K4 & K6

SYLLABUS | Core Paper-10 | IMMUNOLOGY

Unit	Content	Hours
I	History and overview of the immune system. Types of immunity - innate, acquired, passive and active, self vs non-self-discrimination. Physiology of immune response: HI and CMI specificity and memory. Cells and organs of the immune system. Lymphoid tissue, origin and development. Hematopoiesis and differentiation of lymphocytes.	10
II	Lymphocyte-sub-populations of mouse and man. APC cells, lymphokines, Phagocytic cells, macrophage, dendritic cells, K and NK Cells. Nature and biology of antigens, epitopes, haptens, adjuvants. Immunoglobulins- structure, distribution and function. Immunoglobulin super family Isotypic, Allotypic and Idiotypic variants, generation of antibody diversity	10
III	Monoclonal antibody production and its applications. Types of vaccine and vaccination schedule. Role of MHC antigens in immune responses, Structure and function of class I and class II MHC molecules. MHC antigens in transplantation and HLA tissue typing. Transplantation immunology- immunological basis of graft rejection, clinical transplantation and Immunosuppressive therapy. Tumour Immunology - Tumour antigen, Immune response to tumours.	10

IV	Effector mechanisms in immunity - macrophage activation, cell mediated cytotoxicity, cytotoxicity assay. Hypersensitivity reactions and types. The complement system, mode of activation, classical and alternate pathway, biological functions of C proteins.	10
V	Immunotechniques- Principle and Applications: Immuno diffusion, Immuno fluorescence, Insitu localization technique - FISH and GISH. RIA and ELISA, FACS, Western blot, ELISPOT assay. Agglutination tests. VDRL test. Purification of antibodies, Quantitation of immunoglobulin by RID, EID and nephelometry, CMI techniques and Immunotherapy.	10

Reference Books:

- Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt, 2011.
- Roitt's Essential Immunology, 12 edition, Wiley-Blackwell. USA.
- Kannan. I., 2010. Immunology. MJP Publishers, Chennai.
- Abbas, A.K., A.H.L. Lichtman and S. Pillai, 2010. Cellular and Molecular Immunology. 6th Edition. Saunders Elsevier Publications, Philadelphia.
- Seemi Garhat Bashir, 2009. Text Book of Immunology, PHI Learning Pvt. Ltd. New Delhi.
- Thomas J. Kindt, Barbara A. Osborne and Richard A. Goldsby, 2006. Kuby Immunology, 6th edition, W. H. Freeman & Company.
- Nandini Shetty, 1996, Immunology: introductory textbook - I. New Age International, New Delhi.

Useful Websites:

- www.library.csusm.edu/course_guides/biology
- www.immunologylink.com
- <http://www.wiley.com/college/bio/karp12791/weblinks.html>

Core Paper-11
BIOPROCESS TECHNOLOGY

Paper – 11			
Title of the paper	BIOPROCESS TECHNOLOGY	Subject code: 23P3BT09	
Category of the course	Year	Semester	Credits
Core Paper	2 nd	3 rd	4

Learning Outcome:

The paper imparts a thorough knowledge on the basics of bioprocess and industrial fermentation. The student will get to understand the core concepts of fermentation and its commercial application.

Course outcomes:

The student will learn about the:

CO-1	(K2) Outline the basis of Bioprocess Engineering	K1 & K2
CO-2	(K3) Relate reactors in fermentation	K2, K3 & K5
CO-3	(K4) Differentiate fermentation processes	K2 & K5
CO-4	(K5) Assess Scale up and Scale down	K4 & K5
CO-5	(K6) Compile the output of fermentation processes	K3, K4 & K6

SYLLABUS | Core Paper-11 | BIOPROCESS TECHNOLOGY

Unit	Content	Hours
I	Introduction to fermentation. General requirements of fermentation. Microbial growth kinetics of batch and continuous culture. Solid substrate, slurry fermentation and its application. Microbial cell culture. Immobilization of cells and enzymes. Food Safety: Introduction to food safety aspects and food related, hazards – HACCP and ISO.	10
II	Types of bioreactors: Submerged reactors, surface reactors, mechanically agitated reactors, non- mechanically agitated reactors. Design of fermenters, body construction. Production of citric acid, penicillin and insulin. Isolation and improvement of Industrially important Micro-organisms, Media for Industrial fermentation and Sterilization.	10
III	Introduction to bioproducts and bioseparation. Primary recovery process: Cell disruption methods. Cell lysis and Flocculation: Osmotic and mechanical methods of lysis. Flocculation by electrolysis; polymorphic flocculation. Precipitation methods. Filtration: Principles, Conventional, Crossflow filtration. Sedimentation: Principles, Sedimentation coefficients. Extraction Principles, Liquid liquid extraction, aqueous two phase extraction, supercritical fluid extraction.	10
IV	Down Stream Processing: Chromatography Techniques, Membrane separation, ultrafiltration. Drying .Principles and operation of vacuum dryer, shelf dryer, rotary dryer, freezer and spray dryer. Crystallization and Whole broth processing.	10
V	Aerobic and anaerobic fermentation processes and their application in the field of biotechnology industry. Production of commercially important primary and secondary metabolites, Effluent Treatment and Fermentation Economics.	10

Reference Books:

- Min-tzeLiong, 2011. Bioprocess Sciences and Technology. NovaScience Pub Inc.
- Michael L.Shuler, FikretKargi. 2003. Bioprocess Engineering. PHIpublishers.
- P.A.Belter, E.L.Cursler, and W.S.Hu. 1988.Bioseparation: Downstream processing for Biotechnology. John Wiley and sons.
- R.G. Harrison, P.Todd, SR.Rudge and D.P. Petrides. 2003.Bioseparation science andengineering. Oxford Press.

Useful Websites:

- www.wildfermentation.com/John Schollar and BenedikteWatmore, Practical Fermentation-a technicalguide
- web.mit.edu/professional/short.../fermentation_technology.html

Core Paper-12
PRACTICAL-III
(Bioinformatics, Immunology & Bioprocess Technology)

Paper – 12			
Title of the paper	PRACTICAL-III (Bioinformatics, Immunology & Bioprocess Technology)	Subject code: 23P3BTP03	
Category of the course	Year	Semester	Credits
Core Paper	2 nd	3 rd	4

Learning Outcome:

The practical will establish a basic study skill on the subject and will improve the student's ability to calculate and improve their practical skill and knowledge.

Course outcomes:

CO-1	(K2) to learn the Bioinformatics tools for sequence retrieval and alignment	K1,K2,K3,K4&K5
CO-2	(K3) to apply the learned tools for various applications	K1,K2,K3,K4&K5
CO-3	(K4) to isolate, identify & enumerate immune cells	K1,K2,K3,K4&K5
CO-4	(K5) to learn the technique of immunodiagnostics	K2,K3,K4
CO-5	(K6) to study upstream & downstream techniques	K2,K3,K4 & K5

SYLLABUS | Core Paper-12 | PRACTICAL-III

Unit	Content	Hours
A	<p>(A) Bioinformatics-practical</p> <ol style="list-style-type: none"> 1. Sequence retrieval from Genbank 2. Sequence retrieval from Uniprot. 3. Sequence identity search- Sequence similarity search using BLAST 4. Sequence similarity search using FASTA 5. Sequence similarity search using PSI BLAST 6. Sequence similarity search using PHI- BLAST. 7. Prediction of signal sequence using SignalIP online tool 8. Pattern Search (Domains & Motifs) using Pfam 9. ORF gene Search - Genscan 10. Sequence translation using ExpASy translate tool 11. Characterization of retrieved protein sequence by ProtParam tool. 12. Pair-wise global sequence alignment using EBI-EMBOSS Needleman Wunsch tool 13. Pair-wise local sequence alignment using EBI-EMBOSS Smith Waterman tool. 14. Multiple sequence alignment using EBI-CLUSTALW2. 15. PHYLOGENY- Phylogenetic tree using PHYLIP. 16. Prediction of secondary protein structure using GOR (Garnier Osguthorpe-Robson) server. 17. Prediction of tertiary protein structure using SWISS-MODEL Server 18. Validation of the predicted structure using PROCHECK server 19. Molecular visualization of proteins using RASMOL. 20. Docking of small molecule with protein structure using Hex software. 21. Docking of two proteins using PatchDock (Protein-Protein docking) tool. 22. Retrieval of E.Coli glycolytic pathway from KEGG 	15

<p style="text-align: center;">B</p>	<p>(B) Immunology - practical</p> <ol style="list-style-type: none"> 1. Identification of various immune cells from human peripheral blood. 2. Lymphocyte separation and identification 3. Determination of lymphocyte viability by trypan blue method 4. WBC counting 5. Preparation of serum and plasma 6. Electrophoretic profile of human serum in native PAGE 7. Preparation of cellular antigen – human RBC 8. Preparation of antigen-adjuvant mixture for production of polyclonal antibody 9. Isolation of IgG molecule from serum 10. Immunodiagnosics: CRP 11. Immunodiagnosics: ASO 12. Immunodiagnosics: Widal 13. Immunodiagnosics: RA 14. Immunodiagnosics: Blood grouping and typing 15. Immunodiagnosics: hCG 16. ELISA 17. Radial Immunodiffusion 18. Ouchterlony Immunodiffusion 19. Immunoelectrophoresis 20. Rocket electrophoresis 21. Counter current immunoelectrophoresis. 22. Bioassays for cytokines 23. Radioimmunoassays (Demonstration) 	<p style="text-align: center;">15</p>
<p style="text-align: center;">C</p>	<p>(C) Bioprocess Technology - Practical</p> <ol style="list-style-type: none"> 1. Parts and design of fermenter 2. Solid state fermentation 3. Submerged fermentation 4. Foaming and antifoaming agents 5. Media preparation and sterilization 6. Isolation of industrially important microorganisms for microbial processes. 7. Conservation of Bacteria by Lyophilization. 8. Production and estimation of protease 9. Production and estimation of amylase. 10. Production of wine using grapes 11. Production of penicillin 12. Determination of penicillin activity 13. Citric acid production 14. Use of alginate for cell immobilization. 15. Media standardization (C:N ratio) for maximum biomass production of an industrially important microorganism. 16. Cell disruption (Sonication) 17. Aqueous Two Phase Extraction of enzymes 	<p style="text-align: center;">15</p>

Elective Paper-7
NANO BIOTECHNOLOGY

Paper – 7			
Title of the paper	NANO BIOTECHNOLOGY	Subject code: 23P3BTE07	
Category of the course	Year	Semester	Credits
Elective Paper	2 nd	3 rd	3

Learning Outcome:

The subject imparts knowledge on the fundamentals of nanoparticles. The student will be provided with a basic knowledge and understanding about the role of nanoparticles in biotechnology.

Course outcomes:

CO-1	Understand the bases for Introduction to Nanotechnology	K1
CO-2	To impart understanding on Nanoparticle based Drug Delivery.	K4
CO-3	Fabrication of nanomaterials for bone tissue grafting	K1 & K5
CO-4	Methods of Nanofabrication	K2
CO-5	Understand the application of Nanotechnology	K5

SYLLABUS | Elective Paper-7 | NANO BIOTECHNOLOGY

Unit	Content	Hours
I	Introduction to Nanotechnology- Scientific revolution, Feynman's vision, Classification of nanobiomaterials -Types of nanomaterials – nanoparticles, nanotubes, nanowires, Nanofibers, Size dependent variation in the properties of Nanomaterials, Nature's Nanophenomena.	7
II	Preparation of Nanomaterials, Top down and bottom up approaches, Biosynthesis, Nanobiomaterials- Polymer, Ceramic, Metal based Nanobiomaterials, Carbon based Nanomaterials, DNA based Nanostructures, Protein based Nanostructures, Quantum dots, Magnetic Nanoparticles, Nanofibres, Hydrogels, Films and Scaffolds.	7
III	Application of Nanomaterials in Bone substitutes and Dentistry, Food and Cosmetic applications, Bio-sensors and Lab-on-a-chip, Bio-devices and implantable devices, Bioremediation, Nanomaterials for anti-microbial coating – medical implants and paints, Application of Nanotechnology in textile industry.	7
IV	Nanomaterials for diagnosis and therapy, Implications of drug delivery, Nano-carriers for application in medicine, polymeric nanoparticles as drug carriers, Drug release mechanism, Targeted Drug Delivery using nanocarriers, Nanoparticle technologies for cancer therapy and diagnosis, Point of Care and Personalized medicine, Magnetic nanoparticles for imaging and Hyperthermia.	7
V	Nanotoxicology, Portals of Entry of the nanoparticles into the Human Body, Bio-toxicity of Nanoparticles, Nanoparticles in Mammalian systems and Health threats, Biological response and cellular interaction of implant materials and scaffolds, Risk assessment and Safety Regulation of nanoparticles.	7

Reference Books:

- Nanotechnology, S.Shanmugam, Mjp publication. 2011.
- Advanced nanomaterials, kurt E. geckeler, Hiroyuki Nishide , Wiley VHC.2010.
- Nanotechnology and tissue engineering. T.Laurencin, Lakshmi S. Nair, CRC press. 2012.
- Handbook of carbon nanomaterials. Francis D souza, Karl M. Kadish.
- World scientific publishing co. pte. ltd. 2011.
- Oded Shoseyov (Editor), Ilan Levy, 2010. NanoBioTechnology: BioInspired Devices andMaterials of the Future, Humana Press.
- Chad A. Mirkin and Christof M. Niemeyer, 2007. Nanobiotechnology II: More Concepts and Applications, Wiley-VCH.
- Challa S.S.R.Kumar (Ed). 2006. Biologicals and pharmaceutical nanomaterials, Wiley-VCHVerlag GmbH & Co, KgaA.
- K.K.K.Jain 2006. Nanobiotechnology in Molecualr Diagnostics: Current Techniques and Applications Horizon Bioscience
- Niemeyer, C.M., Mirkin, C.A. (Eds). 2004. Nanobiotechnology Concepts, Applications and Perspectives, Wiley-VCH, Weinheim.
- Andrze w. Miziolek, Shashi P.Karna, J malthew Mauro and Richard A.Vaia. 2005 Defense Applications of Nanomaterials :
- Springer Handbook of Nanotechnology- Ed. by B. Bhushan, Springer-Verlag (2004)
- The Chemistry of Nanomaterials: Synthesis, Properties and Applications, C.N.R. Rao, A.Muller, A. K. Cheetham (Eds), Wiley-VCH Verlag (2004)
- Nanomaterials for medical diagnosis and therapy, Challa Kumar, Wiley-VCH, 2007.
- Nanotechnology for cancer therapy, Mansoor M. Amiji, CRC Press, 2007.
- K.K.Jain, Nano Biotechnology, Horizons Biosciences, 2006
- Nanomaterials: An introduction to synthesis, properties and application, Dieter Vollath, Wiley VCH, 2008
- Cato T. Laurencin and Lakshmi S. Nair, Nanotechnology and Tissue Engineering The Scaffold, CRC Press taylor& Francis Group.
- Introduction to Nanoscience and Nanotechnology, Gabor .L et al, Fundamentals of Nanotechnology, Hornyak, G. Louis, Tibbals, H. F., Dutta, Joydeep, CRC Press, 2009.
- Assessing Nanoparticle Risks to Human Health, Gurusurthy Ramachandran, Elsevier, 2011.
- Nanotechnology: Environmental Health and safety, Risks, Regulation and Management, Matthew Hull and Diana Bowman, Elsevier, 2010.
- Nanotechnology: Health and Environmental Risks, Jo Anne Shatkin, CRC Press, 2013

Useful Websites:

<http://www.zyvex.com/nano> www.fda.gov/nanotechnology/ www.nature.com/nnano/

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Elective Paper-8
MOLECULAR DEVELOPMENTAL BIOLOGY

Paper – 8			
Title of the paper	MOLECULAR DEVELOPMENTAL BIOLOGY	Subject code: 23P3BTE08	
Category of the course	Year	Semester	Credits
Elective Paper	2 nd	3 rd	3

Learning Outcome:

The subject imparts knowledge on the fundamentals of developmental biology. The student will be provided with a basic knowledge and understanding about the molecular aspects of developmental biology.

Course outcomes:

CO-1	Illustrate the structure and function of developmental biology, Gametogenesis	K1, K2 & K5
CO-2	Discuss basic fertilization process of animals	K4
CO-3	Demonstrate the functions of embryonic development process	K3
CO-4	Illustrate the organ development of vertebrate animals	K2
CO-5	Demonstrate the impact of gene in developmental biology and developmental disorders	K1 & K4

SYLLABUS | Elective Paper-8 | MOLECULAR DEVELOPMENTAL BIOLOGY

Unit	Content	Hours
I	Definition and scope of developmental biology. Gametogenesis - Spermatogenesis and Oogenesis. Structure of Sperm and oocyte. Instructive and permissive interactions, competence, epithelial - mesenchymal interactions. Important signaling pathways in vertebrate development.	7
II	Fertilization - Definition, mechanism of fertilization in mammal & sea urchin. Types of fertilization. Nieuwkoop center, Molecular role of organizer.	7
III	Cleavage in Xenopus, Chick and mammals, Regulation of cleavage cycle. Morphogenetic movements, Gastrulation in Xenopus, Chick and mammals. Fate Maps	7
IV	Vertebrate Development: Formation of the neural tube, myogenesis, and hematopoiesis. Mechanism of vertebrate eye development.	7
V	Drosophila Maternal effect genes, induction at single cell level - differentiation of photoreceptors in ommatidia. Developmental disorders Spina bifida, Anencephaly, and craniorachischis, Cyclopia, Thanotrophic dysplasia.	7

Reference Books:

- Scott F.Gilbert, 2010. Developmental Biology, 9th edition, Sinauer Associates Inc.
- Subramoniam, T. 2002. Developmental Biology. 1st edition. Narosa publications.
- Richard M.Twynman, 2001 Developmental Biology. (2 nd edition), Viva Publications, NewDelhi.

Useful Websites:

sackler.tufts.edu/.../Cell-Molecular-and-Developmental-Biology www.devbio.com/

SOFT SKILL - III
OMICS DATA ANALYSIS

Paper – 1			
Title of the paper	OMICS DATA ANALYSIS	Subject code: 23P3BTSSP03	
Category of the course	Year	Semester	Credits
SOFT SKILL	2 nd	3 rd	2

Learning Outcome:

contributes to the interdisciplinary techniques required to generate, analyze, and interpret complex biologically derived datasets as part of genomics by providing students the skills and knowledge they need to use bioinformatics tools in research.

Course outcomes:

CO-1	Explain the various sequencing technologies	K3 & K5
CO-2	Understand the pre-processing of High through sequencing data	K3 & K5
CO-3	Analyze and interpret the RNA-Seq data	K3 & K4
CO-4	Analyze and understand the Transcriptome data	K3, K4 & K6
CO-5	Understand the metagenomics and analyse the data	K3, K4, K5 & K6

SYLLABUS | SOFT SKILL - III | OMICS DATA ANALYSIS

Unit	Content	Hours
I	Sequencing technologies – Sanger sequencing – Second generation sequencing – Third generation sequencing – Fourth generation sequencing	7
II	Quality control, basic alignment and pre-processing of Illumina sequencing data- Short read formats - Alignment of reads to a reference genome	7
III	RNA-seq experiments for differential gene expression - ChIP-Seq analysis of DNA regions of interest	7
IV	Transcriptomics - Experiments with DNA microarrays - Data preprocessing: Exploration, normalization, filtering - Classification and prediction from microarray data - Functional analysis and biological interpretation.	7
V	Metagenomics – Quality Control- Sequence Clustering - Taxonomic classification - Alpha Diversity - Beta Diversity - Differential Abundance – Function Predictions	7

Reference Books

- Joaquim Jaumot, Carmen Bedia, Roma Tauler, Data Analysis for Omic Sciences: Methods and Applications (1st Edition) Elsevier, 2018
- Azuaje, Francisco. Bioinformatics and biomarker discovery: "omic" data analysis for personalised medicine. Hoboken, NJ: John Wiley & Sons, 2010
- Tseng, George C., Debashis Ghosh, and Xianghong Jasmine Zhou. Integrating Omics Data. Cambridge University Press, 2015.

INTERNSHIP

Paper –			
Title of the paper	INTERNSHIP		Subject code: 23P3BTINT01
Category of the course	Year	Semester	Credits
Paper	1 st	2 nd	2

Learning Outcome:

To gain hands on training and expertise in handling sophisticated instruments and acquire in depth knowledge in their applications.

Course outcomes:

The student will learn to

CO-1	(K2) understand working principles and the techniques of various processes
CO-2	(K3) apply standard operating procedures followed in industries
CO-3	(K3) prepare to face challenges & gain confidence in the field of study.
CO-4	(K5) critically assess the utilization of sophisticated instruments and expensive consumables
CO-5	(K6) develop work ethics to be followed in a scientific laboratory

Extra disciplinary subject for other department students

GENE MANIPULATION TECHNOLOGY

Paper –			
Title of the paper	GENE MANIPULATION TECHNOLOGY	Subject code: 23P3BTED02	
Category of the course	Year	Semester	Credits
Extra disciplinary subject	1 st	2 nd	3

Learning Outcome:

After studying this course, students will be able to:

- To understand more about the science that underlies the development of genetically modified organisms and in particular how gene transfer is brought about
- To know something of the potential benefits and uncertainties associated with gene transfer and the high levels of technical ingenuity involved
- To understand more the science that underpins the development of Golden Rice and understand why the usefulness of this product has proved so contentious.

Course Outcome:

CO-1	Understand the basics of Basics of Gene Manipulation Technology	K2,K4 &K5
CO-2	Apply the knowledge to create Constructions of DNA Libraries Constructions of DNA Libraries.	K1,K3,K5
CO-3	Acquire adequate knowledge in the use of Genome Sequencing and Transcriptomics	K1,K2,K3 &K4
CO-4	Evaluate the benefits of Protein Engineering & Pharmaceutical Products	K2,K3 &K4
CO-5	Analyse the importance of Gene Cloning & Applications of Gene Cloning	K2,K3 &K4

SYLLABUS | Extra disciplinary subject | GENE MANIPULATION TECHNOLOGY

Unit	Content	Hours
I	Basics of Gene Manipulation Technology-Restriction Enzymes-Cutting and Joining Reactions-Vectors-Selection of Recombinants - Agarose Gel Electrophoresis – outhern Blotting- Hybridization-Autoradiography-PCR- Native Page- SDS-Page-2D Gel Electrophoresis- Western Blotting.	7

II	Constructions of DNA Libraries- Vectors Used In the Construction of CDNA and Genomic DNA Libraries- Chromosome Walking- Positive Selection and Subtractive Hybridization- Preparation Of (BAC/YAC Library).	7
III	Genome Sequencing and Transcriptomics- Sanger's Sequencing, Whole Genome Shot gun Sequencing-Comparative Genome Sequencing- Transcriptome Analysis- DNA Microarray- Expression of Recombinant Proteins.	7
IV	Protein Engineering & Pharmaceutical Products- SiteDirected Mutagenesis- Protein Analysis- Therapeutic Protein- Vaccines.	7
V	Applications of Gene Cloning- creating Transgenic Animals and Plants- Reporter Genes- Animal Cloning, Gene expression in plants- Biosafety and Bioethics.	7

References:

- An Introduction Gene Cloning And Manipulation- Howe.C
- Molecular Cloning: A Laboratory Manual (3- Volume Set)- Sambrook J. et al.
- T.A. Brown 1995. Gene Cloning and Introduction.
- Thiel 2002. Biotechnology Nucleic Acids to Protein: A Laboratory Project. Tata McGraw.Hill
- Desmond S. T. Nicholl, an Introduction To Genetic Engineering 3rd Edition.
- R. W. Old & S.B. Primrose, Principles Of Gene Manipulation, Fifth Edition, Blackwell Science
- Genetic Engineering Principles And Methods By Setlow, Jane K. (VOLUME 24)
- Bernard R Glick and Jack .J. Pasternack, 1994, Molecular Biotechnology, ASM Press.

Core Paper-13
RESEARCH METHODOLOGY

Paper – 13			
Title of the paper	RESEARCH METHODOLOGY	Subject code: 23P4BT10	
Category of the course	Year	Semester	Credits
Core Paper	2 nd	4 th	4

Learning Outcome:

The paper imparts a thorough knowledge on the basics of academic research. The student will get to understand the core concepts of methodologies & ethics to pursue research.

Course outcomes:

CO-1	Understand the bases for research	K1
CO-2	To know about research proposal and dissertation writing.	K2 & K6
CO-3	To know about Statistical application in research	K3
CO-4	To know about office tools used in research	K1 & K4
CO-5	To know about search engines.	K1 & K2

SYLLABUS | Core Paper-13 | RESEARCH METHODOLOGY

Unit	Content	Hours
I	Research Methodology - An Introduction: Meaning of Research, Objectives of Research, Types of Research, Research Approaches, Importance of knowing how research is done, Research Process, Criteria of good research. Defining the Research Problem; Research Design; Sampling Design; Methods of Data Collection; Processing and Analysis of Data; Sampling Fundamentals.	10
II	Review of literature, Writing the Research Report (Thesis and publications): Components of research report - Title, Authors, Addresses, Abstract, Keywords, Introduction, Materials and Methods, Results, Discussion, Summary, Acknowledgements and Bibliography.	10
III	Standard Deviation- T test. Analysis of Variance components (ANOVA) for fixed effect model; Total, treatment and error of squares, Degrees of freedom, Confidence interval; ANOVA for random effects model, Estimation of variance components, Model adequacy checking. Two factor Factorial Design, Basic definitions and principles, main effect and interaction, response surface and contour plots, General arrangement for a two factor factorial design.	10
IV	Spreadsheet Tool: Introduction to spreadsheet application, features and functions, Using formulas and functions, Data storing, Features for Statistical data analysis, Generating charts/ graph and other features. Presentation Tool: Introduction to presentation tool, features and functions, Creating presentation, Customizing presentation, Showing presentation. Tools used may be Microsoft Power Point, Open Office or similar tool.	10

v	Web Search: Introduction to Internet, Use of Internet and WWW, Using search engine like Google, Yahoo, Pubmed, Science direct, Scopus etc, and Using advanced search techniques	10
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Reference Books:

- Montgomery, Douglas C. (2007), 5/e, Design and Analysis of Experiments, (Wiley India).
- Montgomery, Douglas C. & Runger, George C. (2007), 3/e, Applied Statistics & Probability for Engineers (Wiley India).
- Kothari C.K. (2004), 2/e, Research Methodology- Methods and Techniques (New Age International, New Delhi).
- Krishnaswamy, K.N., Sivakumar, Appa Iyer and Mathiranjani M. (2006), Management Research Methodology; Integration of Principles, Methods and Techniques (Pearson Education, New Delhi).
- The complete reference Office Xp – Stephan L. Nelson, Gujulia Kelly (TMH).
- Basic Computer Science and Communication Engineering – R. Rajaram (SCITECH).

Useful Websites

- www.ask.com/Methodology+Research
- www.qmethod.org/

Elective Paper-9 STEM CELL BIOLOGY

Paper – 9			
Title of the paper	STEM CELL BIOLOGY	Subject code: 23P4BTE09	
Category of the course	Year	Semester	Credits
Elective Paper	2 nd	4 th	3

Learning Outcome:

The subject imparts knowledge on the fundamentals of stem cells. The student will be provided with a basic knowledge and understanding about the application of stem cell biology.

Course Outcomes:

At the end of the Course, the Student will be able to:

CO1	To understand the major discoveries of stem cell biology	K1
CO2	To provide basic knowledge about stem cell niche and functions	K1 & K2
CO3	To enlighten the students on Stem cell isolation and culture techniques	K3, K4
CO4	To update the knowledge on Stem cell cycle	K3, K3 & K5
CO5	To assess and appraise Applications of Embryonic stem cells.	K3, K4 & K5

SYLLABUS | Elective Paper-9 | STEM CELL BIOLOGY

Unit	Content	Hours
I	Stem cells - Definition, Characterization, Pluripotency, Self-renewal and differentiation. Types of stem cells- Embryonic stem cells, Adult stem cells and mesenchymal stem Cells, Adipose stem cells.	7
II	Stem cell niche, Niche specification - Drosophila germ line stem cells. Receptors, genes and markers of stem cells.	7
III	Stem cell isolation and culture techniques. Characterization of stem cells	7
IV	Stem cell cycle. Chromatin modification and transcriptional regulation, chromatin modifying factors, Chromosomal inactivation. JAK -STAT pathway, Ras/Raf pathway, PI3K cell signaling, p53 check points, Role of LIF pathway in cell cycle control	7
V	Applications of Embryonic stem cells, Bone marrow stem cells, Adipose derived stem cells and Hematopoietic stem cells. Ethics in human stem cell research.	7

Reference Books:

- Stem Cell Biology, Daniel Marshak, Richard L. Gardener and David Gottlieb, Cold SpringHarbour Laboratory Press
- Stem cell biology and gene therapy, Booth C., Cell Biology International, Academic Press
- Stem Cell and Gene-Based Therapy: Frontiers in Regenerative Medicine, Alexander Battler, Jonathan Leo, Springer, STEM CELL TECHNOLOGY Syllabus - Semester First References:
- Stem Cell Biology and Gene Therapy. Quesenberry PJ, Stein GS, eds. (£65.00.) Wiley, 1998.
- Progress in gene therapy, Volume 2, Pioneering stem cell/gene therapy trials, Roger Bertolotti, Keiya Ozawa and H. Kirk Hammond, VSP international science publishers
- Stem Cells Handbook: Stewart Sell, Humana Press; Totowa NJ, USA; Oct. 2003,
- Human Embryonic Stem Cells: The Practical Handbook by Stephen Sullivan and Chad ACowan

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Elective Paper-10

BIOETHICS, BIOSAFETY, CLINICAL TRIALS, IPR & ENTREPRENEURSHIP

Paper – 10			
Title of the paper	BIOETHICS, BIOSAFETY, CLINICAL TRIALS, IPR & ENTREPRENEURSHIP	Subject code: 23P4BTE10	
Category of the course	Year	Semester	Credits
Elective Paper	2 nd	4 th	3

Learning Outcome:

This course provides the guidelines and regulations governing research; evaluate ethical conduct and social responsibilities; to adhere to safe working practices; to appreciate the need for protection of human subjects; to recognize the potential harms in research and show sensitivity to cultural and ethical issues; to create a general awareness about IPR.

Course Outcome:

CO-1	Understand the basics of biosafety and bioethics and its impact on biological sciences and the importance of human life.	K2,K3 & K4
CO-2	Apply the knowledge to recognize the importance of biosafety guidelines and good clinical practices.	K3, K4 & K5
CO-3	Acquire adequate knowledge in the use of genetically modified organisms and its effect on human health.	K3,K4 & K5
CO-4	Evaluate the benefits of GM technology and importance of IPR	K4, K5 & K6
CO-5	Analyse the importance of protection of new knowledge and innovations and its role in business and entrepreneurship	K4,K5 & K6

SYLLABUS | Elective Paper-10 | BIOETHICS, BIOSAFETY, CLINICAL TRIALS, IPR & ENTREPRENEURSHIP

Unit	Content	Hours
I	Introduction to Bioethics Need for bioethics in social and cultural issues. Bioethics & GMO's Issues and concerns pertaining to Genetically modified foods & food crops, Organisms and their possible health implications and mixing up with the gene-pool. Bioethics in Medicine Protocols of ethical concerns related to prenatal diagnosis, gene therapy, Organ transplantation, Xenotransplantation, Containment facilities for genetic engineering experiments, regulations on field experiments and release of GMO's labeling of GM foods.	10

II	Clinical trials –Regulations. Bioethics & Cloning Permissions and Procedures in Animal Cloning, Human cloning, Risks and hopes. Bioethics in Research Stem cell research, Human Genome Project, Use of animals in research, human volunteers for Clinical research, Studies on Ethnic races. Ethics in patient care, Informed consent.	10
III	Biosafety – Biological risk assessment. Biological agents and Hazard groups. Criteria in biological risk assessment. Guidelines for categorization of genetically modified plants for field test. Regulation, national and international guidelines of Biosafety, rDNA guidelines, Regulatory requirements for drugs and Biologics GLP. Biosafety levels. Safety equipments and Biological Safety cabinets.	10
IV	IPR: Introduction to Intellectual Property rights, Patenting – Factors for patentability – Novelty, Non-obviousness, Marketability. Procedures for registration of Patents. Copyright works, ownership, transfer and duration of Copyright. Renewal and Termination of Copyright. Industrial Designs - Need for Protection of Industrial Designs. Procedure for obtaining Design Protection. Infringement, Right of Goodwill, Passing Off. Trademarks - Introduction to Trademarks. Need for Protection of Trademarks. Classification of Trademarks. Indian Trademarks Law. Procedural Requirements of Protection of Trademarks.	10
V	Geographical Indications - Indication of Source and Geographical Indication. Procedure for Registration, Duration of Protection and Renewal. Infringement, Penalties and Remedies. Layout- Designs of Integrated Circuits: Conditions and Procedure for Registration. Duration and Effect of Registration Protection of Plant variety and Plant breeders' rights in India. Protection of traditional knowledge, Bioprospecting and biopiracy. India's new IP Policy (2016), Govt of India's steps to promote IPR. Career opportunities in IP. Entrepreneurship: Definition and importance, Characteristics and functions of an entrepreneur.	10

Reference Books:

- “Bioethics & Biosafety” by Sateesh MK, IK International publications, 2008
- USPTO Web Patent Databases at: www.uspto.gov/patft
- Government of India's Patents Website: patinfo.nic.in
- Intellectual property India: www.ipindia.nic.in
- “Indian Patent Law : Legal and Business Implications” by Ajit Parulekar, Sarita D'Souza Macmillan India publication, 2006
- “Agriculture and Intellectual Property Rights”, edited by: Santaniello, V., Evenson, R.E., Zilberman, D. and Carlson, G.A. University Press publication, 2003
- Research papers and Reports provided from time to time
- Ganguli P, (2001), Intellectual Property Rights, Tata McGraw Hill.
- Ramesh Chandra, (2004), Issues Of Intellectual Property Rights, Isha Books.
- Erbisch F.h., Maredia K.M, (2000), Intellectual Property Rights In Agricultural Biotechnology, Universities Press.
- Shiv Sahai Singh, (2004), Law Of Intellectual Property Rights, Deep & Deep Publications (p)Ltd.
- Subbian A, Bhaskaran S, (2007), Intellectual Property Rights: Heritage, Science And Society Int. Treaties, Deep & Deep Publications.
- Elad Harison (2008). Intellectual Property Rights, Innovation and Software Technologies. Edward Elgar Publishing Limited, UK.

Core Paper-14
DISSERTATION

Paper – 14			
Title of the paper	DISSERTATION		Subject code: 23P4BTPR01
Category of the course	Year	Semester	Credits
Core Paper	2 nd	4 th	8

Learning Outcome:

The paper imparts a thorough knowledge on the basics of academic research. The student will get to understand the core concepts of pursuing research.

SOFT SKILL - IV
ARTIFICIAL INTELLIGENCE/ML

Paper – 1			
Title of the paper	ARTIFICIAL INTELLIGENCE/ML	Subject code: 23P4BTSSP04	
Category of the course	Year	Semester	Credits
SOFT SKILL	2 nd	4 th	2

Learning Outcome:

To impart the insight into the optimal AI tools for this industry and explore how they can be leveraged for early drug discovery.

Course outcomes:

CO-1	Understand the handling of big data	K3 & K5
CO-2	Classify the algorithms and its applications in cancer classifications	K3 & K5
CO-3	Applying the regression to predict the CVD	K3 & K4
CO-4	Using decision trees and Random Forest algorithms to study drug combination	K3, K4 & K6
CO-5	Implying the machine learning to diagnose the breast cancer	K3,K4, K5 & K6

SYLLABUS | SOFT SKILL - IV | ARTIFICIAL INTELLIGENCE/ML

Unit	Content	Hours
I	Introduction to AI & Machine-learning (ML) - Exploratory data analysis - Plotting and data visualization - Handling big-data sets	7
II	Hypothesis testing - Unsupervised learning and clustering - Classifying cancer sub-types using clustering	7
III	Regression (Linear, Logistic, Lasso, Stepwise, PLS) - Predicting cardiovascular risk using regression - Model validation.	7
IV	Decision trees - Predicting diabetic retinopathy using decision trees; Random Forests (RF), Identifying synergistic drug combinations using RF.	7
V	Neural Networks (NN)/ Deep Learning - Diagnosing breast cancer from biopsy images using NN & Transfer Learning	7

Reference Books

- John Paul Mueller, Artificial Intelligence For Dummies 1st Edition, For Dummies
- Stuart Russell, Artificial Intelligence: A Modern Approach, (3rd Edition), Pearson