PERIYAR UNIVERSITY

Salem – 636 011, Tamil Nadu, India

NAAC A^{++} Grade State University – NIRF Rank 56 -State Public University Rank 25

DEPARTMENT OF BIOTECHNOLOGY

M.Sc
BIOTECHNOLOGY

SYLLABUS

(Choice-Based Credit System)

FROM THE ACADEMIC YEAR

2025-2026

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

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

M.Sc. Biotechnology Programme structure, course work contact hours, credits and maximum internal and external marks for the students admitted in 2025 – 2026 onwards

Course Components	Course Code	Title of Course work	Inst. Hrs/ Wk	Credits	Exam Hrs	Marks		Total Marks
						Int	Ext	
SEMESTER - I								
Core paper- 1	25UPBIT1C01	Biochemistry & Enzymology	7	5	3	25	75	100
Core paper - 2	25UPBIT1C02	Genetics and Molecular Biology	7	5	3	25	75	100
Practical I	25UPBIT1L01	Practical – I: Biochemistry & enzymology, Genetics and Molecular Biology	6	4	6	40	60	100
Elective Paper -1 Discipline Centric	25UPBIT1E01	Bioinstrumentation	5	3	3	25	75	100
Elective Paper -2 Generic	25UPBIT1E02	Cell Biology	5	3	3	25	75	100
Total			**30**	**20**	**--**	**--**	**--**	**500**
SEMESTER - II								
Core Paper-3	25UPBIT1C03	Microbiology	5	5	3	25	75	100
Core Paper-4	25UPBIT1C04	Plant and Animal Biotechnology	5	5	3	25	75	100
Practical II	25UPBIT1L02	Practical – II Microbiology, Plant and Animal Biotechnology	6	4	6	40	60	100
Elective Paper -3/ Elective Paper -4 Discipline Centric	25UPBIT1E03/ 25UPBIT1E04	Regulatory Affairs and Industrial Standards / Pharmaceutical Biotechnology	3	3	3	25	75	100
Elective Paper -5 Generic Elective	25UPBIT1E05	Environmental Biotechnology	3	3	3	25	75	100
NME-I	25UPBIT1N01	MOOC	4	2	3	25	75	100
Skill Enhancement Course -I	25UPBIT1S01	Team Project	4	2	6	40	60	100
Compulsory Paper	23UPPGC1H01	Human Rights	-	1	3	25	75	100
Total			**30**	**25**	**--**	**--**	**--**	**800**

SEMESTER – III									
Core Paper-5	25UPBIT1C05	Bioinformatics	5	5	3	25	75	100
Core Paper-6	25UPBIT1C06	Immunology	5	5	3	25	75	100
Core Paper -7	25UPBIT1C07	Bioprocess Technology	5	5	3	25	75	100
Practical III	25UPBIT1L03	Practical – III Bioinformatics, Immunology and Bioprocess Technology	6	4	6	40	60	100
Elective Paper -6/ Elective Paper -7 Discipline Centric	25UPBIT1E06/ 25UPBIT1E07	Nano Biotechnology / Molecular Developmental Biology	3	3	3	25	75	100
Internship/ Industrial Activity	25UPBIT1I01	Internship in Industries to Biotechnology Field (food / clinical trial/ dairy/ aqua sciences, pharmaceutical) CSIR/DBT/ DST research laboratories	-	2	3	-	100	100
NME - II	25UPBIT1N02	Applied Biotechnology	4	2	3	25	75	100
Skill Enhancement Course -II	25UPBIT1S02	Mini Project	2	2	6	40	60	100
Total			**30**	**28**	**--**	**--**	**--**	**800**

SEMESTER – IV								
Core Paper-8	25UPBIT1C08	Research Methodology	6	5	3	25	75	100
Project - 1	25UPBIT1P01	Dissertation/ Project with Viva-voce	18	8	6	60	240 (40-work book, 150 Dissertation +50-Viva)	300
Elective Paper-8/ Elective Paper-9	25UPBIT1E08/ 25UPBIT1E09	Stem Cell Biology/ Bioethics, Biosafety, Clinical Trials, IPR & Entrepreneurship	4	3	3	25	75	100
Skill Enhancement Course -III	25UPBIT1S03	Bio-Entrepreneurship in Biotechnology	2	2	6	-	100	100
Extension Activity	25UPBIT1X01		-	1	-	-	--	--
Total			**30**	**19**	**--**	**--**	**--**	**600**
Final Total			**--**	**92**	**--**	**--**	**--**	**2700**

PATTERN OF QUESTION PAPER

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

Part A (20 x 1 = 20 marks)

20 Objective questions covering all units of the syllabus

Part B (3 x 5 = 15 marks)

3 Paragraph questions of 5 marks to be answered choosing any three out of five. Open choice pattern.

Part C (5 x 8 = 40 marks)

5 Paragraph questions of 8 marks to be answered choosing one each from each unit following either/or pattern

Internal: 25 Marks

Best two internal assessments out of 3	10 marks
Attendance	5 marks
Seminar	5 marks
Assignment	5 marks
Total	**25 marks**

The following procedure is followed for Internal Marks: Theory Papers & Practical

Internal: 40 Marks

Practical Tests 2 out of 3	20 marks
Practical Observation Note	5 marks
Attendance	5 marks
Record	5 marks
Viva-voce	5 marks
Total	**40 marks**

Break-up Details for Attendance

Category	Marks
91% to100%	5 marks
76% to 90%	4 marks
60% to 75%	3 marks
Below 60%	No marks

Core Paper-1 BIOCHEMISTRY & ENZYMOLOGY

Paper – 1				
Title of the paper	BIOCHEMISTRY & ENZYMOLOGY		Subject code: **25UPBITC01**	
Category of the course	Year	Semester	Credits	Hours
Core Paper	I	I	5	7

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. Additionally, the study of enzymology offers insights into enzyme structure, kinetics and functions, equipping students with essential knowledge of enzyme mechanisms and their clinical and industrial applications.

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 update the knowledge on Amino acids and Protein & To assess and appraise the role of Nucleic acids.
CO-4	Explain the basics of enzyme nomenclature and properties & Examine the equations of steady state kinetics
CO-5	To study the downstream processing of enzymes and compile the Industrial and Clinical applications of enzymes

SYLLABUS | Core Paper-1 | BIOCHEMISTRY & ENZYMOLOGY				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	pH, pK. Acid, base. Buffers- Henderson- Haselbach equation, buffer systems of blood. Carbohydrates: Classification – structure, physical and chemical properties and functions of biologically important monosaccharides, disaccharides, and polysaccharides. Carbohydrate metabolism: Glycolysis, oxidative decarboxylation, citric acid cycle, glycogenesis, glycogenolysis and gluconeogenesis.	10	CO1	K1&K2
II	Lipids: Classification - structure, physical and chemical properties of simple lipids - triglycerides, complex lipids - phospholipids and glycolipids and derived lipids - fatty acids and sterol. Lipid metabolism: Biosynthesis of fatty acids, triglycerols, phospholipids, glycol lipids. Cholesterol biosynthesis. Oxidation of fatty acids - alpha and β-oxidation.	10	CO2	K1, K2& K3

III	Amino acids: Classification - structure, physical and chemical properties of amino acids. Proteins: Classification - Orders of protein structure: Primary, secondary (α-helix, β-pleated sheet), tertiary, and quaternary structures. Nucleic acids: Structure and functions of DNA and RNA. Metabolism: Biosynthesis and catabolism of purine and pyrimidine.	10	CO3	K1, K2 & K3
IV	Enzymes: Introduction to enzymes, Classification and nomenclature. Enzyme catalysis: enzyme specificity and the concept of active site, determination of active site, factors affecting enzyme activity: substrate, pH, temperature, co-factors and coenzymes. Kinetics of catalysed reaction: Single substrate reactions, bisubstrate reactions, concept of Michaelis-Menten equation and line weaver burk plot. Inhibition of enzyme activity.	10	CO4	K1, K2 & K3
V	Theories on mechanism of catalysis: Mechanism of action of lysozyme, chymotrypsin, carboxypeptidase and DNA polymerase. Multienzymes system: Pyruvate dehydrogenase. Iso-enzyme action, co-enzymes. Enzyme regulation - modes for action of allosteric enzymes. Immobilized enzymes. Clinical and industrial applications of enzymes.	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.
- 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 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
- webarchive.mcdb.ucsb.edu/sears/biochemistry/info/website-
- www.lsbu.ac.uk/biology/enztech/
- www. lsbu.ac.uk/biology/enzyme/
- http://www.aetlted.com/tech/applications.html

Core Paper-2

GENETICS AND MOLECULAR BIOLOGY

Paper – 1				
Title of the paper	**GENETICS AND MOLECULAR BIOLOGY**		Subject code: **25UPBIT1C02**	
Category of the course	Year	Semester	Credits	Hours
Core Paper	I	I	5	7

Learning outcome:

On completing the course, the student will learn the basic concept of Mendalian and non-Mendelian inheritance patterns in plants and animals; Relate modern techniques to the understanding of genetics, Microbial genetic process like generation of mutants for genetic analysis as well as to get an in-depth understanding about the molecular genetics. appreciate the principles of gene expression and regulation in prokaryotic and eukaryotic cells. Apprise the importance of epigenetic and methylation systems in gene regulation. Understand the importance of DNA binding motifs in gene regulation.

Course outcomes:

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

CO-1	Understanding the basic concept of Mendalian and non-Mendelian inheritance patterns in plants and animals
CO-2	Relate modern techniques to the understanding of genetics; Microbial genetic process like generation of mutants for genetic analysis as well as to get an in-depth understanding about molecular genetics.
CO-3	Appreciate the principles of gene expression and regulation in prokaryotic and eukaryotic cells.
CO-4	Apprise the importance of epigenetic and methylation systems in gene regulation.
CO-5	Understand the importance of DNA binding motifs in gene regulation.

SYLLABUS | Core Paper-2 | GENETICS AND MOLECULAR BIOLOGY				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Mendelian principles: Dominance, Segregation and independent assortment. Mendelian Crosses and Punnett square. Incomplete dominance, Epistasis, Linkage and crossing over. Genetics of Eukaryotic Linkage and Linkage Mapping. Population genetics: Hardy-Weinberg equilibrium, genetic drift and speciation.	10	CO1	K1,K2& K3
II	Recombination: Plasmids-origin of replication, incompatibility. Mutations and genetic analysis – auxotrophic, conditional lethal, resistant mutants. Isolation, selection and replica plating of mutants – complementation and recombination test. Transformation, Transduction. Conjugation: F-factor and Mating types	10	CO2	K1,K2&K3

III	DNA as Genetic Material; DNA: Types and structure. DNA replication in prokaryotes and eukaryotes. DNA Repair Mechanisms: SOS, thymine dimerization, mismatch repair. Transposons: Early experiments of McClintock in maize. Insertion sequences in prokaryotes. Complex transposons (ex. Tn3, Tn5, Tn9 and Tn10). Mechanisms, control consequences and application of transposition by simple and complex elements	10	CO3	K1,K2&K3
IV	RNA: Types of RNA, RNA polymerase, and Promoters: classes and consensus sequences, Transcription factors. Transcription in prokaryotes and eukaryotes. Genetic Code. Translation: Steps; protein folding and Intracellular protein trafficking and targeting	10	CO4	K1 &K2
V	Regulation of gene expression in prokaryotes: Lactose and tryptophan; epigenetic regulation of gene expression in eukaryotes. DNA methylation – histone modification – acetylation and deacetylation, DNA binding motifs –Zinc finger, Leucine Zipper, HLH, and HTH	10	CO5	K1,K2& K3

References:

- Principles of Genetics- 8th Edition, Gardner, Simmons and Snustad, 2002.
- 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.
- Genetics of Population Hedrick P.W. Jones & Bartlett 4th Edition
- Daniel L. Hartl and Andrew G. Clark.Sinauer and Associates, Sunderland, MA, 2007. xv + 652 pp, ISBN-10: 0-87893-308-5.
- Benjamin Lewin. Genes XI.2013. Benjamin-Cummings Pub Co.
- Twyman, R.M. 2000. Advanced Molecular Biology: A Concise Reference. Garland/bios Scientific Publishers
- Larry Snyder, Wendy Champness.2002.Molecular Genetics of Bacteria. 2 nd Edn. Amer Society for Microbiology.
- The Cell- A Molecular Approach. 3rd Edition. Geoffrey M. Cooper, Robert E. Hausman, 2003.

Useful website

- https://teach.genetics.utah.edu/
- https://www.biologyonline.com/

PRACTICAL-I

Biochemistry & Enzymology, Genetics and Molecular Biology

Practical-I				
Title of the paper	PRACTICAL-I Biochemistry & Enzymology, Genetics and Molecular Biology		Subject code: **25UPBIT1L01**	
Category of the course	Year	Semester	Credits	Hours
Practical	I	I	4	6

Learning Outcome: The practical will establish a basic study skills on the subject will provide and improve the practical course knowledge in students about the laboratory experimental knowledge of genetics, molecular biology, Biochemistry and enzymology

Course outcomes:

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

CO 1	Study the methods of estimation of biomolecules
CO 2	Separation and estimation of proteins & Optimization of enzymes
CO 3	Isolate and analyze DNA, RNA & protein
CO 4	Critically analyze the isolated biomolecules
CO 5	Evaluate the quality and purity of DNA, RNA & Protein

SYLLABUS | PRACTICALS | PRACTICAL-I				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
	A) Biochemistry & Enzymology 1. Extraction of proteins (enzyme-catalase, amylase) from biological materials 2. Protein separation methods:-Ammonium sulphate Precipitation 3. SDS-PAGE for separation of proteins 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 8. Separation of sugars by Paper Chromatography 9. Separation of amino acids by Thin layer chromatography 10. Effect of pH, Temperature, Substrate concentration and enzyme concentration on catalase / amylase **(B) Genetics & Molecular Biology** 1. Agarose gel electrophoresis of DNA 2. Restriction digestion of DNA 3. Giant chromosome studies in Chironomous larvae 4. Cell counting and cell viability; 5. Meiotic study in flower bud, sand cockroach or grasshopper.	15	CO1 CO2 CO3 CO4 CO5	K3 & K4

	6. Subcellular fractionation and marker enzyme detection (mitochondria). 7. Preparation of single cell suspension from spleen and thymus. 8. Isolation of DNA from bacteria. 9. Isolation of DNA from plants. 10. Plasmid DNA isolation. 11. Radiation induced genetic damage assessment. 12. Chemical induced genetic damage assessment. 13. Preparation of metaphase chromosomes form blood. 14. Histochemical staining to localize proteins 15. Histochemical staining to localize carbohydrates 16. Histochemical staining to localize lipids.			

Elective Paper-1

BIOINSTRUMENTATION

Elective Paper – 1				
Title of the paper	BIOINSTRUMENTATION		Subject code: **25UPBIT1E01**	
Category of the course	Year	Semester	Credits	Hours
Elective Paper	I	I	3	5

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	Understanding of various types of Microscopic techniques
CO-2	Impart understanding on centrifugation instruments and techniques
CO-3	Separation of Biomolecules using electrophoretic techniques
CO-4	Analytical methods on Spectroscopic Analysis
CO-5	Understand the principle and applications and Radioisotope techniques

SYLLABUS | Elective Paper-1 | 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, Atomic Force Microscopy, Confocal Microscopy, FRET and Flow Cytometry.	7	CO1	K1 & K2
II	pH meter. Centrifugation: Principle and applications of various types of centrifugation, RCF, Density Gradient Centrifugation. 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, Immuno Electrophoresis (Immunofixation EP), Southern, Northern and Western Blotting. Electro blotting, PCR and RT-PCR, Microarray (DNA, Proteins)	7	CO3	K1, K2 & K3
IV	Spectroscopic Techniques: Theory and Application of UV and Visible Spectroscopy, Fluorescence Spectroscopy, Mass Spectroscopy, IR Spectroscopy NMR, Atomic Absorption Spectroscopy, X- ray Spectroscopy, Laser Spectroscopy, FT-IR spectroscopy.	7	CO4	K1,K2& K3
V	Radio-isotopic Techniques: Introduction to Radioisotopes, Uses and their Biological Applications, Radioactive Decay – Types and Measurement, Principles and Applications of GM Counter, Solid and Liquid Scintillation Counter, Autoradiography, 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
- Jefrey. 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-2

CELL BIOLOGY

Elective Paper – 2				
Title of the paper	CELL BIOLOGY		Subject code: **25UPBIT1E02**	
Category of the course	Year	Semester	Credits	Hours
Elective Paper	I	I	3	5

Learning Outcome:

This course will provide understanding about the cell structure and function of Prokaryotic and eukaryotic cells. Topics such as Cell transport, signaling and communication, cell division, cell cycle regulation, and cell mobility will empower the student in understanding the functioning of the cell with various applications such as cancer biology, immunology and nanotechnology

Course outcomes:

CO-1	Understand the Cellular Organization of Prokaryotes and Eukaryotes
CO-2	Understand the cellular transport of nutrients and other molecules
CO-3	Comprehensive view of components of cell communication and functioning
CO-4	Understand the mechanism of cell mobility
CO-5	Understand cell cycle and application in cancer

SYLLABUS | Elective Paper-2 | CELL BIOLOGY				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Molecular organization of prokaryotes and eukaryotes, Structure and function of peroxisomes and Nucleus. Structure and function of cell organelles: Mitochondria, chloroplast, golgi apparatus, lysosomes, endoplasmic reticulum and ribosomes	7	CO1	K1 & K2
II	Fluid Mosaic model. Gap junction, Tight junction and Desmosomes. Membrane transport: passive and facilitated diffusion, active transport, symport, antiport, ATPase, ABC transporters, ion channels and aquaporins. Intercellular communication	7	CO2	K3 & K5
III	Concept, ligands and receptors. Endocrine, paracrine and autocrine signaling. G protein coupled receptors, receptor kinases. Signal transduction: Cytoplasmic and nuclear receptors. Secondary Messengers: cAMP, Ca+, cGMP and Nitrous oxide	7	CO3	K3, K4 & K5
IV	Microtubules, Microfilaments, Intermediate filaments, Amyleoid fibers. Cell mobility: Endocytosis and Exocytosis. Proton pump	7	CO4	K3, K4 & K5
V	Mitosis, Meiosis, Cell Cycle: phases. Cell cycle regulation, checkpoints. Cell death: Apoptosis and necrosis	7	CO5	K1, K2, K3 & K4

Reference Books

- Bruce Alberts , Alexander Johnson , Julian Lewis, Martin Raff , Keith Roberts, Peter Walter. 2014. Molecular Biology of the Cell, 6th Edn . Academic Press. NewYork.
- E. D. P. De Robertis, E. M. F. De Robertis Jr. Cell and Molecular Biology 8th Ed., South Asian Edition. Lippincott, Williams and Wilkins.
- Gerald Karp. 2013. Cell and Molecular Biology: Concepts and Experiments, 7th Edn. Wiley.
- Geoffrey Cooper. 2013. The Cell: A molecular approach. 6th Edn. Sinauer AssociatesInc.
- Lodish, Baltimore et al. 2007. Molecular Cell Biology. 6th Edn. W.H. Freeman &Co.

Useful Websites

- https://library.stanford.edu
- http://www.cellbiol.com

Semester I Ends

II SEMESTER

Course Components	Course Code	Title of Course work	Inst. Hrs/ Wk	Credits	Exam Hrs	Marks		Total Marks
						Int	Ext	
SEMESTER - II								
Core Paper-3	25UPBIT1C03	Microbiology	5	5	3	25	75	100
Core Paper-4	25UPBIT1C04	Plant and Animal Biotechnology	5	5	3	25	75	100
Practical II	25UPBIT1L02	Practical – II Microbiology, Plant and Animal Biotechnology	6	4	6	40	60	100
Elective Paper -3/ Elective Paper -4 Discipline Centric	25UPBIT1E03/ 25UPBIT1E04	Regulatory Affairs and Industrial Standards / Pharmaceutical Biotechnology	3	3	3	25	75	100
Elective Paper -5 Generic Elective	25UPBIT1E05	Environmental Biotechnology	3	3	3	25	75	100
NME-I	25UPBIT1N01	MOOC	4	2	3	25	75	100
Skill Enhancement Course –I	25UPBIT1S01	Team Project	4	2	3	40	60	100
Compulsory Paper	23UPPGC1H01	Human Rights	-	1	3	25	75	100
Total			**30**	**25**	**--**	**--**	**--**	**800**

Core Paper-3

MICROBIOLOGY

Paper – 3				
Title of the paper	MICROBIOLOGY		Subject code: **25UPBIT1C03**	
Category of the course	Year	Semester	Credits	Hours
Core Paper	I	II	5	5

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-3 | MICROBIOLOGY				
Unit	**Content**	**Hours**	**Cos**	**Cognitive level**
I	History of microbiology: Major discoveries related to the field of microbiology: Antony Von Leeuwenhoek, Louis Pasteur, Robert Koch and Edward Jenner. Microbial taxonomy: Bacteria, viruses, fungi, algae and protozoa, Microbial diversity: Biovars, and Serovars. Microbial metabolism-Methanogenesis, acetogenesis and auxotrophs	10	CO1	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, Identification of bacteria: Staining methods - simple and differential, Biochemical - IMViC and 16s rRNA sequencing. Microbial growth: Growth curve and factors affecting growth– Heat, Filtration, Low Temperatures, High Pressure, Desiccation, Osmotic Pressure, Radiation; Chemical methods.	10	CO2	K2, K3, K5

III	Host microbe interaction. Symbiotic relationship of microbes: Symbiosis, Mutualism, Parasitism, Commensalism and endophyte. Human microbiome; Skin, Gastrointestinal tract, Oral cavity, Lung.	10	CO3	K1, K2, K3
IV	Microbial Diseases: General characteristics, pathogenesis, laboratory diagnosis and control measures of Pandemic and Epidemic diseases. Epidemiology of microbes: causes, types and transmission of epidemic - Cholera, Typhoid, Yellow Fever, Dengue; endemic - Tuberculosis, Leprosy and Malaria and pandemic - COVID-19, AIDS, Smallpox diseases: Tuberculosis, Leprosy, Cholera, Typhoid, COVID-19, Yellow Fever, Flu, AIDS, Ebola, Zika Virus, Smallpox, Dengue, Chikungunya, Malaria, filariasis, Candidiasis, superficial mycosis	10	CO4	K4 &K5
V	Agricultural and Environmental Microbiology: Biological nitrogen fixation, free living, symbiotic nitrogen fixation, mechanism of Nitrogen fixation, Biofertilizers- types and applications; Rhizosphere effect. Biogeochemical cycles-Carbon, Nitrogen, Sulphur and Phosphorous; Methanogenic bacteria Extremophiles- Thermophiles, Acidophiles, Halophiles and alkaliphiles; Biotechnological application of extremophiles	10	CO5	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-4

PLANT AND ANIMAL BIOTECHNOLOGY

Paper –4				
Title of the paper	PLANT AND ANIMAL BIOTECHNOLOGY		Subject code: **25UPBIT1C04**	
Category of the course	Year	Semester	Credits	Hours
Core Paper	I	II	5	5

Learning Outcome:

The paper imparts a thorough knowledge on the basics of all the biotechnological applications on plants 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 plants and animals to improve sustainability, productivity and suitability for agriculture, pharmaceutical and industrial applications.

SYLLABUS | Core Paper-4 | PLANT AND ANIMAL BIOTECHNOLOGY				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Introduction of plant tissue culture, composition of media, Micropropagation, organogenesis, somatic embryogenesis, haploid and triploid production, protoplast isolation and fusion, hybrid and cybrid, synthetic seed production. Secondary metabolites of plants using plant cell cultures: Glycosides, Flavonoids, Anthocyanins, Coumarins - Lignans, Terpenes, Volatile oils and Saponins; Carotenoids and Alkaloids. Role of Precursors and Elicitors in plant secondary metabolites.	10	CO1	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, Molecular Marker aided breeding: RFLP maps, Linkage analysis, RAPD markers, STS Mirco satellite, SCAR, QTL, Map based cloning and Molecular marker assisted selection.	10	CO2	K1, K2 & K5

III	Nutrient requirements of mammalian cells. Media for culturing cells. Growth supplements. Primary cultures. Established cell lines. Stationary and Suspension culture techniques. Characterization and maintenance of cells, cryopreservation and revival. Detection of contaminants in cell cultures. Cell viability and cytotoxicity.	10	CO3	K4 & K5
IV	Stem cells: Types - embryonic and adult, isolation, identification, expansion, differentiation and uses. Manipulation of reproduction in animals: Artificial insemination, in vitro fertilization and embryo transfer.	10	CO4	K2, K3, K4 & K5
V	Development of Herbicide, insecticide and disease resistant plants. Gene silencing and Seed terminator technology. Plant breeders and Farmers Right. Production of industrial and pharmaceutical products in plants and animals. Production of regulatory proteins, blood products, hormones and other therapeutic proteins in transgenic animals. Transgenic animals knockouts.	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, Textbook 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
- Carl Pinkert, 2014. Transgenic animal technology - A laboratory handbook, 3rd edition, Elsevier Inc.

PRACTICAL-II

Microbiology, Plant and Animal Biotechnology

PRACTICAL-II				
Title of the paper	PRACTICAL-II Microbiology, Plant and Animal Biotechnology		Subject code: **25BIT1L02**	
Category of the course	Year	Semester	Credits	Hours
Practical	I	II	4	6

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	Isolate and identify microbes from various sources.
CO-2	Characterize microbes.
CO-3	Examine Plant and Animal cells and their functions
CO-4	Assess extracted DNA, RNA and protein for rDNA technology
CO-5	To study cloning tools

SYLLABUS | PRACTICALS | PRACTICAL-II				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
A	**Microbiology-Practical** 1. Sterilization and media preparation 2. Streak plate method 3. Pour plate method 4. Spread plate method 5. Enumeration of total count of the bacteria 6. Isolation of microbes from soil 7. Isolation of microbes from water 8. Isolation of microbes from air 9. Isolation of microbes from plant surface 10. Isolation of pure culture of *E.coli* 11. Isolation of pure culture of *Aspergillus niger* 12. Gram staining and morphological characterization of microbes. 13. Negative staining of bacteria 14. Determination of growth curve of bacteria – *E.coli* 15. IMViC test of enteric bacteria **Plant and Animal Biotechnology – Practical** 1. Plant tissue culture - media preparation and sterilization	15	CO1 CO2 CO3 CO4 CO5	K1, K2, K3, K4, K5 & K6

	2. Generation of Callus from leaf/ root/bud 3. Maintenance of callus culture 4. Anther culture 5. Pollen culture 6. Embryo culture 7. Isolation of plant protoplast 8. Agrobacterium culture maintenance and isolation of plasmid DNA 9. Animal cell culture - media preparation and sterilization 10. Preparation of sera for animal cell culture 11. Preparation of single cell suspension from chicken liver/spleen 12. Trypsinization of cell culture 13. Cell counting and viability - staining of cells Vital Staining -Trypan blue, Erythrosin B, Giemsa staining			

Elective Paper-3

REGULATORY AFFAIRS AND INDUSTRIAL STANDARDS

Elective Paper – 3				
Title of the paper	REGULATORY AFFAIRS AND INDUSTRIAL STANDARDS		Subject code: **25UPBIT1E03**	
Category of the course	Year	Semester	Credits	Hours
Elective Paper	I	II	3	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-3 | REGULATORY AFFAIRS AND INDUSTRIAL STANDARDS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Planning, Organization and setting of Food testing laboratory and laboratory safety Laboratory setup requirements for defensible analytical data. Laboratory design, layout and air handling microbiological testing environment etc., Introduction to accreditation, Overview of accreditation bodies (NABL, APLAC, ILAC), ISO/IEC 17025:2017 standards, documentation, pre-requisites. Laboratory safety: Personnel hygiene, emergency planning, hazards management, safety equipment, storage of chemicals, handling and biological spills and waste disposal.	7	CO1	K2, K3, K4

II	Principles of Food Preservation Technology-Heat: Principles of Heat transfer, Blanching, Pasteurization, sterilization, cooking. Water Removal: Forms of Water, Sorption, drying and evaporation technology. Temperature reduction: chilling and freezing. Radiation: Ionizing Radiation and Microwave. Use of chemicals: Class-I & Class-II preservatives, smoke additives. New non-thermal methods: High hydrostatic pressure, modified atmosphere, pulsed electric, magnetic fields, hurdle technology, pulsed light, ultrasonic and ohmic heating etc.	7	CO2	K2 & K3
III	Principles of Food Packaging Technology- Effect of environment on food stability: light, oxygen, water, temperature, mechanical and biological factors. Different packaging materials food packaging: Glass, metals, paper, plastics, biodegradable and edible films and aseptic combinations. Packaging material and design for various food commodities tailored for fresh produce, 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. Packaging technologies- CAP/MAP, aseptic, irradiated, retort pouch and microwaveable packaging.	7	CO3	K2, K3 & K4
IV	Food Microbiology and testing: Introduction of Food microbiology: Classification, morphology of yeast, and molds, bacteria and viruses. Important genera of Gram-positive, Gram-negative, facultative aerobic, anaerobic, endospore-forming and non-sporulating bacteria. Microbial groups: lactic acid, acetic acid, butyric acid, thermophilic, proteolytic, saccharomyces etc, coliforms, enteric pathogens and emerging microbes. Sources of microorganisms: raw materials, water, air, equipment and microbiological quality. Microbial growth in foods: intrinsic (pH, Moisture content, antimicrobial constituents) and extrinsic parameters (temperature, humidity, gases). Thermal destruction of microorganisms: D Value, Z- Value, F-Value, thermal death time curve and 12 D Concept. Microbial food spoilage: food-borne diseases and food pathogens. Microbiological examination of foods: Sampling, isolation, culturing and pure culture maintenance. Observation of indicator organisms: Direct, enumeration (plate count, MPN), Rapid methods-detection of	7	CO4	K2, K3, K4

	specific microorganisms.			
V	HACCP and Food safety management systems - ISO 22000 and HACCP -Importance, application, principles and limitations. Food safety objectives (FSO). Food safety audits: Management review, audit certification and importance. Good manufacturing practices (GMP), Good hygienic practices (GHP), Food safety plan, traceability food product recalls and sanitation.	7	CO5	K2, K3 & K6

Reference

Food safety standards authority regulation 2011.

Elective Paper-4

PHARMACEUTICAL BIOTECHNOLOGY

Elective Paper-4				
Title of the paper	PHARMACEUTICAL BIOTECHNOLOGY		Subject code: **25UPBIT1E04**	
Category of the course	Year	Semester	Credits	Hours
Elective Paper	I	II	3	3

Learning Outcome

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

Course outcomes

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

SYLLABUS | Elective Paper-4 | PHARMACEUTICAL BIOTECHNOLOGY				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Pharmacology and Ethnopharmacology: Scope and Importance. Pharmaceutical biotechnology: Introduction, technologies in pharmaceutical biotechnology and industrial applications. Biosensors- Working principle and applications of biosensors in pharmaceutical Industries.	7	CO1	K1
II	Scientific, technical and economic aspects of vaccine research and development: Preparation of bacterial vaccines, toxoids, viral vaccine and antitoxins. Storage conditions and stability of vaccines. Recombinant DNA technology: Introduction and application of rDNA technology in the production of Interferon, Vaccine - hepatitis- B and Hormone - Insulin. Protein Engineering: Introduction and production of enzymes - General consideration –	7	CO2	K3 & K4

	Amylase, Catalase, Peroxidase, Lipase, Protease and 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 and Glutamic acid. Somatic gene therapy. Xenotransplantation in pharmaceutical biotechnology. Bio safety in pharmaceutical industry	7	CO3	K2
IV	Pharmacological activity of Plant derived drugs: Role of 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 structural 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 drug use. Mechanism of drug action: Pharmacodynamics - Therapeutic efficacy, Therapeutic index and tolerance. Factors affecting drug action. Dosage forms and routes of drug action. Adverse Drug reactions (ADR) and drug poisoning: Classification and causes of ADR; principle clinical manifestations and treatment of ADR. Management of drug poisoning: General principles of antidotes. Drug classification.	7	CO5	K1,K2&K5

Reference Books

- Harbanslal, 2011. Pharmaceuticals biochemistry. CBS Publishers and distributors Pvt. Ltd, Chennai.
- Carlos A. Guzmán and Giora Z. Feuerstein, 2009. Pharmaceutical Biotechnology, 1st edition, Springer.
- Daniel Figeys (Ed.). 2005. Industrial Proteomics: Applications for Biotechnology and Pharmaceuticals. Wiley, John & Sons, Incorporated.
- Kayser, O and Muller R.H.. 2004. Pharmaceutical Biotechnology Drug Discovery and Clinical Applications. WILEY-VCH
- Leon Shargel, Andrew B. C. Yu, Susanna Wu-Pong, and Yu Andrew B. C. 2004. Applied Biopharmaceutics & Pharmacokinetics. McGraw-Hill Companies
- Stefania Spada, Garywalsh. 2004. Directory of approved biopharmaceutical
- Gary Walsh. 2003. Biopharmaceutical, Biochemistry & Biotechnology.
- Heinrich Klefenz. 2002. Industrial pharmaceutical biotechnology.
- Thomas Lengauer (Ed.). 2002. Bioinformatics – from Genomes to Drugs. Volume I& II. Wiley-VCH.
- John F. Corpenter (editor), Mark C. Manning. 2002. Rational Design of stable formulation Theory and Practice (Pharmaceutical Biotechnology). Plenum, US. Ist 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-5

ENVIRONMENTAL BIOTECHNOLOGY

Elective Paper – 5				
Title of the paper	ENVIRONMENTAL BIOTECHNOLOGY	Subject code: **25UPBIT1E05**		
Category of the course	Year	Semester	Credits	Hours
Elective Paper	I	II	3	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	Explain the basic and legal views of Environment
CO-2	Understanding the design and mechanism of biofilm reactors
CO-3	Examine the techniques involved in remediation of polluted environments
CO-4	Gaining knowledge on various types of pollution & its control
CO-5	Compile biotechnological approaches to degrade xenobiotic compounds and assess the toxicity

SYLLABUS | Elective Paper-5 | 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	K1 & K2
II	Biofilm Kinetics: Completely mixed biofilm reactor-Soluble microbial products and inert biomass-Special-case biofilm solution. Biofilms and Biofilm Reactors-	7	CO2	K3 & K4

	Biofilm Reactor Design Approaches and Considerations- Moving Bed Biofilm Reactors-Biologically Active Filters-Expanded and Fluidized Bed Biofilm Reactors-Emerging Biofilm Reactors. Engineering design of reactors			
III	Waste water management, source and treatment of waste water, - physical, chemical and biological treatment. Microbiology of Waste water; Aerobic and anaerobic process, BOD and COD.	7	CO3	K4 & K5
IV	Toxicity: Types and Test for evaluating Toxicity. Biosensors, Biomonitoring of toxic materials Biomagnification, Biomining and Biofuels	7	CO4	K4 & K5
V	Bioremediation:*In-situ and Ex-situ* 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	K4 & K5

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.

Useful Websites:

- lbewww.epfl.ch/LBE/Default_E.htm
- http://lbe.epfl.ch

Extra disciplinary subject for other Department students (NME)

MOOC

NME Paper – 1				
Title of the paper	MOOC		Subject code: **25UPBIT1N01**	
Category of the course	Year	Semester	Credits	Hours
Extra disciplinary subject	I	II	2	4

SPECIAL ELECTIVE PAPER *

25UPBITSW1: BIODIVERSITY CONSERVATION

*(A special elective paper for students who have not completed a MOOC course)

Paper – SW 1				
Title of the paper	**BIODIVERSITY CONSERVATION**		Subject code: **25UPBITSW1**	
Category of the course	Year	Semester	Credits	Hours
Extra disciplinary subject	I	II	2	4

Learning Outcomes:

Completely read this paper student will learn following knowledge:

CO1	To learn about threats, values and current status of biological diversity in India and global level
CO 2	To understand the methods used for the study plant and animal diversity
CO 3	To learn the methods for studying microbial diversity in different environment
CO 4	e the mode of biodiversity conservation at global level
CO 5	To understand the laws and agreements that help protect biodiversity in India and the world.

SYLLABUS | BIODIVERSITY CONSERVATION				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Biodiversity: Definition, types, levels. values. Threats to biodiversity - Indian context and climate change impact. Biodiversity hotspots in India, IUCN red listed species. Climate change and biodiversity; Biodiversity of Indian subcontinent: biodiversity hotspots and their characteristics	7	CO1	K1,K2& K3
II	Plant and Animal Biodiversity: Techniques for assessing biodiversity in plants and animals; Diversity indices., Biotic communities in forest and ecosystems. Biotechnology tools for genetic diversity evaluation - molecular markers and DNA–Protein Profiling	7	CO2	K2,K3,K4
III	Microbial diversity: Microbes in different environments and their roles in ecosystems. Tools for assessing microbial diversity- basic and molecular methods. Techniques for preserving and conserving microbes	7	CO3	K2, K3,K5

IV	Biodiversity conservation strategies: *in situ* conservation: Biosphere reserve, sanctuaries, national parks, *ex situ* conservation: botanical garden, zoological garden, *in vitro* conservation: germplasm or gene bank, Global and indigenous approaches to biodiversity conservation	7	CO4	K2, K3,K4,K5
V	International Conventions: CBD, CITES, ITTA, UNFCCC, Kyoto Protocol, TRIPS, Ramsar Convention. Indian Biodiversity Regulations: Biodiversity Act 2002, Biodiversity Rules 2004, NBSAP, NBA. Protected Areas: Biosphere Reserves, Community Conservation Areas.	7	CO5	K2,K3,K4,K5

Suggested Books

1. Gaston, K.J and Spicer, J.I. 2004. Biodiversity: An Introduction. Blackwell Publishing Company, USA.

2. Richard. B. Primack. 1998. Essentials of conservation biology. Sinauer Associates, Inc. USA.

3. Ray S. and Ray A.K. 2010. Biodiversity and biotechnology. New central book Agency (P) Ltd. Kolkata

4. Agarwal, S.K. 2002. Biodiversity conservation. Rohini Publishers, Jaipur.

5. Nautiyal, S and Kaul, A.K. 1999. Forest Biodiversity and its conservation Practices in India. Oriental Enterprises, Dehradun.

6. Benson, E.E., 1999. Plant conservation Biotechnology. Taylor and Francis Ltd., London.

7. Sinha, P.C., 1998. Wildlife and forest conservation. Anmol Publication Pvt. Ltd, New Delhi. 13. Edward, O.G., 2004. *Ex situ* plant conservation. Island Press, Washington, DC

SKILL ENHANCEMENT COURSE (SEC - 1) PAPER – 1				
Title of the paper	Team Project		Subject code: **25UPBIT1S01**	
Category of the course	Year	Semester	Credits	Hours
Skill enhancement course	I	II	2	4

Compulsory Paper			
Title of the paper	Human Rights	Subject code: **25UPPGC1H01**	
Category of the course	Year	Semester	Credits
Compulsory Course	I	II	1

II SEMESTER END

III SEMESTER

Course Components	Course Code	Title of Course work	Inst. Hrs/ Wk	Credits	Exam Hrs	Marks		Total Marks
						Int	Ext	
SEMESTER – III								
Core Paper-5	25UPBIT1C05	Bioinformatics	5	5	3	25	75	100
Core Paper-6	25UPBIT1C06	Immunology	5	5	3	25	75	100
Core Paper -7	25UPBIT1C07	Bioprocess Technology	5	5	3	25	75	100
Practical III	25UPBIT1L03	Practical – III Bioinformatics, Immunology and Bioprocess Technology	6	4	6	40	60	100
Elective Paper - 6/ Elective Paper - 7 Discipline Centric	25UPBIT1E06/ 25UPBIT1E07	Nano Biotechnology / Molecular Developmental Biology	3	3	3	25	75	100
Internship/ Industrial Activity	25UPBIT1I01	Internship in Industries to Biotechnology Field (food / clinical trial/ dairy/ aqua sciences, pharmaceutical) CSIR/DBT/ DST research laboratories	-	2	3	-	100	100
NME - II	25UPBIT1N02	Applied Biotechnology	4	2	3	25	75	100
Skill Enhancement Course -II	25UPBIT1S02	Mini Project	2	2	6	40	60	100
Total			**30**	**28**	**--**	**--**	**--**	**800**

Core Paper-5

BIOINFORMATICS

Core Paper-5				
Title of the paper	BIOINFORMATICS		Subject code: **25UPBIT1C05**	
Category of the course	Year	Semester	Credits	Hours
Core Paper	II	III	5	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 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-5 | BIOINFORMATICS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Introduction to Bioinformatics, Scope and Applications, Introduction to Internet and Its Applications, Biological Databases – Nucleotide and Protein Databases (GenBank, EMBL, DDBJ, UniProt), Structure Databases (PDB, PDBSum, SCOP, CATH), Functional Databases (KEGG, Gene Ontology, Pfam, InterPro), Information Retrieval from Biological Databases, Molecular Visualization Tools – RasMol, PyMOL, Chime, Spdb Viewer.	10	CO1	K1 & K2

II	Concepts of Sequence Alignment – Match, Mismatch, Similarity, Scoring, Gap Penalty, Pairwise Sequence Alignment – Dot-matrix Alignment, Global (Needleman-Wunsch) and Local (Smith-Waterman) Alignment, Multiple Sequence Alignment – Progressive and Iterative Alignment Algorithms, Consensus Sequence, Patterns, and Profiles, Database Searching – Pairwise Alignment-based Methods (Smith-Waterman), Heuristic Algorithms (FASTA, BLAST, PSI-BLAST), Substitution Matrices – PAM and BLOSUM.	10	CO2	K2,K3 & K5
III	Protein Structure Prediction – Secondary Structure Prediction (Chou-Fasman, GOR Method), Fold Recognition, Homology Modeling, Structure Alignment and Comparison – VAST, DALI, Structural Biology Techniques – X-ray Crystallography, NMR Spectroscopy, Cryo-EM, Molecular Docking and Structure-Based Drug Discovery, Structure Alignment for Drug Target Identification.	10	CO3	K2 & K5

IV	Big Data Analysis in Genomics – DNA/RNA/Protein Sequences, Gene Expression, Protein-Protein Interaction (PPI) Data, Genome Sequencing and Assembly – Whole-Genome Sequencing, EST Clustering, Gene Prediction in Prokaryotes and Eukaryotes, Regulatory Sequence Analysis – Promoter and Motif Discovery, Genome Maps and Variation Analysis, Bioinformatics for Microarray Data and Transcriptional Profiling.	10	CO4	K4 & K5
V	Bioinformatics for Metabolic Reconstruction and Pathway Analysis, Gene Ontology (GO) and Functional Annotation, Phylogenetics and Evolutionary Analysis, Medical Bioinformatics – Disease Gene Identification, Drug Discovery Process – Target Identification and Validation, QSAR, ADME, Preclinical Pharmacology and Toxicology, Rational Drug Design, Computer-Aided Drug Design – Ligand-based and Target-based Approaches.	10	CO5	K3,K4 & K6

Reference Books:

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

Core Paper-6

IMMUNOLOGY

Core Paper-6				
Title of the paper	IMMUNOLOGY		Subject code: **25UPBIT1C06**	
Category of the course	Year	Semester	Credits	Hours
Core Paper	II	III	5	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, and vaccine development.

Course outcomes

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

CO-1	Illustrate various mechanisms that regulate immune responses and maintain tolerance
CO-2	Describe key events and cellular players in antigen presentation, and how the nature of the antigen will shape resulting effector responses
CO-3	Learn the concepts of cellular and molecular processes that represents the human immune system.
CO-4	Elucidate the role of immunological regulation and tolerance at a cellular and molecular level
CO-5	Compile concepts on immunological principles and diagnosis

SYLLABUS | Core Paper-6 | 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. Basics / introduction to Humoral and Cell Mediated Immune response. Cells and organs of the immune system. Hematopoiesis and differentiation of lymphocytes.	10	CO1	K1 & K2
II	Lymphocyte- sub-populations of mouse and man. Antigen Presenting Cells, lymphokines, Phagocytic cells, macrophage, dendritic cells, T Cells - TH, Tc 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 for children. Role of MHC antigens in immune response, 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: Type I, II, III and Delayed type hypersensitivity reaction. Complement system - introduction, mode of activation, classical, alternative and lectin pathways. Biological functions of C proteins.	10	CO4	K4 & K5

V	Immunotechniques- Principle and Applications: Immunodiffusion, Immunofluorescence, In-Situ 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, Cell mediated immunity techniques and Immunotherapy.	10	CO5	K3,K4 & K6

Reference Books:

- K.M.Murphy, C.Weaver, Leslie J Berg, Janeways's Immunobiology 10th Edition Norton & Co. New York, USA. .2022.
- Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt, Essential Immunology. 13th edition Wiley-Blackwell. USA 2011.
- Abbas, A.K., A.H.L. Lichtman and S.Pillai, 2021. Cellular and Molecular Immunology. 10th Edition. Saunders Elsevier Publications, Philadelphia.
- Jenni Punt, Sharon A Stanford, Particia P Jones and Judith A Owen. 2019.Kuby Immunology, 8th edition, W. H. Freeman & Company.

Useful Websites:

- www.library.csusm.edu/course guides/biology
- www.immunologylink.com
- http://www.wiley.com/college/bio/karp12791/weblinks.html

Core Paper-7

BIOPROCESS TECHNOLOGY

Core Paper-7				
Title of the paper	BIOPROCESS TECHNOLOGY		Subject code: **25UPBIT1C07**	
Category of the course	Year	Semester	Credits	Hours
Core Paper	II	III	5	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	Outline the basis of Bioprocess Engineering and food safety measures
CO-2	Relate reactors in fermentation
CO-3	Differentiate fermentation processes
CO-4	Assess Scale up and Scale down
CO-5	Compile the output of fermentation processes

SYLLABUS | Core Paper-7 | 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. Food Safety: Introduction to food safety aspects and food related hazards – HACCP and ISO.	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 Micro-organisms, 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, supercritical fluid extraction.	10	CO3	K2 & K5
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

Reference Books:

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

Useful Websites:

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

PRACTICAL-III

Bioinformatics, Immunology & Bioprocess Technology

PRACTICAL				
Title of the paper	PRACTICAL-III Bioinformatics, Immunology & Bioprocess Technology		Subject code: **25UPBIT1L03**	
Category of the course	Year	Semester	Credits	Hours
Practical	II	III	4	6

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	To learn the Bioinformatics tools for sequence retrieval and Alignment
CO-2	To apply the learned tools for various applications
CO-3	To isolate, identify & enumerate immune cells
CO-4	To learn the technique of immunodiagnostics
CO-5	To study upstream & downstream techniques

SYLLABUS | PRACTICALS | PRACTICAL-III				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
A	**(A) Bioinformatics-Practical**	15	CO1	K1,K2,K3,K4

	1. Sequence retrieval from Genbank 2. Sequence retrieval from Uniprot. 3. Sequence identity search- Sequence similarity search using BLAST 4. Sequence similarity search using FASTA 5. Sequence similarity search using PSI BLAST 6. Sequence similarity search using PHI- BLAST. 7. Prediction of signal sequence using SignalP online tool 8. Pattern Search (Domains & Motifs) using Pfam 9. ORF gene Search - Genscan 10. Sequence translation using ExPASy translate tool 11. Characterization of retrieved protein sequence by ProtParam tool. 12. Pair-wise global sequence alignment using EBI-EMBOSS Needleman Wunsch tool 13. Pair-wise local sequence alignment using EBI-EMBOSS Smith Waterman tool 14. Multiple sequence alignment using EBI-CLUSTALW2. 15. PHYLOGENY- Phylogenetic tree using PHYLIP. 16. Prediction of secondary protein structure using GOR (Garnier Osguthorpe-Robson) server. 17. Prediction of tertiary protein structure using SWISS-MODEL Server 18. Validation of the predicted structure using PROCHECK server 19. Molecular visualization of proteins using RASMOL. 20. Docking of small molecule with protein structure using Hex software. 21. Docking of two proteins using PatchDock (Protein-Protein docking) tool. 22. Retrieval of E.Coli glycolytic pathway from KEGG		CO2 CO3 CO4 CO5	&K5
B	**(B) Immunology - Practical** 1. Identification of various immune cells from human peripheral blood. 2. Lymphocyte separation and identification 3. Determination of lymphocyte viability by trypan blue method 4. WBC counting 5. Preparation of serum and plasma 6. Electrophoretic profile of human serum in native PAGE 7. Preparation of cellular antigen – human RBC 8. Preparation of antigen-adjuvent mixture for production of polyclonal antibody 9. Isolation of IgG molecule from serum	15	CO1 CO2 CO3 CO4 CO5	K2,K3,K4

	10. Immunodiagnostics: CRP 11. Immunodiagnostics: ASO 12. Immunodiagnostics: Widal 13. Immunodiagnostics: RA 14. Immunodiagnostics: Blood grouping and typing 15. Immunodiagnostics: hCG 16. ELISA 17. Radial Immunodiffusion 18. Ouchterlony Immunodiffusion 19. Immunoelectrophoresis 20. Rocket electrophoresis 21. Counter current immunoelectrophoresis. 22. Bioassays for cytokines 23. Radioimmunoassays (Demonstration)			
C	**(C) Bioprocess Technology - Practical** 1. Parts and design of fermenter 2. Solid state fermentation 3. Submerged fermentation 4. Foaming and antifoaming agents 5. Media preparation and sterilization 6. Isolation of industrially important microorganisms for microbial processes. 7. Conservation of Bacteria by Lyophilization. 8. Production and estimation of protease 9. Production and estimation of amylase. 10. Production of wine using grapes 11. Production of penicillin 12. Determination of penicillin activity 13. Citric acid production 14. Use of alginate for cell immobilization. 15. Media standardization (C:N ratio) for maximum biomass production of an industrially important microorganism. 16. Cell disruption (Sonication) 17. Aqueous Two Phase Extraction of enzymes	15	CO1 CO2 CO3 CO4 CO5	K2,K3,K4 & K5

Elective Paper-6

NANO BIOTECHNOLOGY

Elective Paper-6				
Title of the paper	NANO BIOTECHNOLOGY		Subject code:**25UPBIT1E06**	
Category of the course	Year	Semester	Credits	Hours
Elective Paper	II	III	3	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-6 | NANO BIOTECHNOLOGY				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Nanotechnology: Introduction, Scientific revolution and Emergence. Feynman's vision. Classification of nanobiomaterials: Types of nanomaterials – nanoparticles, nanotubes, nanowires, Nanofibers. Size dependent variation in the properties of Nanomaterials, Nature's Nanophenomena.	7	CO1	K1
II	Preparation of Nanomaterials, Top down and bottom up approaches, Biosynthesis, nanobiomaterials - Polymer, Ceramic, metal based nanomaterials and Carbon based nanomaterials in tissue engineering, DNA based Nanostructures, Protein based Nanostructures, Quantum dots, Magnetic Nanoparticles, Nanofibres, Hydrogels, Films and nanocomposites.	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, Nanoparticles in Mammalian systems and Health threats, Biological response and cellular interaction of implant materials and scaffolds, Risk assessment and Safety Regulation of nanoparticles.	7	CO5	K5

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. Pvt. Ltd. 2011.
- Oded Shoseyov (Editor), Ilan Levy, 2010. NanoBioTechnology: BioInspired Devices and Materials of the Future, Humana Press.
- Chad A. Mirkin and Christof M. Niemeyer, 2007. Nanobiotechnology II: More Concepts and Applications, Wiley-VCH.
- ChallaS.S.R.Kumar (Ed). 2006. Biologicals and pharmaceutical nanomaterials, Wiley-VCH Verlag Gmbh& Co, KgaA.
- K.K.K.Jain 2006. Nanobiotechnology in Molecualr Diagnostics: Current Techniques and Applications Horizon Bioscience
- Niemeyer, C.M., Mirkin, C.A. (Eds). 2004. Nanobiotechnology Concepts, Applications and Perspectives, Wiley-VCH, Weinheim.
- Andrze w. Miziolek, Shashi P.Karna, J malthew Mauro and Richard A.Vaia. 2005 Defense Applications of Nanomaterials :
- Springer Handbook of Nanotechnology- Ed. by B. Bhushan, Springer-Verlag (2004)
- The Chemistry of Nanomaterials: Synthesis, Properties and Applications, C.N.R. Rao, A. Muller, A. K. Cheetham (Eds), Wiley-VCH Verlag (2004)
- Nanomaterials for medical diagnosis and therapy, Challa Kumar, Wiley-VCH, 2007.
- Nanotechnology for cancer therapy, Mansoor M. Amiji, CRC Press, 2007.
- K.K.Jain, Nano Biotechnology, Horizions Biosciences, 2006
- Nanomaterials: An introduction to synthesis, properties and application, Dieter Vollath, Wiley VCH, 2008
- Cato T. Laurencin and Lakshmi S. Nair, Nanotechnology and Tissue Engineering The Scaffold, CRC Press taylor& Francis Group.
- Introduction to Nanoscience and Nanotechnology, Gabor .L et al, Fundamentals of Nanotechnology, Hornyak, G. Louis, Tibbals, H. F., Dutta, Joydeep, CRC Press, 2009.
- Assessing Nanoparticle Risks to Human Health, 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-7

MOLECULAR DEVELOPMENTAL BIOLOGY

Elective Paper-7				
Title of the paper	MOLECULAR DEVELOPMENTAL BIOLOGY		Subject code: **25UPBIT1E07**	
Category of the course	Year	Semester	Credits	Hours
Elective Paper	II	III	3	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-7 | 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 neural tube, myogenesis, and hematopoiesis. Mechanism of vertebrate eye development	7	CO4	K2
V	Drosophila Maternal effect genes, induction at single	7		K1 & K4

	cell level - differentiation of photoreceptors in ommatidia. Developmental disorders Spina bifida, Anenecephaly, and craniorachischis, Cyclopia, Thanotrophic dysplasia		CO5	

Reference Books:

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

Useful Websites:

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

INTERNSHIP/ INDUSTRIAL ACTIVITY

Summer Internship				
Title of the paper	INTERNSHIP	Subject code: **25UPBIT1I01**		
Category of the course	Year	Semester	Credits	Hours
Paper	II	III	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	Understand the working principles and the techniques of various processes
CO-2	Apply standard operating procedures followed in industries
CO-3	Prepare to face challenges & gain confidence in the field of study.
CO-4	Critically assess the utilization of sophisticated instruments and expensive consumables
CO-5	Develop work ethics to be followed in a scientific laboratory

Extra disciplinary subject for other Department students (NME)
APPLIED BIOTECHNOLOGY

NME Paper – 2				
Title of the paper	APPLIED BIOTECHNOLOGY		Subject code: **25UPBIT1N02**	
Category of the course	Year	Semester	Credits	Hours
Extra disciplinary subject	I	II	2	4

Learning Outcomes:

- Completely read this paper student will learn following knowledge:

CO-1	This paper provides an in-depth scope and significance of various ecotechnological applications
CO-2	The student will gain knowledge in production and utilization of the Biofuel for commercial application
CO-3	To learn the techniques for production of vermiculture, sericulture and biofertilizers.
CO-4	To gain the basic knowledge on aquaculture and design for aquafarms.

SYLLABUS | NME-II| APPLIED BIOTECHNOLOGY				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Vermiculture: Vermicomposting - Definition and methods - pit method, heap method and indoor method. Factors affecting vermicomposting: pH, moisture, temperature, nutritional value of feed. Application of vermicompost in agricultural and horticultural practices.	7	CO1	K1,K2& K5
II	Sericulture: Silkworm - life cycle. Rearing programme-hatching, feeding, cleaning and spacing, care at mounting. Environmental conditions: Leaf quality-rearing early age silkworms- rearing late age silkworms-mounting and harvesting. Process of stifling: Reeling techniques- process of reeling- methods of collection of silk.	7	CO2	K3,K4

III	Biofertilizers: Definition, Types-Rhizobium, Azotobacter, Azospirillum and Mycorrhizal Biofertilizers. Mass production and formulation of Biofertilizers. Biofertilizers in Sustainable Agriculture and Organic Farming. Nano-Biofertilizers	7	CO3	K2, K3,K5
IV	Aquaculture: Definition, scope and significance. Aquaculture systems -Extensive, Semi-Intensive, Intensive, and Raceway Cultures. Freshwater vs. Marine Aquaculture. Fish nutrition and feeding habits - Herbivores, carnivores, omnivores and feeding strategies. Aqua farms: Design and construction. Selection of cultivable species - choosing fish for aquaculture. Recent advancements in aquaculture technology.	7	CO4	K2, K3,K4,K5
V	Biofuel: Bioenergy sources – Sugar waste, Starch waste, Lignocellulosic waste, livestock waste Categories - Biodiesel: Source & production; Biogas: Source & production; Bioethanol: Source & production.	7	CO5	K1,K3 & K4

Reference Books:

- Ranganathan, L.S., 2006. Vermitechnology from soil health to human health, Agrobios (India), Agrohoude, Chopasani Road, Jodhpur.
- Ramalingam, R., 2007. Vermiculture. Tamil Nadu State Council for Higher Education (TANCHE), Chennai.
- Ramakrishnan Iyer, T.V., 1984. Handbook of economic entomology for South India. International Books and periodicals Supply Service, New Delhi.
- Fenemar, P.G. and Alka Prakash, 1992. Applied entomology. Wiley Eastern Ltd., New Delhi.
- Kaushik. B.D. Deepak Kumar. Shamim. Md. 2019. Biofertilizers and Biopesticides in Sustainable Agriculture. 1st Edition. Apple Academic Press. USA.
- Pillay. T.V.R. and M.N. Kutty, 2005. Aquaculture – Principles and Practices, Black Well Sciences, U.K.
- Joachim W. Hertrampf and Felicitas Piedad-Pascual. 2000. Handbook on ingredients for aquaculture feeds. Kluwer Academic Publishers, London.
- Damian Price. 2017. Biodiesel Production Processes and Technologies. Larsen and Keller Education. USA.
- Alemayehu Gashaw. Solomon Libsu. 2016. Biodiesel, Bio-Ethanol and Biogas as an Alternative Fuels. American Academic Press. USA

SKILL ENHANCEMENT COURSE (SEC - II) Paper – 2				
Title of the paper	Mini Project		Subject code: **25UPBIT1S02**	
Category of the Course	Year	Semester	Credits	Hours
Skill Enhancement Course	II	III	2	2

III SEMESTER END

IV SEMESTER

Course	Course Code	Title of Course work	Inst. Hrs/	credits	Exam hrs	Marks		Total Marks
Components						**Int**	**Ext**	
SEMESTER – IV								
Core Paper-8	25UPBIT1C08	Research Methodology	6	5	3	25	75	100
Project-1	25UPBIT1P01	Dissertation/ Project with Viva-voce	18	8	6	60	240 (40-work book, 150 Dissertation +50-Viva)	300
Elective Paper -6	25UPBIT1E08/ 25UPBIT1EB06	Stem Cell Biology/ Bioethics, Biosafety, Clinical Trials, IPR & Entrepreneurship	4	3	3	25	75	100
Skill Enhancement Course –III	25UPBIT1S03	Bio-Entrepreneurship in Biotechnology	2	2	6	--	100	100
Extension Activity	25UPBIT1X01		-	1		-	--	--
Total			**30**	**19**	**--**	**--**	**--**	**600**

Core Paper-8

RESEARCH METHODOLOGY

Core Paper-8			
Title of the paper	RESEARCH METHODOLOGY		Subject code: **25UPBIT1C08**
Category of the course	Year	Semester	Credits
Core Paper	II	IV	5

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 proposals 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-8 | RESEARCH METHODOLOGY				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Introduction to Research, Objectives and Types of Research - qualitative and quantitative research, Types of Research Design - Experimental, Correlational and Descriptive. Review of Literature - Importance, Process of Conducting Review of Literature, Sources of Literature, Summarising and Synthesising the existing research. Formulating Hypothesis - Null and Alternate Hypothesis and its importance in research. Sampling Methods-Types (Random, Stratified, Cluster, Convenience). Collection of Data - Surveys, interviews, observations, experiments, and questionnaires. Pros and cons of each method. Ethical Considerations: Ethical issues in research, informed consent, confidentiality, and research integrity.	10	CO1	K1
II	Writing the Research Report (Thesis and publications): Components of Research report - Title, Authors, Addresses, Abstract, Keywords, Introduction, Review of literature, , Aim and Objectives, Materials and Methods, Results, Discussion, Summary, Acknowledgements and Bibliography	10	CO2	K2 &K6
III	Collection and classification of data: diagrammatic and graphical representation of data. Measures of central tendency; Measures of deviation; Hypothesis testing Parametric and nonparametric Test; Student t test; Correlation and regression; Chi square test; One Way ANOVA and Post-hoc tests	10	CO3	K3
IV	Spreadsheet Tool (Microsoft Excel): Introduction to spreadsheet application, Using formulas and functions, Data storing, Features for Statistical data analysis, Generating graphs. Presentation Tool (Microsoft Powerpoint): Introduction to presentation tool, features and functions, Creating presentation, Customizing presentation, Showing presentation.	10	CO4	K1 & K4
V	Plagiarism Tools for Thesis and Manuscript. Using Google Drive for Preparing your reports - google docs, google excel, PowerPoint. Reference Manager - Mendeley and EndNote. Search Engines and their Importance in Research - Google, Yahoo, SCOPUS, Clarivate Analytics, PubMed. Use of Boolean Expression in Searches. Ethical Issues Regarding the Use of AI in Research Writing for Journals and Dissertations. Important Scientific Publishing Houses - Elsevier, Springer Nature, CRC Press , Wiley	10	CO5	K1 & K2

Reference Books:

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

Useful Websites

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

PROJECT-1				
Title of the paper	DISSERTATION		Subject code: **25UPBIT1P01**	
Category of the course	Year	Semester	Credits	Hours
Core Paper	2nd	4th	8	18

PROJECT-1

DISSERTATION

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-8

STEM CELL BIOLOGY

Elective Paper-8			
Title of the paper	STEM CELL BIOLOGY	Subject code: **23UPBIT1E08**	
Category of the course	Year	Semester	Credits
Elective Paper	2	4	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-8 | 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	7	CO1	K1
II	Stem cell niche, Niche specification - Drosophila germ line stem cells. Receptors, genes and markers of stem cells	7	CO2	K1 & K2
III	Stem cell isolation and culture techniques. Characterization of stem cells	7	CO3	K3, K4
IV	Cell cycle. Chromatin modification and transcriptional regulation, chromatin modifying factors, Chromosomal inactivation. JAK -STAT pathway, Ras\Raf pathway, PI3K cell signaling, p53 check points, Role of LIF pathway in cell cycle control	7	CO4	K3,K3 & K5
V	Therapeutic application of stem cells, Embryonic stem cells, Bone marrow stem cells, Adipose derived stem cells and Hematopoietic stem cells. Bio-safety and bio-ethics in human stem cell research as per ICMR guidelines.	7	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-9

BIOETHICS, BIOSAFETY, CLINICAL TRIALS, IPR & ENTREPRENEURSHIP

Elective Paper-9			
Title of the paper	BIOETHICS, BIOSAFETY, CLINICAL TRIALS, IPR & ENTREPRENEURSHIP	Subject code: **25MBTEB09**	
Category of the course	Year	Semester	Credits
Elective Paper	2	4	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-9 | 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 pertaining to Genetically modified foods & food crops, Organisms and their possible health implications and mixing up with the gene-pool. Bioethics in Medicine Protocols of ethical concerns related to prenatal diagnosis, gene therapy, Organ transplantation, Xenotransplantation, Containment facilities for genetic engineering experiments, regulations on field experiments and release of GMO`s labeling of GM foods.	10	CO1	K2,K3 & K4

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 - CCSCA guidelines, 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: Ideation, registration, implementation, finances and marketing	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 AjitParulekar, 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
- Ganguli P, (2001), Intellectual Property Rights, Tata Mcgraw Hill.
- Ramesh Chandra, (2004), Issues Of Intellectual Property Rights, Isha Books
- 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.
- EladHarison (2008). Intellectual Property Rights, Innovation and Software Technologies. Edward Elgar Publishing Limited, UK.

SKILL ENHANCEMENT COURSE (SEC - III) Paper – 3				
Title of the paper	Bio-Entrepreneurship in Biotechnology		Subject code: **25UPBIT1S03**	
Category of the course	Year	Semester	Credits	Hours
Skill Enhancement Course	II	IV	2	2

Learning Outcome:

Students will be able to Gain knowledge in selling their biotechnological innovative ideas. Find problems worth solving in entrepreneurial setup Mobilize people and resources Add value for their innovation by company formation, Social Innovation and Intellectual property Licensing.

Course Outcome:

CO-1	To learn the basic elements of Entrepreneurship and Bio-Entrepreneurship skill development
CO-2	To gain fundamental knowledge on becoming a bioentrepreneur and legal steps for establishing a biotech company/industry.
CO-3	To learn the elements and development of HR and its role in the success of an industrial sector.
CO-4	To gain the skills related to marketing strategies of new biotech products and management of IPR
CO-5	To gain the knowledge on the funding agencies for establishment of new biotech industry/company

SYLLABUS | SKILL ENHANCEMENT COURSE (SEC - III) Paper – 3 **Bio-Entrepreneurship Skill in Biotechnology**				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Entrepreneurship and Bioentrepreneurship - Scope and Importance – Characters and Skills of Bioentreprenuer, Organization chart, Process, competencies, opportunités and avenues. Types of Bio-industries, Strategy and operation of bio-sector firms. Entrepreneurial motivation	7	CO1	K2,K3 & K4

II	Entrepreneurship in Biotechnology-Profiling of Bioentrepreneur, Elements - problem identification, idea generation, innovation, idea transformation and assessment. Entrepreneurial planning, Taxation and Legalization steps for establishing a biotech company.	7	CO2	K3, K4 & K5
III	Human Resource management: Workflow strategy, functions of HRM, Recruitment, Training and Development process of human resources. Government initiatives in India: Biotech Parks, Technology Business incubators, Startup India & Startup Tamil Nadu.	7	CO3	K3,K4 & K5
IV	Bio-Product Marketing: Value chain, business models, process of commercialization, Product lifecycle, Management of IPR- patents, Trademarks, Trade secrets. National and international agencies for marketing of biotech products	7	CO4	K4, K5 & K6
V	Schemes for Funding: DBT-Biotechnology Industry Partnership Program (BIPP), Small Business innovation Initiative (SBIRI), Biotechnology ignition Grant (BIG). DST- Promoting Innovations in individuals, startups and MSMs (PRISM), DSIR- Patent Acquisition and collaborative research and Technology Development (PACE). Schemes of the Ministry of Micro, Small and Modern Enterprises.	7	CO5	K4,K5 & K6

Reference Books/Journals/Report:

- National Biotechnology Development Strategy – Promoting Bioscience Research education and entrepreneurship. Department of Biotechnology, Govt. of India (2015)
- Report of the Expert committee on Innovation and Entrepreneurship, NITI Aayog, New Delhi, Aug, 2015.
- Damian Hine, John Kapeleris, 2006. Innovation and Entrepreneurship in Biotechnology – An international Perspective- Concepts, theories and Cases.
- Mark J Ahn, and Michael Meeks, 2008. Building a conducive environment for life Science –based entrepreneurship and industry clusters. Journal of Commercial Biotechnology 14 (1): 20-30.

EXTENSION ACTIVITY

Title of the paper	Extension activity		Subject code:**25UPBIT1X01**	
Category of the course	Year	Semester	Credits	Hours
Extension activity	II	IV	1	--

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