

M.SC.,
BIO-TECHONOLOGY

SYLLABUS

FROM THE ACADMIC YEAR

2023-2024

PERIYAR UNIVERSITY, SALEM-636011

TANSICHE REGULATIONS ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION	
Programme	M.Sc. BIO-TECHNOLOGY
Programme Code	
Duration	PG – 2 YEARS
Programme Outcomes (Pos)	<p>PO1: Problem Solving Skill Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context.</p> <p>PO2: Decision Making Skill Foster analytical and critical thinking abilities for data-based decision-making.</p> <p>PO3: Ethical Value Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities.</p> <p>PO4: Communication Skill Ability to develop communication, managerial and interpersonal skills.</p> <p>PO5: Individual and Team Leadership Skill Capability to lead themselves and the team to achieve organizational goals.</p> <p>PO6: Employability Skill Inculcate contemporary business practices to enhance employability skills in the competitive environment.</p> <p>PO7: Entrepreneurial Skill Equip with skills and competencies to become an entrepreneur.</p> <p>PO8: Contribution to Society Succeed in career endeavors and contribute significantly to society.</p>

	<p>PO 9 Multicultural competence</p> <p>Possess knowledge of the values and beliefs of multiple cultures and a global perspective.</p> <p>PO 10: Moral and ethical awareness/reasoning</p> <p>Ability to embrace moral/ethical values in conducting one’s life.</p>
<p>Programme Specific Outcomes (PSOs)</p>	<p>PSO1 – Placement</p> <p>To prepare the students who will demonstrate respectful engagement with others’ ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.</p> <p>PSO 2 - Entrepreneur</p> <p>To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.</p> <p>PSO3 – Research and Development</p> <p>Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development.</p> <p>PSO4 – Contribution to Business World</p> <p>To produce employable, ethical and innovative professionals to sustain in the dynamic business world.</p> <p>PSO 5 – Contribution to the Society</p> <p>To contribute to the development of the society by collaborating with stakeholders for mutual benefit.</p>

Template for P.G., Programmes

Semester-I	Credit	Hours	Semester-II	Credit	Hours	Semester-III	Credit	Hours	Semester-IV	Credit	Hours
1.1. Core-I	4	6	2.1. Core-IV	4	5	3.1. Core-VII	5	6	4.1. Core-X	5	6
1.2 Core-II	4	6	2.2 Core-V	4	5	3.2 Core-VIII	5	5	4.2 Core-XI	5	6
1.3 Core – III	4	6	2.3 Core – VI	4	5	3.3 Core – IX	5	5	4.3 Project with viva voce	7	10
1.4 Core Practical I	4	6	2.4 Core Practical II	4	6	3.4 /Core Practical III	4	6	4.4 Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	3	4
1.5 Discipline Centric Elective -I	2	3	2.5 Discipline Centric Elective – III	2	3	3.5 Discipline Centric Elective - V	3	3	4.5 Non Major Elective [NME] –III	2	4
1.6 Generic Elective-II:	2	3	2.6 Generic Elective -IV:	2	3	3.6 Human Rights	2	2	4.6 Extension Activity	1	
			2.7 Non Major Elective [NME] - I	2	3	3.7 Non Major Elective [NME] - II	2	3			
						3.8 Internship/ Industrial	2	-			

						Activity					
	20	30		22	30		28	30		23	30
Total Credit Points -93											

**Choice Based Credit System (CBCS), Learning Outcomes Based Curriculum Framework
(LOCF) Guideline Based Credits and Hours Distribution System
for all Post – Graduate Courses including Lab Hours**

First Year – Semester – I

Part	List of Courses	Credits	No. of Hours
	Core – I	4	6
	Core – II	4	6
	Core – III	4	6
	Core practical I	4	6
	Elective – I	2	3
	Elective – II	2	3
		20	30

Semester-II

Part	List of Courses	Credits	No. of Hours
	Core – IV	4	5
	Core – V	4	5
	Core – VI	4	5
	Core practical II	4	6
	Elective – III	2	3
	Elective – IV	2	3
	Non Major Elective [NME] – I	2	3
		22	30

Second Year – Semester – III

Part	List of Courses	Credits	No. of Hours
	Core – VII	5	6
	Core – VIII	5	5
	Core – IX	5	5
	Core practical III (Industry Module)	4	6
	Elective – V	3	3
	Human Rights	2	2
	Non Major Elective [NME] – II	2	3
	Internship / Industrial Activity [Credits]	2	-
		28	30

Semester-IV

Part	List of Courses	Credits	No. of Hours
	Core – X	5	6
	Core – XI	5	6
	Project with VIVA VOCE	7	10
	Elective – VI (Industry Entrepreneurship)	3	4
	Non Major Elective [NME] – III	2	4
	Extension Activity	1	-
		23	30

Total 93 Credits for PG Courses

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.

3. COURSE OF STUDY AND SCHEME OF EXAMINATIONS:

FIRST SEMESTER

S .No.	Course Components	Name of Course	Inst. Hours	Credits	Exam HRS	Max. Marks	
						CIA	External
1	Core Paper-1	Biochemistry	6	4	3	25	75
2	Core Paper-2	Molecular Genetics	6	4	3	25	75
3	Core Paper-3	Molecular Cell Biology	6	4	3	25	75
4	Core Practical I	Practical – I (A) Biochemistry (B) Molecular Genetics (C) Molecular Cell biology	6	4	6	40	60
5	Elective –I	Bioinstrumentation /Phytochemistry	3	2	3	25	75
6	Elective-II	Enzymology/Food technology	3	2	3	25	75
Total Credits : 20							

SECOND SEMESTER

S. No.	Course Components	Name of Course	Inst. Hours	Credits	Exam HRS	Max. Marks	
						CIA	External
7	Core Paper-4	Microbiology	5	4	3	25	75
8	Core Paper-5	Plant and Animal Biotechnology	5	4	3	25	75
9	Core Paper-6	Genetic Engineering	5	4	3	25	75
10	Core Practical II	Practical – II (A) Microbiology (B) Plant and Animal Biotechnology (C) Genetic Engineering	6	4	6	40	60
11	Elective Paper-3	Regulatory affairs and Industrial standards / Pharmaceutical Biotechnology	3	2	3	25	75
12	Elective Paper-4	Environmental Biotechnology /Marine Biotechnology	3	2	3	25	75
13	NME I		3	2	3	25	75

		Total	30	22			
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- **NME to be opted from the course offered from other department paper**

THIRD SEMESTER

S. No.	Course Components	Name of Course	Inst. Hours	Credits	Exam HRS	Max. Marks	
						CIA	External
14	Core Paper-7	Bioinformatics	6	5	3	25	75
15	Core Paper-8	Immunology	5	5	3	25	75
16	Core Paper-9	Bioprocess Technology	5	5	3	25	75
17	Core Practical-III	Practical – III (A) Bioinformatics (B) Immunology (C) Bioprocess Technology	6	4	6	40	60
18	Elective Paper-5	Nano Biotechnology / Molecular Developmental Biology	3	3	3	25	75
19	Human Rights	Human Rights	2	2	3	25	75
20	NME II		3	2	3	25	75
21	Internship / Industrial Activity	Internship in Industries to Biotechnology Field (food / clinical trial/ dairy/ aqua sciences, pharmaceutical)CSIR/DBT/DST research laboratories	-	2	-	-	100
		Total	30	28			

FOURTH SEMESTER

S. No.	Course Components	Name of Course	Inst. Hours	Credits	Exam HRS	Max. Marks	
						CIA	External
22	Core Paper-10	Research Methodology	6	5	3	25	75
23	Core Paper-11	Biostatistics	6	5	3	25	75
24	Project Work & <i>Vive Voce</i>	Dissertation	10	7	-	60	240 (40-work book, 150 Dissertation + 50- Viva)
25	Elective Paper-6	Stem Cell Biology/ Bioethics, Biosafety, Clinical Trials, Ipr &	4	3	3	25	75

		Entrepreneurship					
26	NME III		4	2	3	25	75
27	Extension Activity		-	1			
		Total	30	23			

Biotechnology Department Courses Offering NME course

Semester	NME course	Credit	Inst. Hours
II	Gene Manipulation Technology	2	3
III	Tissue Engineering/ Bio Entrepreneurship	2	3
IV	Ecotechnology	2	4

Core Paper-1
BIOCHEMISTRY

Paper – 1			
Title of the paper	BIOCHEMISTRY	Subject code: 23PBTCT01	
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.
CO-2	To provide basic knowledge about lipid metabolism and related significance.
CO-3	To enlighten the students on Bio-energetics and Biological oxidation pathways.
CO-4	To update the knowledge on Amino acids and Protein.
CO-5	To assess and appraise the role of Nucleic acids.

SYLLABUS Core Paper-1 BIOCHEMISTRY				
Unit	Content	Hours	COs	Cognitive level
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. Carbohydrates: Nomenclature, classification, structure, chemical and physical properties of carbohydrates. Metabolisms: glycogenesis, glycogenolysis, gluconeogenesis, pentose phosphate pathway, glycolysis, citric acid cycle, cori’s cycle, glyoxalate pathway	10	CO1	K1&k2
II	Lipids: Nomenclature, classification, structure, chemical and physical properties of fatty acids. Metabolisms: biosynthesis of fatty acids, triglycerols,	10	CO2	K1,K2 & K3

	phospholipids, glycol lipids. Cholesterol biosynthesis, bile acids and salt formation. Oxidation of fatty acids, β -oxidation, alpha and gamma oxidation.			
III	Bioenergetics – Concept of energy, Principle of thermodynamics. Laws of thermodynamics, Biological oxidation: Electron transport chain, oxidative phosphorylation. Photosynthesis (Oxygenic and Anoxygenic), Hormonal regulation of fatty acids and carbohydrates metabolisms.	10	CO3	K1,K2 & K3
IV	Amino acids and Protein: Nomenclature, Classification, structure, chemical and physical properties. Metabolisms: Biosynthesis of amino acids. Degradation of proteins, nitrogen metabolisms and carbon skeleton of amino acids, Urea cycle. Over all in born errors of metabolisms.	10	CO4	K1,K2 & K3
V	Nucleic acids: Nomenclature, Classification, structure, chemical and physical properties. <i>De novo</i> and salvage synthesis of purine and pyrimidine bases, nucleosides and nucleotides. Catabolisms of purine and pyrimidine bases. Synthetic analogues of nitrogenous bases.	10	CO5	K1,K2 & K3

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, LubertStryer, 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 – 2			
Title of the paper	MOLECULAR GENETICS	Subject code: 23PBTCT02	
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.
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.
CO-3-	Make the students understand different range of DNA damage and range of their tools for their detection an.
CO-4	Learn the concepts of the transposons and their applications.
CO-5	Detects the Allele frequencies and genotype frequencies in populations and describe the concepts behind the theory of evolution

SYLLABUS | Core Paper-2 | MOLECULAR GENETICS

Unit	Content	Hours	COs	Cognitive level
I	Genes and chromosomes, Co-linearity 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).	10	CO1	K1,K2 & K3

II	Gene expression and regulation in prokaryotes and eukaryotes. Mutation: Spontaneous and virus induced mutation, Radiation induced mutation. Chromosomal Abnormalities and associated genetic diseases, Techniques in the study of chromosomes and their applications, Recombination – models	10	CO2	K1,K2 &K3
III	DNA Damage and Repair-Internal and external agents causing DNA damages, Mechanisms of DNA damage (transition, transversion, frameshift, nonsense mutations), Repair mechanisms (Photo reactivation, excision repair, mismatch repair, post replication repair, SOS repair), Transposons and its mechanisms, control consequences and application by simple and complex elements.	10	CO3	K1,K2 &K3
IV	Allele and genotype frequencies, Random mating population, Hardy-Weinberg principle, complications of dominance, special cases of random mating – multiple alleles, autosomal and X-linked frequencies. 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	CO4	K1 &K2
V	Extra chromosomal heredity: Biology of Plasmids, their discovery, structure and types. Replication and partitioning, Incompatibility and copy number control-natural and artificial plasmid transfer and their applications- Genomics and Modern methodologies in understanding genome -Human Genome Project, DNA markers -VNTR, STR, microsatellite, SNP and their detection techniques.	10	CO5	K1,K2 & K3

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

Core Paper-3

MOLECULAR CELL BIOLOGY

Paper – 3			
Title of the paper	MOLECULAR CELL BIOLOGY	Subject code: 23PBTCT03	
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 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.
CO-2	Identify the structures and purposes of basic components in prokaryotic and eukaryotic cells and their molecular mechanism
CO-3-	Demonstrate knowledge and understanding of the principles and basic mechanisms of nuclear envelope and its functions.
CO-4	Understand the metabolic pathways and the process of transmission of extracellular signals
CO-5	Demonstrate the operation of various microscopes and microtomy in the laboratory

SYLLABUS | Core Paper-3 | MOLECULAR CELL BIOLOGY

Unit	Content	Hours	COs	Cognitive level
I	Introduction to cell Biology- Basic properties of cells- Cellular dimension-Size of cells and their composition-Cell origin and Evolution (Endosymbiotic theory)-Microscopy types and its Application in cell biology, Organelles of the eukaryotic cell and its functions; Biomembranes - structural organization and the transport systems (Passive, Active and Bulk transport), Cell-Cell adhesion- Cell junctions, Extra cellular matrix	10	CO1	K1,K2 &K3

	components and its role.			
II	Genome organization in Eukaryotes, DNA Replication, Transcription, and 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, protein glycosylation – mechanism and regulation of vesicular transport – golgi and post-golgi sorting and processing – receptor mediated endocytosis; Synthesis of membrane lipids.	10	CO2	K1,K2 &K3
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	CO3	K1,K2 &K3
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	CO4	K1, K2 & K3
V	Cancer Biology: Multistage cancer development Mitogens, carcinogens, oncogenes and proto-oncogenes, tumor suppressor genes-Rb, p 53, Apoptosis and significance of apoptosis.	10	CO5	K1,K2 & K3

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- 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.

Core Practical I

PRACTICAL-I

(Biochemistry, Molecular Genetics & Molecular Cell biology)

Practical I			
Title of the paper	PRACTICAL-I (Biochemistry, Molecular Genetics & Molecular Cell biology)	Subject code: 23PBTCP01	
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
CO 2	(K3) study the methods of estimation of biomolecules
CO 3	(K4) isolate & Analyze DNA, RNA & protein
CO 4	(K5) critically analyze the isolated biomolecules
CO 5	(K5) evaluate the quality and purity of DNA, RNA & Protein

SYLLABUS Core Practical – I PRACTICAL-I				
Unit	Content	Hours	COs	Cognitive level
A	<p>(A) Biochemistry – Practical</p> <p>Major</p> <ol style="list-style-type: none"> 1. Extraction of Proteins from biological materials 2. Protein separation methods:-Ammonium sulphate Precipitation, 3. SDS PAGE 4. Estimation of Proteins by Lowry's method 5. Estimation of RNA by orcinol method 6. Estimation of DNA by diphenylamine method 7. Estimation of Carbohydrate by Anthrone method <p>Minor Experiments</p> <ol style="list-style-type: none"> 1. Preparation of biological buffer - phosphate buffer 2. Separation of amino acids by Paper 	15	CO1 CO2 CO3 CO4 CO5	K3 & K4

	<p>Chromatography</p> <p>3. Separation of sugars by Thin layer Chromatography</p> <p>Demo Experiments</p> <p>1. Gel permeation chromatography, 2. Affinity chromatography, 3. Ion. Exchange chromatography 4. Western blotting 5. PCR</p>			
B	<p>(B) Molecular Genetics – Practical</p> <p>Major</p> <p>1. Agarose gel electrophoresis of DNA 2. Isolation of RNA 3. Restriction digestion of DNA 4. Giant chromosome studies in Chironomous larvae</p> <p>5. Cell counting and cell viability; 6. Meiotic study in flower bud sand cockroach or grasshopper. 7. Preparation of single cell suspension from spleen and thymus.</p> <p>Minor</p> <p>1. Isolation of DNA from bacteria. 2. Isolation of DNA from plants. 3. Plasmid DNA isolation. 4. Preparation of metaphase chromosomes form blood. 9. Histochemical staining to localize carbohydrates 11. Histochemical staining to localize lipids.</p>	15	CO1 CO2 CO3 CO4 CO5	K3,K4 &K5
C	<p>Demo Experiments</p> <p>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. Preparation of tissue culture medium and membrane filtration 7. Embryonic development and stem cells (serpulidpolychaete Hydroideselegans/chick/ frog)</p>	15	CO1 CO2 CO3 CO4 CO5	K3,K4 & K5

Elective Paper-I
BIOINSTRUMENTATION

Elective Paper – A 1			
Title of the paper	BIOINSTRUMENTATION	Subject code: 23PBTMEA1	
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
CO-2	Impart understanding on centrifugation instruments and techniques
CO-3-	Separation of Biomolecules
CO-4	Analytical methods on Spectroscopic Analysis
CO-5	Understand the application and Detection on Bioinstrumentation

SYLLABUS Elective Paper-1A BIOINSTRUMENTATION				
Unit	Content	Hours	COs	Cognitive level
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	CO1	K1 & K2
II	Centrifugation: Principle and Applications of various types of centrifuges, Chromatography Techniques: Principle and Application of Paper Chromatography, TLC, Gel Filtration Chromatography, Ion Exchange Chromatography, Affinity Chromatography, GC & HPLC.	7	CO2	K1, K2, K3
III	Electrophoretic Techniques: Principle and Application of Agarose Gel Electrophoresis, 2D-gel Electrophoresis, PAGE- NATIVE & SDS PAGE, Iso-electric Focusing, High resolution Electrophoresis,	7	CO3	K1, K2 & K3

	Immuno Electrophoresis (Immunofixation EP,), ELISA, RIA, Southern, Northern and Western Blotting. Electro blotting, PCR and RT-PCR, Microarray (DNA, Proteins)			
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.	7	CO4	K1,K2 & K3
V	Radio-isotopic Techniques: Introduction to Radioisotopes, Uses and their Biological Applications, Principles and Applications of GM Counter, Solid and Liquid Scintillation Counter, Autoradiography, RIA, Radiation Dosimetry, Health effects of Radiations.	7	CO5	K1,K2 & K3

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 el 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-1

PHYTOCHEMISTRY

ELECTIVE PAPER – B 1			
Title of the paper	PHYTOCHEMISTRY	Subject code: 23PBTMEB1	
Category of the course	Year	Semester	Credits
Elective Paper	1 st	1 st	3

Learning Outcome:

Course outcomes:

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

CO-1	To study the history and scope of plant derived drugs
CO-2	To study the characteristic and importance of major phytochemicals
CO-3	To know the extraction, purification and characterization of phytochemicals
CO-4	To know the process for development of plant drugs Course outcome
CO-5	Knowledge on the history and scope of plant derived drugs

SYLLABUS | Elective Paper-1B | PHYTOCHEMISTRY

Unit	Content	Hours	COs	Cognitive level
I	Secondary metabolites and classification Phytochemistry - Definition, history, principal, secondary metabolites: Definition, classification, occurrence and distribution in plants, their function, chemical constituents. Alkaloids, Terpenoids, flavonoids, steroids coumarins, volatile oils and other related compounds.	10	CO1	K1&K2
II	Biosynthetic pathway of phytochemical and its applications Biosynthetic pathway of secondary metabolites: Shikimic acid pathway, Acetate-Mevalonate pathway, pathway for commercially important phytochemicals: Ephedrine, taxol and Vinca Alkaloids. Application of phytochemicals in medicine, pharmaceuticals, food, flavor and cosmetic industries.	10	CO2	K1,K2&K3
III	Biologically active secondary metabolites Biological source, uses and chemical constituents of bio active compounds: carbohydrate and derived	10	CO3	K1,K2&K3

	compound – gums (Acacia gum, Indian gum and gum Arabic, isabgol), pectin – Ghatti gum). Glycosides (Alove, Digitalis, Olender, Dioscorea, Ginseng, Vanilla, Shatavari). Cyanogenic glycosides – (Amygdalin). Alkaloids (Belladonna, Ergot; Rauwolfia, Cinchona, Opium, Holarrhenna, Ashwagandha, Cocoa). Tannins (Malbar Kino, Arjuna, Black catechu). Volatile oil (Peppermint, Pudina, Sandalwood oil, Chinese cinnamon, Citronella oil, Clove, Gaultheria oil. Resins (Indian cannabis, Ginger). Lipid – (Almond oil, Rice bran oil, Safflower oil). Enzymes and protein drugs - Bromelin, Papain, Malt extract, Gelatinum, Ficin).			
IV	Extraction of Phytochemicals Extraction methods of phytochemical: organic solvent extraction, extraction with supercritical gas, steam distillation, soxhlet extraction, Purification, concentration, lyophilization. Qualitative screening of phytochemical compounds. Quantification 52 compound: TLC, HPLC, GC-MS, LC-MS .Characterization of phytochemical spectroscopic analysis UV-VIS, IR, NMR and MASS Spectra, FTIR.	10	C04	K1,K2&K3
V	Quantification of Phtochemicals Quantification of Bioactive compounds: TLC, HPLC, GC-MS, LC-MS .Characterization of phytochemical spectroscopic analysis UV-VIS, IR, NMR and MASS Spectra, FTIR.	10	CO5	K1,K2&K3
References Books				
<ul style="list-style-type: none"> • Phytochemical Drug Discovery for Central Nervous System Disorders, Biochemistry and Therapeutic Effects, <u>Chukwuebuka Egbuna, Mithun Rudrapal</u> • Recent Frontiers of Phytochemicals, Applications in Food, Pharmacy, Cosmetics and Biotechnology, <u>Siddhartha Pati, Tanmay Sarkar, Dibyajit Lahiri</u> 				

Elective Paper-II

ENZYMOLGY

Elective Paper – A 2			
Title of the paper	ENZYMOLGY		Subject code: 23PBTMEA2
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
CO-2	(K3) Classify and Cognize the native and immobilized enzyme
CO-3	(K4) Examine the equations of steady state kinetics
CO-4	(K5) Assess extraction and downstream processing of enzymes
CO-5	(K6) Compile the uses of enzymes and design enzymes for Industrial and Clinical application

SYLLABUS Elective Paper-2A ENZYMOLGY				
Unit	Content	Hours	COs	Cognitive level
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, liquid-liquid extraction methods	7	CO1 CO5	K3 & K5
II	Kinetics of catalyzed reaction : Single substrate reactions, bisubstrate reactions, concept of Michaelis – Menten and Limitations. Line weaver burk plot, Hanes wolf equation, Eadie hoofstee equation ,Inhibition of enzyme activity	7	CO1 CO2 CO5	K3 & K5
III	Enzyme catalysis: enzyme specificity and the concept of active site, determination of active site. Mechanism of catalysis: Proximity and orientation effects, general acid-base catalysis, nucleophilic and electrophilic	7	CO1 CO3	K3 & K4

	attacks, metal ion catalysis,			
IV	Theories and mechanism of Enzyme catalysis.- Mechanism of enzymes action- lysozyme, chymotrypsin, carboxypeptidase and DNA polymerase. Multienzymes system, Mechanism of action and regulation of pyruvate dehydrogenase and fatty acid synthetase complex	7	CO1 CO4	K3, K4 & K6
V	Coenzyme action and Enzyme regulation: Allosteric enzymes, sigmoidal kinetics and their physiological significance, Reversible and irreversible covalent modification of enzymes. Immobilized enzymes and their industrial applications. Clinical and industrial applications of enzymes, Enzyme Engineering.	7	CO1 CO5	K3,K4, K5 & K6

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>

Elective Paper-II
FOOD TECHNOLOGY

Elective Paper – B 2			
Title of the paper	FOOD TECHNOLOGY	Subject code: 23PBTMEB2	
Category of the course	Year	Semester	Credits
Elective Paper	1 st	1 st	3

Learning Outcome:

The subject imparts knowledge on the fundamentals of food preservatives and additives. 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 food preservative techniques
CO-2	(K3) Classify and summarize the detailed methodologies of food preservative techniques
CO-3	(K4) Examine the packing system of food and additives
CO-4	(K5) Assess extraction and downstream processing of food
CO-5	(K6) Compile the uses of food and design the packages for Industrial and public.

SYLLABUS Elective Paper-2B FOOD TECHNOLOGY				
Unit	Content	Hours	COs	Cognitive level
I	Introduction, scope and important of food biotechnology. Microorganisms associated with food - bacteria, fungi & yeast. Enzymes in food preparation. Food contaminations. Food preservation & Food spoilage- types. Canning of foods.	7	CO1 CO5	K3 & K5
II	Food borne diseases and prevention – infection, intoxication – Salmonellosis, poliomyelitis. Food colors (natural and artificial food colourants), Food flavoring agents.	7	CO1 CO2 CO5	K3 & K5
III	Food engineering operations: Characteristics of food	7	CO1	K3 & K4

	raw materials, preparative operations in food industry, cleaning of food raw materials, sorting of foods, grading of foods.		CO3	
IV	Food quality: Sensory evaluation of food quality, quality factors for consumer safety, food safety standards. FSSA, HACCP and FDA. Processing plant - Cleaning and sanitation methods.	7	CO1 CO4	K3, K4 & K6
V	General principle, plant design – design, construction, functionality of building, design & fabrication of equipment. Plant layout Pest proofing/ fumigation methods. Water supply to food processing unit.	7	CO1 CO5	K3,K4, K5 & K6

TEXT BOOKS:

S. No.	Title of the Book	Author	Publishing Company	Year of Publication
1.	Food Microbiology	William C.Frazier, Dennis C. Westhoff	McGraw Hill Publications	2017
2.	Fundamentals of Food Engineering	D.G. Rao	PHI Learning Pvt. Ltd.	2010

REFERENCE BOOKS:

S. No.	Title of the Book	Author	Publishing Company	Year of Publication
1.	Food Biotechnology	Yiu Hui & G. Khachatourians	Wiley-Inter science	1995
2.	Fundamentals of Food Microbiology	Bibek, Laramie & Bhunia	CRC Press	2004
3.	Food Processing & Preservation	B. Siva	PHI Learning Pvt. Ltd.	2011

Core Paper-4
MICROBIOLOGY

Paper – 4			
Title of the paper	MICROBIOLOGY	Subject code: 23PBTCT04	
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.
CO-2	To provide basic knowledge about microbial culture, identification of microbes, principle and working of microscopes and sterilization techniques
CO-3	To enlighten the students on host microbe interaction and Epidemiology of microbial disease
CO-4	To update the knowledge on epidemic and pandemic diseases.
CO-5	To assess and appraise the role of novel microbes in environment and integrate them in specific innovative approaches.

SYLLABUS Core Paper-4 MICROBIOLOGY				
Unit	Content	Hours	Cos	Cognitive level
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 growth and metabolism: Microbial growth: Growth curve, factors affecting growth, Microbial metabolism- Methanogenesis, acetogenesis and auxotrophs	10	CO1 CO2	K1,K2 &K3
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), Microscopy: principles and applications of Bright	10	CO2 CO3 CO5	K2,K3,K5

	field, florescent and Scanning electron microscopes, Microbial growth control: Physical Methods – Heat, Filtration, Low Temperatures, High Pressure, Desiccation, Osmotic Pressure, Radiation; Chemical Methods			
III	Host microbe interaction and Epidemiology: Human microbiome; Skin, Gastrointestinal tract, Oral cavity, Lung. Microbial interaction: Symbiosis, Mutualism, Parasitism, Commensalism and endophyte. Epidemiology of microbes: causes, types and transmission of epidemic, endemic and pandemic diseases	10	CO1 CO3 CO4	K1,K2,K3
IV	Microbial Diseases: Microbial diseases - General characteristics, pathogenesis, laboratory diagnosis and control measures of Pandemic and Epidemic diseases: Tuberculosis, Cholera, Typhoid, COVID-19, AIDS, , Malaria, Candidiasis.	10	CO4 CO5	K4 &K5
V	Agricultural Microbiology: Biological nitrogen fixation, free living, symbiotic nitrogen fixation, mechanism of Nitrogen, Biofertilizers- types and applications; Rhizosphere, Rhizobium Azospirillum, Azolla, BGA	10	CO1 CO2 CO3	K4 & K5

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-5

PLANT AND ANIMAL BIOTECHNOLOGY

Paper – 5			
Title of the paper	PLANT AND ANIMAL BIOTECHNOLOGY	Subject code: 23PBTCT05	
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.
CO-2	Importance of secondary metabolites and production in plants.
CO-3	To develop concepts, principles and processes in animal biotechnology.
CO-4	Concept and different types in Animal Cell Culture and animal cell lines.
CO-5	Use of molecular biology techniques genetically engineer the animals to improve sustainability, productivity and suitability for pharmaceutical and industrial applications.

SYLLABUS | Core Paper-5 | PLANT AND ANIMAL BIOTECHNOLOGY

Unit	Content	Hours	COs	Cognitive level
I	Introduction of plant tissue culture, composition of media, Micropropagation, somatic embryogenesis, haploid and triploid production, protoplast isolation and fusion, hybrid and cybrid, synthetic seed production.	10	CO1 CO5	K1,K2 &K3
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	10	CO1 CO2 CO5	K1,K2 & K5

	Marker aided breeding: RFLP maps, RAPD markers, QTL, Map based cloning and Molecular marker assisted selection.			
III	An Introduction about animal cell culture, Planning and Construction of Lab layout, Equipments - Laminar-flow hood, CO2 Incubators, Inverted microscope, Cryostorage containers, Aseptic concepts and Cell culture vessel. Preparation of Media- defined media and supplements, Types of cell culture media; Physical and chemical property of Medium, Balanced salts, Antibiotics, growth supplements; Fetal bovine serum; Serum free mediaprimary and established culture; organ culture; tissue culture	10	CO1 CO3 CO5	K4 & K5
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	CO4 CO5	K2,K3,K4 & K5
V	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.	10	CO5	K3,K4 & K6

Reference Books

- Razdan. M. K., 2011. Plant tissue culture. Oxford and IBH publishing Company Pvt. Ltd, New Delhi.
- 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.Witkowski 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-6
GENETIC ENGINEERING

Paper – 6			
Title of the paper	GENETIC ENGINEERING	Subject code: 23PBTCT06	
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.
CO-2	Getting detailed knowledge of gene transfer methods and identifying suitable hosts for cloning.
CO-3	Acquiring theoretical knowledge in the techniques, tools, and application and safety measures of genetic engineering.
CO-4	Describes the genome mapping and sequencing and methods for gene therapy.
CO-5	Elucidate different techniques involved in genetic engineering

SYLLABUS Core Paper-6 GENETIC ENGINEERING				
Unit	Content	Hours	COs	Cognitive level
I	Gene cloning. Genetic engineering tools. Nucleic acid manipulating enzymes. Promoters, Selectable markers and reporters used in rDNA technology. Restriction digestion, Ligation, Transformation.	10	CO1	K1,K2, K5
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	CO2	K2,K3, K4
III	Cloning in yeast <i>Saccharomyces cerevisiae</i> . Life cycle and types of vectors; Eukaryotic vectors. SV40 (molecular genetics and expression); Construction of gene libraries: Genomic and cDNA library, Specialized cloning vector for cDNA; Synthesis of	10	CO4	K3,K4 &K6

	specific RNA in vitro; Vectors for cloning promoters and terminators; vectors with adjustable copy number			
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	CO4	K3,K4,K5 & K6
V	Site directed mutagenesis; DNA microarray, 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	CO5	K3,K4,K5 & K6

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 Practical - II

PRACTICAL-II

(Microbiology, Plant and Animal Biotechnology & Genetic Engineering)

PRACTICAL-II			
Title of the paper	PRACTICAL-II (Microbiology, Plant and Animal Biotechnology & Genetic Engineering)	Subject code: 23PBTCP02	
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 hands on experience on the above core subjects.

Course outcomes:

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

SYLLABUS Core Practical II PRACTICAL-II				
Unit	Content	Hours	COs	Cognitive level
A	(A) Microbiology-Practical 1. Sterilization of glassware using dry heat- hot air oven 2. Sterilization of media. 3. Liquid media preparation – nutrient broth 4. Solid media preparation – SDA plates 5. Preparation of Agar slants 6. Streak plate method 7. Pour plate method 8. Spread plate method 9. Gram staining and morphological characterization of microbes. 10. Negative staining of bacteria 11. IMViC test of enteric bacteria 12. Isolation of microbes from soil, water and air. 13. Enumeration of total count of the bacteria 14. Isolation of pure culture of E.coli 15. Determination of growth curve of bacteria – E.coli	15	CO1 CO2 CO3 CO4 CO5	K, K2, K3, K4, K5 & K6

<p>B</p>	<p>(B) Plant and Animal Biotechnology - Practical: 1. Plant tissue culture media preparation 2. Plant tissue culture sterilization techniques. 3. Callus induction. 4. Isolation of plant protoplast 5. Protoplast viability test. 6. Mass culture of Chlorella /Spirulina 7. Introduction to Animal Cell culture: Procedure for handling cells and medium. 8. Cleaning and sterilization of glassware and plastic tissue culture flasks 9. Preparation of tissue culture media 10. Preparation of single cell suspension from chicken liver (Primary cell culture). 11. Trypsinization of established cell culture. 12. Cell counting and viability - staining of cells Vital Staining (Trypan blue) 13. MTT Assay</p>	<p>15</p>	<p>CO1 CO2 CO3 CO4 CO5</p>	<p>K3,K4 & K5</p>
<p>C</p>	<p>(C) Genetic Engineering - Practical 1. Preparation of plasmid DNA by alkaline lysis method. 2. Elution of DNA from agarose gel. 3. Restriction enzyme digestion. 4. Ligation. 5. Competent cell preparation 6. Transformation and selection of recombinants by Insertional inactivation/Blue white screening. 7. RAPD 8. Amplification of DNA - PCR 9. Determination of molecular weight of DNA by electrophoresis.</p>	<p>15</p>	<p>CO1 CO2 CO3 CO4 CO5</p>	<p>K3,K4 &K5</p>

Elective Paper-3
REGULATORY AFFAIRS AND INDUSTRIAL STANDARDS

Elective Paper – A 3			
Title of the paper	REGULATORY AFFAIRS AND INDUSTRIAL STANDARDS	Subject code: 23PBTMEA3	
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
CO-2	Describe the Scientific, technical knowledge about various food preservation techniques
CO-3	Describe the basic concepts of packing of food materials, various parameters observed during packaging
CO-4	Describe the testing of food materials and identifying of microbial food contaminant
CO-5	Explain the basic of food safety management system, good manufacturing practice and good hygienic practices

SYLLABUS Elective Paper-3A REGULATORY AFFAIRS AND INDUSTRIAL STANDARDS				
Unit	Content	Hours	COs	Cognitive level
I	Planning, Organisation and setting of Food testing laboratory and laboratory safety	7	CO1	K2,K3,K4

	<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>			
II	<p>Principles of Food Preservation technology 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	CO2	K2 & K3
III	<p>Principles of Food Packaging technology 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</p>	10	CO3	K2, K3 & K4

	<p>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 microwavable packaging.</p>			
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, saccharomycetc, 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-</p>	10	CO4	K2,K3,K4

	<p>Value, F-Value, thermal death time curve, 12 D Concept, Microbial food spoilage and food borne diseases, food pathogens, <i>bacillus cereus and other bacillus species, campylobacter, clostridium species, Enterobacteriaceae, E. coli, listeria monocytogens, salmonella, shigella, staphylococcus aureus, vibrio species, yersinia enterocolitica, fungi, virus etc.</i>, Methods for the Microbiological examination of foods: Sampling activity and 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.</p>			
V	<p>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). Food safety audits: Management review, audit certification and importance. Good manufacturing practices (GMP), Good hygienic practices (GHP), Food safety plan, food safety management risk analysis. Traceability food products recall and sanitation.</p>	7	CO5	K2,K3 & K6
<p>References:</p> <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-3
PHARMACEUTICAL BIOTECHNOLOGY

Elective Paper – B 3			
Title of the paper	PHARMACEUTICAL BIOTECHNOLOGY	Subject code: : 23PBTMEB3	
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	1. Explain the basic components of pharmaceutical and biotechnology industry and methods and applications of biosensor
CO-2	2. Describe the Scientific, technical and economic aspects of vaccine & rDNA technology
CO-3	3. Describe the basic concepts of protein Engineering, therapeutic proteins and enzyme immobilization techniques
CO-4	4. Describe the concepts of hybridoma technology, microbial biotransformation and microbial bio-transformed products
CO-5	5. Explain the basic components of somatic gene therapy, Xeno-transplantation and fermenter and bio safety methods

SYLLABUS Elective Paper-3B PHARMACEUTICAL BIOTECHNOLOGY				
Unit	Content	Hours	COs	Cognitive level
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	CO1	K1
II	Scientific, technical and economic aspects of vaccine research and development, Preparation of bacterial	7	CO2	K3 & K4

	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			
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	CO3	K2
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	CO4	K2 & K4
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	7	CO5	K1,K2 &K5

treatment of ADR, General principles of management of drug poisoning; antidotes, classification of drugs.			
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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 Figey (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, Gary Walsh. 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-4
ENVIRONMENTAL BIOTECHNOLOGY

Elective Paper – A 4			
Title of the paper	ENVIRONMENTAL BIOTECHNOLOGY		Subject code: 23PBTMEA4
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
CO-2	(K3) classify potential methods of biodegrading organic pollutants.
CO-3	(K4) examine the techniques involved in remediation of polluted environments
CO-4	(K5) assess types of pollution & its control
CO-5	(K6) compile biotechnological approaches to degrade xenobiotic compounds

SYLLABUS Elective Paper-4A ENVIRONMENTAL BIOTECHNOLOGY				
Unit	Content	Hours	COs	Cognitive level
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	CO1 CO5	K2
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	CO1 CO2 CO5	K3
III	Waste water management, source of waste water, Waste water treatment- physical, chemical and	7	CO3	K4

	biological treatment. Microbiology of Waste water; Aerobic and anaerobic process, BOD and COD.			
IV	Toxicity: Types and Test for evaluating Toxicity. Biosensors, Biomonitoring of toxic materials .Biomagnification, Biomining and Biofuels	7	CO4	K5
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	CO5	K6

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 Life Sciences, 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://lbe.epfl.ch>

Elective Paper-4
MARINE BIOTECHNOLOGY

Elective Paper – B 4			
Title of the paper	MARINE BIOTECHNOLOGY	Subject code: 23PBTMEB4	
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	To gain employment in state and federal marine laboratories as well as private marine companies and aquariums.
CO-2	To understand the extensive underwater and field research abilities coupled with synergistic molecular bench skills.
CO-3	To assess the benefits of marine biotechnology is its potential to produce novel pharmaceuticals.
CO-4	To enlighten the marine organisms such as sponges, tunicates, and algae are a rich source of biologically active compounds, including anti-cancer, anti-inflammatory, and anti-viral agents.
CO-5	To develop the new pharmaceutical drugs, chemical products, enzymes, and other products and processes

SYLLABUS Elective Paper-4B MARINE BIOTECHNOLOGY				
Unit	Content	Hours	Cos	Cognitive level
I	Biotechnology in marine science- history of marine biotechnology application in aquaculture, pharmaceutical, environment remediation, biofouling and biocorrosion.	10	CO1	K1&K2
II	Developmental biotechnology induced breeding in-vitro fertilization cryo preservation biotechnological tools - ELISA, FISH, PCR Gene probes, dot immuno binding activity, monoclonal antibodies biosafety ethics.	10	CO2	K1,K2&K3
III	Bioactive marine natural products membrane	10	CO3	K1,K2&K3

	receptors, anti tumor compounds, anti inflammatory / analgesic compounds, anti viral agents, isolation and identification of marine bioactive compounds such as labile proteins, toxins, carotenoids bioterminator Commercial development of marine natural products- chitosan, chitin.			
IV	Algal biotechnology single cell-protein, hydrocolloids, agarose, carrageen alginates and other by products. Marine Enzymes sources and their applications Marine Lipids sources and their applications.	10	CO4	- K1,K2&K3
V	Microbial biodegradation - natural and synthetic material in the marine environment- pesticide. Bioremediation of xenobiotics oil, heavy metals, pesticides, plastics, etc. Mining and metal biotechnology.	10	CO5	K1,K2&K3
Reference Books				
<ul style="list-style-type: none"> • Italy, E (Eds). 1998, New Developments in Marine Biotechnology, Plenum Pub. Corp. • Milton Fingerman and Rachakonda Nagabhushanam, 1996, Molecular Genetics of Marine Organisms, Science Pub Inc. • Y. Le Gal and H.O.Halvorson 1998, New Developments in Marine Biotechnology. Springer. 				
Text Books				
<ul style="list-style-type: none"> • David H. Attaway, 2001. Marine Biotechnology, Volume 1, Pharmaceutical and Bioactive Natural Products. • Rita R. Colwell 1984. Biotechnology in the Marine Sciences (Advances in Marine Science & Biotechnology) Wiley Interscience. • Scheupr, P.J. (Ed.), 1984. Chemistry of Marine Natural Products, ,Chemical and Biological Perspectives. Vol. I III, Academic Press, New York. 				

**Core Paper-7
BIOINFORMATICS**

Paper – 7			
Title of the paper	BIOINFORMATICS	Subject code: 23PBTCT07	
Category of the course	Year	Semester	Credits
Core Paper	2	3	5

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.
CO-2	Describe the history, scope and importance of Bioinformatics and role of internet in Bioinformatics.
CO-3	Explain about the methods to characterize and manage the different types of Biological data.
CO-4	Classify different types of Biological Databases.
CO-5	Introduction to the basics of sequence alignment and analysis

SYLLABUS Core Paper-7 BIOINFORMATICS				
Unit	Content	Hours	COs	Cognitive level
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	CO1	K1 & K2
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	10	CO2	K2,K3 & K5

	matrices			
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 Genome Variation. protein databank and the PDB Sum-SCOP, CATH, DALI and HSSP ;Visualization of molecular structures-RasMol and Pymol; Protein secondary structure prediction, Fold Recognition; Transmembrane topology prediction	10	CO3	K2 & K5
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	CO4	K4 &K5
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	CO5	K3,K4 & K6

Reference Books:

- Dassanayake S.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.
- Bosu Orpita, Simminder Kaur Thukral, 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-8

IMMUNOLOGY

Paper – 8			
Title of the paper	IMMUNOLOGY	Subject code: 23PBTCT08	
Category of the course	Year	Semester	Credits
Core Paper	2	3	5

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

SYLLABUS Core Paper-8 IMMUNOLOGY				
Unit	Content	Hours	COs	Cognitive level
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	CO1	K1 & K2
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	CO2	K2,K3 & K5

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	CO3	K2 & K5
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	CO4	K4 & K5
V	Immunotechniques- Principle and Applications: Immunodiffusion, 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	CO5	K3,K4 & K6
<p>Reference Books:</p> <ul style="list-style-type: none"> • 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. <p>Useful Websites:</p> <ul style="list-style-type: none"> • www.library.csusm.edu/course_guides/biology • www.immunologylink.com • http://www.wiley.com/college/bio/karp12791/weblinks.html 				

Core Paper-9
BIOPROCESS TECHNOLOGY

Paper – 9			
Title of the paper	BIOPROCESS TECHNOLOGY	Subject code: 23PBTCT09	
Category of the course	Year	Semester	Credits
Core Paper	2	3	5

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
CO-2	(K3) Relate reactors in fermentation
CO-3	(K4) Differentiate fermentation processes
CO-4	(K5) Assess Scale up and Scale down
CO-5	(K6) Compile the output of fermentation processes

SYLLABUS Core Paper-9 BIOPROCESS TECHNOLOGY				
Unit	Content	Hours	COs	Cognitive level
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.	10	CO1	K1 & K2
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 Microorganisms, Media for Industrial fermentation and Sterilization.	10	CO2	K2,K3 & K5
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,	10	CO3	K2 & K5

	supercritical fluid extraction.			
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	CO4	K4 & K5
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	CO5	K3,K4 & K6
<p>Reference Books:</p> <ul style="list-style-type: none"> • 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 forBiotechnology. John Wiley and sons. • R.G. Harrison, P.Todd, SR.Rudge and D.P. Petrides. 2003.Bioseparation science andengineering. Oxford Press. <p>Useful Websites:</p> <ul style="list-style-type: none"> • www.wildfermentation.com/John Schollar and BenedikteWatmore, Practical Fermentation-atechnicalguide • web.mit.edu/professional/short.../fermentation_technology.html 				

**Core Practical III PRACTICAL-III
(Bioinformatics, Immunology & Bioprocess Technology)**

Practical III			
Title of the paper	PRACTICAL-III (Bioinformatics, Immunology & Bioprocess Technology)		Subject code: 23PBTCP03
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
CO-2	(K3) to apply the learned tools for various applications
CO-3	(K4) to isolate, identify & enumerate immune cells
CO-4	(K5) to learn the technique of immunodiagnostics
CO-5	(K6) to study upstream & downstream techniques

SYLLABUS Core Paper-12 PRACTICAL-III				
Unit	Content	Hours	COs	Cognitive level
A	<p>(A) Bioinformatics-practical MAJOR</p> <ol style="list-style-type: none"> Prediction of signal sequence using SignalP online tool Pattern Search (Domains & Motifs) using Pfam ORF gene Search - Genscan Sequence translation using ExPASy translate tool Characterization of retrieved protein sequence by ProtParam tool. <p>MINOR</p> <ol style="list-style-type: none"> Sequence retrieval from Genbank Sequence retrieval from Uniprot. Sequence identity search- Sequence similarity search using BLAST Sequence similarity search using FASTA Sequence similarity search using PSI BLAST 	15	CO1 CO2 CO3 CO4 CO5	K1,K2,K3,K4 &K5
	<p>DEMONSTRATION</p> <ol style="list-style-type: none"> Molecular visualization of proteins using RASMOL. Docking of small molecule with protein structure using Hex software. Docking of two proteins using PatchDock (Protein-Protein docking) tool. 			

<p>B</p>	<p>(B) Immunology - practical MAJOR</p> <ol style="list-style-type: none"> 1. Identification of various immune cells from human peripheral blood. 2. Determination of lymphocyte viability by trypan blue method 3. Radial Immunodiffusion 4. Ouchterlony Immunodiffusion 5. Immunoelectrophoresis 6. Counter current immunoelectrophoresis. <p>MINOR</p> <ol style="list-style-type: none"> 1. Immunodiagnosics: CRP 2. Immunodiagnosics: ASO 3. Immunodiagnosics: Widal 4. Immunodiagnosics: RA 5. Immunodiagnosics: Blood grouping and typing 6. Immunodiagnosics: hCG 7. Preparation of serum and plasma <p>DEMONSTRATION</p> <ol style="list-style-type: none"> 1. Lymphocyte separation and identification 2. Bioassays for cytokines 3. ELISA 4. Radioimmunoassays 	<p>15</p>	<p>CO1 CO2 CO3 CO4 CO5</p>	<p>K2,K3,K4</p>
<p>C</p>	<p>(C) Bioprocess Technology - Practical MAJOR</p> <ol style="list-style-type: none"> 1. Isolation of industrially important microorganisms for microbial processes. 2. Production and estimation of protease 3. Production and estimation of amylase. 4. Production of wine using grapes 5. Production of penicillin 6. Determination of penicillin activity 7. Citric acid production 8. Use of alginate for cell immobilization. <p>MINOR</p> <ol style="list-style-type: none"> 1. Solid state and Submerged fermentation 2. Media preparation and sterilization 	<p>15</p>	<p>CO1 CO2 CO3 CO4 CO5</p>	<p>K2,K3,K4 &K5</p>
	<p>DEMONSTRATION</p> <ol style="list-style-type: none"> 1. Parts and design of fermenter 2. Media standardization (C:N ratio) for maximum biomass production of an industrially important microorganism. 			

Elective Paper-5

NANO BIOTECHNOLOGY

Elective Paper – A 5			
Title of the paper	NANO BIOTECHNOLOGY		Subject code: 23PBTMEA5
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
CO-2	To impart understanding on Nanoparticle based Drug Delivery.
CO-3	Fabrication of nanomaterials for bone tissue grafting
CO-4	Methods of Nanofabrication
CO-5	Understand the application of Nanotechnology

SYLLABUS Elective Paper-5A NANO BIOTECHNOLOGY				
Unit	Content	Hours	COs	Cognitive level
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,	7	CO1	K1
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, Hydrogels, Films and Scaffolds.	7	CO2	K4
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	CO3	K1 & K5

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	CO4	K2
V	Nanotoxicology, Portals of Entry of the nanoparticles into the Human Body, Bio-toxicity of Nanoparticles,	7	CO5	K5
	Nanoparticles in Mammalian systems and Health threats, Biological response and cellular interaction of implant materials and scaffolds, Risk assessment and Safety Regulation of nanoparticles.			

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.
- OdedShoseyov (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 andApplications, Wiley-VCH.
- ChallaS.S.R.Kumar (Ed). 2006. Biologicals and pharmaceutical nanomaterials, Wiley-VCHVerlagGmbH& Co, KgaA.
- K.K.K.Jain 2006. Nanobiotechnology in Molecualr Diagnostics: Current Techniques andApplications Horizon Bioscience
- Niemeyer, C.M., Mirkin, C.A. (Eds). 2004. Nanobiotechnology Concepts, Applications andPerspectives, Wiley-VCH, Weinheim.
- Andrze w. Miziolek, Shashi P.Karna, J malthew Mauro and Richard A.Vaia. 2005 DefenseApplications 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, WileyVCH, 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 ofNanotechnology, Hornyak, G. Louis,Tibbals, H. F., Dutta, Joydeep, CRC Press, 2009.
- Assessing Nanoparticle Risks to Human Health, Gurumurthy Ramachandran, Elesvier, 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/

Elective Paper-5

MOLECULAR DEVELOPMENTAL BIOLOGY

Elective Paper – B 5			
Title of the paper	MOLECULAR DEVELOPMENTAL BIOLOGY	Subject code: 23PBTMEB5	
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
CO-2	Discuss basic fertilization process of animals
CO-3	Demonstrate the functions of embryonic development process
CO-4	Illustrate the organ development of vertebrate animals
CO-5	Demonstrate the impact of gene in developmental biology and developmental disorders

SYLLABUS Elective Paper-5B MOLECULAR DEVELOPMENTAL BIOLOGY				
Unit	Content	Hours	COs	Cognitive level
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	CO1	K1, K2 & K5
II	Fertilization - Definition, mechanism of fertilization in mammal & sea urchin. Types of fertilization. Nieuwkoop center, Molecular role of organizer	7	CO2	K4
III	Cleavage in Xenopus, Chick and mammals, Regulation of cleavage cycle. Morphogenetic movements, Gastrulation in Xenopus, Chick and mammals. Fate Maps	7	CO3	K3
IV	Vertebrate Development: Formation of the neuraltube, myogenesis, and hematopoiesis. Mechanism of vertebrate eye development	7	CO4	K2
V	Drosophila Maternal effect genes, induction at single cell level - differentiation of photoreceptors in ommatidia. Developmental disorders Spina bifida, Anencephaly, and craniorachischis, Cyclopia,	7	CO5	K1 & K4

Thanotrophic dysplasia			
Reference Books: <ul style="list-style-type: none"> • 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/			

HUMAN RIGHTS

Title of the paper	HUMAN RIGHTS		Subject code: 23PBTHR1
Category of the course	Year	Semester	Credits
Core Paper	2 nd	3 rd	2

INTERNSHIP

Internship in Industries to Biotechnology Field (Food / Clinical Trials/ Dairy/ Aquasciences, Pharmaceutical / CSIR/DBT/DST Research Laboratories			
Title of the paper	INTERNSHIP		Subject code: 23PBTI01
Category of the course	Year	Semester	Credits
Paper	2	3	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

Core Paper-10
RESEARCH
METHODOLOGY

Paper – 11			
Title of the paper	RESEARCH METHODOLOGY	Subject code: 23PBTCT10	
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
CO-2	To know about research proposal and dissertation writing.
CO-3	To know about Statistical application in research
CO-4	To know about office tools used in research
CO-5	To know about search engines.

SYLLABUS Core Paper-11 RESEARCH METHODOLOGY				
Unit	Content	Hours	COs	Cognitive level
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	CO1	K1
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	CO2	K2 & K6
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	10	CO3	K3

	interaction, response surface and contour plots, General arrangement for a two factor factorial design			
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	10	CO4	K1 & K4
	presentation, Customizing presentation, Showing presentation. Tools used may be Microsoft Power Point, Open Office or similar tool			
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	CO5	K1 & K2
<p>Reference Books:</p> <ul style="list-style-type: none"> • 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, AppaIyer and Mathiranjana M. (2006), Management Research Methodology; Integration of Principles, Methods and Techniques (Pearson Education, New Delhi). • The complete reference Office Xp – Stephan L. Nelson, Gajula Kelly (TMH). • Basic Computer Science and Communication Engineering – R. Rajaram (SCITECH). <p>Useful Websites</p> <ul style="list-style-type: none"> • www.ask.com/Methodology+Research • www.qmethod.org/ 				

Core paper -11
BIOSTATISTICS

Core paper – 11			
Title of the paper	BIOSTATISTICS	Subject code: 23PBTCT11	
Category of the course	Year	Semester	Credits
Elective Paper	2 nd	4 th	5

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
CO-2	To provide basic knowledge about methods of analysis of variance
CO-3	To enlighten the students about the methods of setting hypothesis and calculation of errors.
CO-4	To update the knowledge on Tests of significance for large and small samples.
CO-5	To assess and appraise the role of novel microbes in environment and integrate them in specific innovative approaches.

SYLLABUS | Core Paper -12 | BIOSTATISTICS

Unit	Content	Hours	COs	Cognitive level
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 – skewness, kurtosis, moments	7	CO1 CO2 CO3	K1,K2,K3 & K4
II	Correlation and regression – correlation table – coefficient of correlation – Z transformation – regression – relation between regression and correlation. Probability – Markov chains applications – Probability distributions – Binomial (Gaussian distribution) and negative binomial, compound and	7	CO1 CO2 CO5	K1,K2,K3 & K4

	multinomial distributions – Poisson distribution			
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	CO1 CO4 CO5	K1,K2,K3 & K4
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 – c2 test for independence of two attributes – Fisher and Behrens ‘d’ test – 2×2 table – testing heterogeneity – r X c table – chi-square test in genetic experiments – partition X 2 – Emerson's method	7	CO1 CO2 CO3	K1,K2,K3 & K4
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	CO1 CO2 CO4 CO5	K1,K2,K3 & K4

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

DISSERTATION

PROJECT			
Title of the paper	DISSERTATION	Subject code: 23PBTPR01	
Category of the course	Year	Semester	Credits
Core Paper	2 nd	4 th	7

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.

Elective Paper-6 STEM CELL BIOLOGY

Elective Paper –A 6			
Title of the paper	STEM CELL BIOLOGY	Subject code: 23PBTMEA6	
Category of the course	Year	Semester	Credits
Elective Paper	II	IV	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
CO2	To provide basic knowledge about stem cell niche and functions
CO3	To enlighten the students on Stem cell isolation and culture techniques
CO4	To update the knowledge on Stem cell cycle
CO5	To assess and appraise Applications of Embryonic stem cells.

SYLLABUS Elective Paper-6 STEM CELL BIOLOGY				
Unit	Content	Hours	COs	Cognitive level
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	10	CO1	K1
II	Stem cell niche, Niche specification - Drosophila germ line stem cells. Receptors, genes and markers of stem cells	10	CO2	K1 & K2
III	Stem cell isolation and culture techniques. Characterization	10	CO3	K3, K4

	of stem cells			
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	10	CO4	K3,K3 & K5
V	Applications of Embryonic stem cells, Bone marrow stem cells, Adipose derived stem cells and Hematopoietic stem cells. Ethics in human stem cell research	10	CO5	K3,K4 & K5

Reference Books:

- Stem Cell Biology, Daniel Marshak, Richard L. Gardener and David Gottlieb, Cold Spring Harbour 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 A Cowan.

Elective Paper-6

BIOETHICS, BIOSAFETY, CLINICAL TRIALS, IPR & ENTREPRENEURSHIP

Elective Paper – 6			
Title of the paper	BIOETHICS, BIOSAFETY, CLINICAL TRIALS, IPR & ENTREPRENEURSHIP		Subject code:
Category of the course	Year	Semester	Credits
Elective Paper	II	IV	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.
CO-2	Apply the knowledge to recognize the importance of biosafety guidelines and good clinical practices.
CO-3	Acquire adequate knowledge in the use of genetically modified organisms and its effect on human health.
CO-4	Evaluate the benefits of GM technology and importance of IPR
CO-5	Analyse the importance of protection of new knowledge and innovations and its role in business and entrepreneurship

SYLLABUS | Elective Paper-6 | BIOETHICS, BIOSAFETY, CLINICAL TRIALS, IPR & ENTREPRENEURSHIP

Unit	Content	Hours	COs	Cognitive level
I	Introduction to Bioethics Need for bioethics in social and cultural issues. Bioethics & GMO's Issues and concerns	10	CO1	K2,K3 & K4

	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.			
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	CO2	K3, K4 & K5
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	CO3	K3,K4 & K5
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	CO4	K4, K5 & K6
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	CO5	K4,K5 & K6

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.

Non-Major Elective subject for other department students

GENE MANIPULATION TECHNOLOGY

NME Paper – 1			
Title of the paper	GENE MANIPULATION TECHNOLOGY		Subject code: 23PBTNME1
Category of the course	Year	Semester	Credits
Extra disciplinary subject	1	2 nd	2

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
CO-2	Apply the knowledge to create Constructions of DNA Libraries Constructions of DNA Libraries.
CO-3	Acquire adequate knowledge in the use of Genome Sequencing and Transcriptomics
CO-4	Evaluate the benefits of Protein Engineering & Pharmaceutical Products
CO-5	Analyse the importance of Gene Cloning & Applications of Gene Cloning

SYLLABUS Extra Disciplinary Subject GENE MANIPULATION TECHNOLOGY				
Unit	Content	Hours	COs	Cognitive level
I	Basics of Gene Manipulation Technology- Restriction Enzymes-Cutting and Joining Reactions-Vectors- Selection of Recombinants- Agarose Gel Electrophoresis-Southern Blotting-Hybridization- Autoradiography-PCR- Native Page- SDS-Page- 2D Gel Electrophoresis- Western Blotting.	7	CO1	K2,K4 &K5
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	CO2	K1,K3,K5
III	Genome Sequencing and Transcriptomics- Sanger's	7	CO3	K1,K2,K3 &K4
	Sequencing, Whole Genome Shot gun Sequencing- Comparative Genome Sequencing- Transcriptome Analysis- DNA Microarray- Expression of Recombinant Proteins.			
IV	Protein Engineering & Pharmaceutical Products- Site Directed Mutagenesis- Protein Analysis- Therapeutic Protein- Vaccines.	7	CO4	K2,K3 &K4
V	Applications of Gene Cloning- creating Transgenic Animals and Plants- Reporter Genes- Animal Cloning, Gene expression in plants- Biosafety and Bioethics.	7	CO5	K2,K3 &K4
References:				
<ul style="list-style-type: none"> 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. 				
<ul style="list-style-type: none"> Kaushik. B.D. Deepak Kumar. Shamim. Md. 2019. Biofertilizers and Biopesticides in Sustainable Agriculture. 1st Edition. Apple Academic Press. USA. Aneesa Padiniakkara. Aparna Thankappan, Fernando Gomes Souza. Jr. Sabu Thomas. 2018. Biopolymers and Biomaterials. CRC press, USA. A text book on Molecular Biotechnology by Glick. 				

TISSUE ENGINEERING

NME Paper – 2			
Title of the paper	TISSUE ENGINEERING	Subject code: 23PBTNME2A	
Category of the course	Year	Semester	Credits
Extra disciplinary subject	2 nd	3 rd	2

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 Tissue Engineering
CO-2	Apply the knowledge to create tissue culture methods
CO-3	Acquire adequate knowledge in the use of tissue in medical application
CO-4	Evaluate the benefits of Tissue Engineering & Pharmaceutical Products
CO-5	Analyze the importance of applications of tissue engineering

SYLLABUS Extra disciplinary subject TISSUE ENGINEERING				
Unit	Content	Hours	Cos	Cognitive level
I	Basic biology of tissue engineering: The basis of growth and differentiation-morphogenesis and tissue Engineering	7	CO1	K4 & K5
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	CO2	K3 & K5
III	Biomaterials in tissue engineering- Scaffolds, extracellular matrix, polymers and nanocomposites. Approaches to transplanting engineered cells	7	CO3	K1, K2, K3 & K4
IV	Bioartificial pancreas, Hepatocyte liver support system, Artificial Womb, Hematopoietic system: Red blood cell substitutes, Renal replacement devices	7	CO4	K2, K3, K4, K5
V	Structural tissue engineering- Bone regeneration through cellular engineering, Skin tissue engineering, Brain implants- Neural stem cells, Periodontal Applications	7	CO5	K2, K3, K4 & K6

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.,LoutitJohn.F., 2004, Tissue grafting and radiation, Academic Press, New York..
- 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

BIOENTREPRENEURSHIP

NME-2 Paper			
Title of the paper	BIOENTREPRENEURSHIP		Subject code: 23PBTNME2B
Category of the course	Year	Semester	Credits
Extra disciplinary subject	2 nd	3 rd	2

Learning Outcome:

The paper imparts a thorough knowledge of the the sources of innovation opportunities and development of the skills to identify and analyze these opportunities for bioentrepreneurship and innovation. And also helps the students to develop personal skills set for creativity, innovation and entrepreneurship and specific concepts and tools for combining and managing creativity in organization

Course outcomes:

CO-1	Students will know the legal and financial conditions for starting a business venture
CO-2	Will be able to explain the importance of marketing and management in small businesses venture and can interpret their own business plan
CO-3	Able to identify the elements of success of bioentrepreneurial scheme and projects
CO-4	Can able to specify the basic performance indicators of various entrepreneurial activities
CO-5	Student will be able to analyse the business environment in order to identify business Opportunities

SYLLABUS Extra disciplinary subject BIOENTREPRENEURSHIP				
Unit	Content	Hours	COs	Cognitive level
I	BASICS OF BIOENTREPRENEURSHIP: Introduction to bioentrepreneurship – Biotechnology in a global scale, Scope in Bioentrepreneurship, Importance of entrepreneurship. Meaning of entrepreneur, function of an entrepreneur, types of entrepreneur, and advantages of being entrepreneur. Innovation – types, out of box thinking, opportunities for Bioentrepreneurship. Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup and Make in India).	7	CO1	K1 & K2
II	MANAGEMENT, ACCOUNTING AND FINANCE: Business plan preparation: business feasibility analysis by SWOT, socio-economic costs benefit analysis, Sources of financial assistance – making a business proposal, approaching loan from bank and other financial institutions, budget planning and cash flow management. Collaborations and partnerships,	7	CO2	K2,K3 & K4

	information technology for business administration and expansion.			
III	KNOWLEDGE CENTRE AND R & D: Knowledge centers - Universities, innovation centre, research institutions and business incubators. R&D - technology development and upgradation, assessment of technology development, managing technology transfer, industry visits to successful bio-enterprises, regulations for transfer of foreign technologies, quality control, technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO,NBA, GLP, GCP & GMP)	7	CO3	K3, K4 & K5
IV	MEDIUM & SMALL SCALE INDUSTRY: Definition, characteristics, need and rationale, objectives, scope and advantages of small scale industries. Types of bioindustries – Pharma, Agri and Industry. Biofertilizers production - Azospirillum, Azolla, Cyanobacteria and its applications. Biopesticides production - Bacterial, fungal, viral and plant insecticides. Sericulture. Apiculture. Dairy farming. Single Cell Protein Production and applications. Vermicomposting and its applications. Mushroom cultivation and its application. Ancillary and tiny industries	7	CO4	K4,K5& K6
V	MARKETING AND HUMAN RESOURCE DEVELOPMENT: Assessment of market demand for potential product(s) of interest, Market conditions, segments, prediction of market changes, identifying needs of customers. Branding issues, developing distribution channels – franchising policies, promotion, advertising, branding and market linkages. Marketing of agro products. Recruitment and selection process, leadership skills, managerial skills, organization structure, training, team building and teamwork.	7	CO5	K4,K5& K6
Reference Books:				
<ul style="list-style-type: none"> • Entrepreneurship Ideas in Action—South-Western, • Principles of Management, PC Tripathi, PN Reddy,–Tata Mc Graw Hill • Dynamics of Entrepreneurial Development & Management, Vasant Desai Himalaya Publishing House • Management Fundamentals, Robert Lusier – Concepts, Application, Skill Development, Thomson • Entrepreneurship Development, S SKhanka, S Chand & Co 				

ECOTECHNOLOGY

NME Paper – 3			
Title of the paper	ECOTECHNOLOGY		Subject code: 23PBTNME3
Category of the course	Year	Semester	Credits
Extra disciplinary subject	2 nd	4 th	2

Learning Outcome:

This course will give the student an understanding of the basic principles of technologies adopted in various aspects of biotechnology. This course will elaborate the latest trends and applications in the field of Biofuels, Eco-friendly polymers, Biofertilizers, Biopesticides and Biostimulants. The student will understand the critical issues in waste management. Student will acquire knowledge about these modern eco technologies as a resource for further technological processing and application.

Course Outcome:

CO-1	Understanding the basics of bioresources
CO-2	Understanding the concepts of polymers developed using biological contents
CO-3	Acquiring the knowledge about biocontrol methods
CO-4	Develop and inferencing the biological products in agriculture fields
CO-5	Examining the quality and categorizing the biological products in the environment

SYLLABUS Extra Disciplinary Subject ECOTECHNOLOGY				
Unit	Content	Hours	COs	Cognitive level
I	Introduction to Biofuel, Bioenergy sources – Sugar waste, Starch waste, Lignocellulosic waste, livestock waste	7	CO1	K2 & K3
II	Introduction to Biopolymers ; Sources – natural sources, microbial polysaccharides, poly hydroxyl Alkaonates	7	CO2	K2 & K4
III	History, Principles & scope of Biological control, Principles of classical Biological control, Microbial control – definition & concept.	7	CO3	K3 & K4
IV	Definition & types, Importance of Biofertilizers in Agriculture, Commercial Biofertilizers – Rhizobium, Azatobacter, Acetobacter, Blue Green Algae	7	CO4	K3, K4 & K5
V	Definition & categories – Humic Acid, Protein hydrolysate, Sea weed extract, Inorganic compounds, Microbial Innoulants	7	CO5	K5 & K6

References:

- John Love. Bryant. A. J. 2017. Biofuels and Bioenergy. Wiley Blackwell. UK.
- Shakeel Ahmed, SuvadhanKanchi., Gopalakrishnan Kumar. 2019. Handbook of Biopolymers advances and multifaceted applications. Pan Stanford Publishing Pte. Ltd. NewYork.
- Leo M. L. Nollet., Hamir Singh Rathore. 2015. Biopesticides handbook. CRC Press. USA.
- Arshad Anwer. Md. 2017. Biopesticides and Bioagents: Novel tools for pest management. Apple Academic press. USA.

