

பெரியார் பல்கலைக்கழகம், சேலம்

PERIYAR UNIVERSITY

**(State University-NAAC A++ Grade-NIRF 94, State Public
University Rank 40-SDG Institutions Rank Band-11-50)**

Salem - 636011, Tamil Nadu, India



M.Sc., Biotechnology

SYLLABUS

FROM THE ACADEMIC YEAR

2026-2027

Programme Outcomes (POs)

Programme Outcome (PO)	Outcome Description
PO1 – Problem Solving Skill	Apply biological and biotechnological knowledge to analyze and solve scientific and industrial problems.
PO2 – Decision Making Skills	Make informed decisions in biotechnology research, laboratory practices, and industrial applications using scientific evidence.
PO3 – Ethical Values	Practice biotechnology with integrity while adhering to biosafety, biosecurity, and ethical standards.
PO4 – Communication Skill	Communicate biotechnology concepts, research findings, and technical information effectively to scientific and non-scientific audiences.
PO5 – Individual and Team Leadership Skill	Work independently and collaboratively in multidisciplinary biotechnology laboratories, research, and industrial teams.
PO6 – Employability Skill	Develop technical, analytical, and professional skills required for careers in biotechnology, healthcare, pharmaceuticals, agriculture, and related industries.
PO7 – Entrepreneurial Skill	Apply innovation and biotechnology knowledge to develop sustainable products, processes, and start-up ventures.
PO8 – Contribution to Society	Utilize biotechnology to address societal challenges in healthcare, agriculture, food security, and environmental sustainability.
PO9 – Multicultural Competence	Collaborate effectively with professionals from diverse cultural and scientific backgrounds in global biotechnology initiatives.
PO10 – Moral and Ethical Awareness	Demonstrate ethical reasoning and social responsibility in biotechnology research, innovation, and the application of emerging technologies.

Programme Specific Outcomes

Programme Specific Outcome (PSO)	Description (Single Line)
PSO1 – Placement	Acquire theoretical knowledge and practical skills for employment in biotechnology industries, healthcare, research, and academia.
PSO2 – Entrepreneurship	Develop innovation and entrepreneurial skills to establish and manage biotechnology-based enterprises.
PSO3 – Research and Development	Apply advanced biotechnological techniques and research methodologies for scientific investigation and higher studies.
PSO4 – Contribution to Industry	Utilize biotechnology knowledge to enhance industrial production, quality assurance, and product development.
PSO5 – Contribution to Society	Apply biotechnology and emerging technologies, including artificial intelligence, to promote sustainable development and improve societal well-being.

K- Level	Cognitive Level	Description
K1	Knowledge	Recall and remember facts, definitions, concepts, and basic information.
K2	Understanding	Explain ideas or concepts and demonstrate comprehension.
K3	Practice (Application)	Apply knowledge and skills to solve problems or perform tasks.
K4	Analysis	Analyze information by breaking it into parts and examining relationships.
K5	Evaluating	Make judgments based on criteria and evidence.
K6	Creation	Create, design, or produce something new by integrating knowledge and skills.

CREDITS DISTRIBUTION (Post -Graduate Courses)
M.Sc., Biotechnology- Admitted in 2026-2027 Onwards

First Year- Semester – I

Part	List of Courses	Credits	No. of Hours
Core -I	Cell and Developmental Biology	5	6
Core- II	Biochemistry	5	6
Core- III	Microbiology	5	6
Core Practical -I	Lab in Cell and Developmental Biology, Biochemistry and Microbiology	4	6
Elective -I	*Any one of the following 1. Bioinstrumentation 2. Enzymology	3	4
Skill Enhancement Course-I	Food Science and Technology	2	2
		24	30

First Year- Semester –II

Part	List of Courses	Credits	No. of Hours
Core-IV	Molecular Biology	5	6
Core-V	Genetic Engineering	5	6
Core- VI	Immunology	5	6
Core Practical-II	Lab in Molecular Biology, Genetic Engineering and Immunology	4	6
Elective-II	*Any one of the following 1. Pharmaceutical Biotechnology 2. Genomics and Proteomics	3	3
Non-Major Elective-I	*NME to be opted from the course offered from other department paper	2	2
Common Paper	Human Rights	1	1
		25	30

Second Year- Semester- III

Part	List of Courses	Credits	No. of Hours
Core-VII	Plant and Animal Biotechnology	5	6
Core-VIII	Bioinformatics and AI Tolls	5	6
Core- IX	Bioprocess Technology	5	6
Core Practical-III	Lab in Plant and Animal Biotechnology, Bioinformatics and Bioprocess Technology	4	6
Elective-III	*Any one of the following 1. Nanobiotechnology 2. Bioentrepreneurship / Stem Cell Technology	3	4
Non-Major Elective-II	*NME to be opted from the course offered from other department paper	2	2
	Internship	1	Comme nded/ Highly Comme nded
		25	30

Second Year- Semester- IV

Part	List of Courses	Credits	No. of Hours
Core-X	Research Methodology and Biostatistics	5	6
Core-XI	Environmental Biotechnology	5	6
	Project with Viva Voce	7	18
	Extension Activity	1	
		18	30

Total 92 credits for PG Courses

Biotechnology Department Courses offering NME course

Semester	NME Courses	Credits	No. of Hours
II	An Introduction to Biotechnology	2	3
III	Analytical Techniques in Biotechnology/ Agricultural Biotechnology	2	3
IV	Bioenergy Technology	2	3

**M.Sc., Biotechnology programme Structure, Coursework, Contact Hours, Credits and
Maximum Internal and External Marks for the Student
Admitted in 2026-2027 Onwards**

S. No	Sem	Part	Course Group	Paper Code	Subject Title	Inst . Hours/ Week	Credits	Internal	External	Total Marks
1	I	I	Core Paper – I	26PBT01	Cell and Developmental Biology	6	5	25	75	100
2		II	Core Paper – II	26PBT02	Biochemistry	6	5	25	75	100
3		III	Core Paper – III	26PBT03	Microbiology	6	5	25	75	100
4		IV	Core Practical – I	26PBTP01	Lab in Cell and Developmental Biology, Biochemistry and Microbiology	6	4	40	60	100
5		–	Elective – I	26PBTE01 / 26PBTE02	Bioinstrumentation / Enzymology	4	3	25	75	100
6		–	Skill Enhancement Core – I	26PBTS01	Food Science and Technology	2	2	25	75	100
			Semester I Total			30	24			600
7	II	V	Core Paper – IV	26PBT04	Molecular Biology	6	5	25	75	100
8		VI	Core Paper – V	26PBT05	Genetic Engineering	6	5	25	75	100
9		VII	Core Paper – VI	26PBT06	Immunology	6	5	25	75	100
10		VII I	Core Practical – II	26PBTP02	Lab in Molecular Biology, Genetic Engineering and Immunology	6	4	40	60	100
11		–	Elective – II	26PBTE03 / 26PBTE04	Pharmaceutical Biotechnology / Genomics and Proteomics	4	3	25	75	100
12		–	NME – I	—	Non-Major	2	2	25	75	100

					Elective – I					
13		–	Common Paper	26PHR01	Human Rights	1	1	25	75	100
			Semester II Total			30	25			700
14	III	IX	Core Paper – VII	26PBT07	Plant and Animal Biotechnology	6	5	25	75	100
15		X	Core Paper – VIII	26PBT08	Bioinformatics and AI Tools	6	5	25	75	100
16		XI	Core Paper – IX	26PBT09	Bioprocess Technology	6	5	25	75	100
17		XII	Core Practical – III	26PBTP03	Lab in Plant and Animal Biotechnology, Bioinformatics and AI Tools and Bioprocess Technology	6	4	40	60	100
18		–	Elective – III	26PBTE05 / 26PBTE06 / 26PBTE07	Nanobiotechnology / Bioentrepreneurship / Stem Cell Technology	4	3	25	75	100
19		–	NME – II	—	Non-Major Elective – II	2	2	25	75	100
20		–	Internship	—	Internship	—	1	—	—	Commended / Highly Commended
			Semester III Total			30	25			600
21	IV	XII I	Core Paper – X	26PBT10	Research Methodology and Biostatistics	6	5	25	75	100
22		XI V	Core Paper – XI	26PBT11	Environmental Biotechnology	6	5	25	75	100
23		XV	Project and Viva Voce	26PBTPR1	Dissertation	18	7	50	150	200
24		–	Extension Activity	—	Extension Activity	—	1	—	—	—
			Semester IV Total			30	18			400

REGULATIONS

1. ELIGIBILITY CONDITION FOR ADMISSION TO M.Sc., BIOTECHNOLOGY PROGRAMMES FOR THE ACADEMIC YEAR 2026-2027 ONWARDS

A candidate who has passed a Bachelor degree in Science with Biotechnology / Botany / Zoology / Biology / Microbiology / Microbial Gene technology / Bioinstrumentation / Bioinformatics / Biochemistry / Chemistry / Agriculture / Marine Biology / Home Science / Farm Science / Nutrition and Dietetics / Integrated Biology / Plant Science / Animal Science / Fisheries Science / Aquaculture / Mathematics with Physics, Chemistry as Ancillary / Medical Lab Technology / MBBS / BDS / B. Pharm / BSMS of this University or any of the above degree of any other University accepted by syndicates as equivalent thereto, subject to such conditions as may prescribed therefore shall be permitted to appear and qualify for the M. Sc., Biotechnology Degree Examination of this University after a course of study of two academic years.

2. ELIGIBILITY FOR THE AWARD OF DEGREE

A candidate shall be eligible for the award of the degree only if he / she has undergone the prescribed course of study in a college affiliated to the University for a period of not less than two academic years, passed the examination of all the four semesters prescribed earning 91credits (plus1credits for Human Rights) and fulfilled such conditions as have been prescribed therefore.

2.1 DURATION OF THE COURSE

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

2.2. EXAMINATIONS

There shall be four semester examinations: first semester examinations at the middle of the first academic year and the second semester examination at the end of the first academic year. Similarly, the third and fourth semester examinations shall be held at the middle and the end of the second academic year, respectively.

1. SCHEME OF EXAMINATIONS

The scheme of examinations for different semesters shall be as follows: **THEORY:**

Time – 3hrs. Maximum marks–75Marks

Part A Answer ALL questions (a),(b),(c),(d) Multiple choice	15Marks (15x1=15marks)
Part B Answer any TWO questions out of FIVE	10 Marks (2x5= 10 marks)
Part C Answer ALL questions Either (or) type FIVE questions (one question from each unit)	50 Marks (5x10=50 marks)

Internal marks	25
External marks	75
Total marks	100

The following procedure will be followed for Internal Marks:

Internal Marks- Theory Papers:

➤ Best two tests out of 3

Test	10 marks
Attendance	5 marks
Seminar	5 marks
Assignment	5 marks
Total	25 marks

Practical Internal 40 marks

Practical Test Best 2 out of 3	30 Marks
Attendance	5 Marks
Record	5 Marks
Total	40 Marks

Practical External 60 marks

External- Practical	60 Marks
Total Internal +External	100 Marks

Project:- 200 Marks

Internal marks	50
External marks	150

Internship	Commended /highly commended
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Break up details for attendance

Below 60%	No marks
60% to 75%	3 marks
76% to 90%	4 marks
91% to 100%	5 marks

REQUIREMENTS FOR PROCEEDING TO SUBSEQUENT SEMESTERS

Candidates shall register their names for the First semester examination after the admission in the PG Courses. Candidates shall be permitted to proceed from the First Semester up to the Final Semester irrespective of their failure in any of the Semester Examination subject to the condition that the candidates should register for all the arrear subjects of earlier semesters along with current (subject) Semester subjects. Candidates shall be eligible to proceed to the subsequent semester, only if they earn sufficient attendance as prescribed therefore by the Syndicate from time to time. Provided in case of candidate earning less than 50% of attendance in any one of the semester due to any extraordinary circumstance such as medical grounds, such candidates who shall produce Medical Certificate issued by the Authorized Medical Attendant (AMA), duly certified by the Principal of the College, shall be permitted to proceed to the next semester and to complete the course of study. Such candidate shall have to repeat the missed semester by rejoining after completion of final semester of the course, after paying the fee for the break of study as prescribed by the University from time to time.

PASSING MINIMUM

There shall be no Passing Minimum for Internal.

- For External Examination, Passing Minimum shall be of 50 % (Fifty Percentage) of the maximum marks prescribed for the paper.
- In the aggregate (External, Internal) the passing minimum shall be of 50% for each Paper/Practical/Project and Viva-voce.
- Grading shall be based on overall marks obtained (internal + external).

CLASSIFICATION OF SUCCESSFUL CANDIDATES

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

GRADING SYSTEM

The term grading system indicates a Seven (7) Point Scale of evaluation of the performances of students in terms of marks obtained in the Internal and External Examination, grade points and letter grade.

SEVEN POINT SCALE (As per UGC notification 1998)

GRADE	GRADE POINT	PERCENTAGE OF EQUIVALENT
'O'=Outstanding	5.50– 6.00	75– 100
'A'=Very Good	4.50– 5.49	65–74
'B'=Good	3.50– 4.49	55–64
'C'= Average	3.00– 3.49	50–54
„D'=Below Average	1.50– 2.99	35–49
'E'=Poor	0.50– 1.49	25–34
„F'= Fail	0.00– 0.49	0–24

SEMESTER I

Core paper-I
CELL AND DEVELOPMENTAL BIOLOGY

Paper-			
Title of the paper	Cell and Developmental Biology		Subject Code: 26PBT01
Category of the course	Year	Semester	Credits
Core Paper	Ist	1	5

Learning Outcome:

On the successful completion of this course help the student to understand complete functioning and development process of cell in living organisms.

Course Outcomes:

CO-1	Understanding the structures and functions of various types of cells in the living organism
CO-2	Gaining knowledge on structure and functions of intracellular components
CO-3	Overview of cell to cell communication pathways and inter cellular communication
CO-4	Analyzing cell cycle regulation and events in cell division in living organisms
CO-5	Understanding the process of cell and organism development from the germ cells in living organisms

SYLLABUS Core Paper-1 CELL AND DEVELOPMENTAL BIOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	Evolution of a cell, basic structure of a cell – prokaryotes and eukaryotes, diversity of cell - based on size, shape and function - bacterial cell, animal cell, plant cell & fungal cells. Specialised cells – Nerve cell, muscle cells, motile cells, blood cells, etc. tissues and types (plant and animal), cell to cell communication, intercellular matrix, cell junctions and other components.	10	CO1 CO5	K1,K2 & K3
II	Cell wall (bacteria and plant), cell membrane structure, plasma membrane, membrane transport – active and passive transport, ion channels, regulation of cell transport, nerve impulse conduction, endocytosis, phagocytosis, pinocytosis, Nucleus, chloroplast, mitochondria, lysosome, peroxisomes, endoplasmic reticulum, golgi apparatus, cytoskeleton, vacuoles, etc.	10	CO1 CO2 CO5	K2 & K5
III	Cell to cell communication – autocrine, paracrine and endocrine signaling, hormones in cell signaling, cell receptors, G-protein coupled receptor, surface	10	CO1 CO3 CO5	K4 & K6

	receptors, secondary messengers. Signaling pathways and its regulation-MAPK/ERK Pathway, PI3K/AKT/mTOR Pathway, JAK/STAT Pathway, Notch Signaling, Wnt Signaling Pathway, TGF- β Signaling and Hedgehog Pathway. Regulation of Cell death, Apoptosis.			
IV	Cell cycle, cell division – mitosis, meiosis and their regulation, Cancer cells, Properties of cancer cells, Cell differentiation, types of differentiation – biochemical, physiological, morphological modes, totipotency, factors controlling cell differentiation.	10	CO4 CO5	K3& K5
V	Principles of developmental biology, genes and development, Parthenogenesis, germ cells, gametogenesis (Oogenesis and Spermatogenesis), gametes (Ovum and Spermatoocyte), fertilization – Types of fertilization, Cleavage – types of cleavage, blastulation, gastrulation, neurulation, cell differentiation, organogenesis.	10	CO5	K2 &K4
Reference Books: • Gerald Karp, Janet Iwasa, Wallace Marshall (2019), Cell and Molecular Biology, 9th Edition. • Geoffrey M. Cooper, Robert E. Hausman, Geoffrey M. Cooper, Robert E. Hausman (2013) The Cell: A Molecular Approach • De Robertis E.D.P., (2019) Cell and Molecular Biology, 8th edition, • V K Agarwal (2022) Cell Biology, Genetics, Molecular Biology, Evolution and Ecology (Library Editions). • Scott F. Gilbert and Michael J. F. Barresi, (2016), Developmental Biology, 11th edition.				

**Core paper-II
BIOCHEMISTRY**

Paper-			
Title of the paper	Biochemistry		Subject Code: 26PBT02
Category of the course	Year	Semester	Credits
Core Paper	Ist	1	5

Learning Outcome:

This course brings thorough knowledge to the students regarding atoms, molecules, biomolecules present in the living organisms and their synthesis and breakdown and energy transduction process.

Course Outcomes:

CO-1	Understanding the chemicals, molecules present in the cell
CO-2	Gaining information on basic of biochemical reaction, energy production, transfer on different levels
CO-3	Gives the overview of carbohydrate metabolism in the cell
CO-4	Update the protein metabolism in the cell
CO-5	Analyzing the role of nucleic acid and lipid in the cell and metabolism

SYLLABUS Core Paper-I1 BIOCHEMISTRY				
Unit	Contents	Hours	COs	Cognitive level
I	Atoms and Molecules in living organisms, Chemical bond – types of bonding, energy rich bonds and weak interactions, Biomolecules, Micromolecules (aminoacids, monosaccharides, fatty acids, water, nucleotides, vitamins, minerals, etc), Macromolecules (Carbohydrates, Lipids, Nucleic acid, etc).	10	CO1 CO2	K1&K2
II	Acids, bases, pH, pK, buffers, Henderson - Hassel Balch Equation, biological buffer solutions. Concept of free energy: Principles of thermodynamics; Kinetics, dissociation and association constants; Coupled reactions; group transfer; biological energy transducers.	10	CO1 CO5	K2,K3 & K4
III	Chemical nature, properties and biological importance. Carbohydrate metabolism: Glycolysis, TCA cycle, Glycogenesis, Glycogenolysis, Gluconeogenesis, interconversion of hexoses and pentoses. Carbohydrates in extracellular matrix. Photosynthesis (light and dark reaction –	10	CO1 CO3 CO5	K4 & K6

	Calvin cycle)			
IV	Chemical nature, properties. Biosynthesis of amino acids. Catabolism of amino acids. Peptides. Primary, secondary, tertiary and quaternary structures of proteins; Protein based hormones, Enzymes, Enzyme Nomenclature; Active site, Enzyme kinetics; Michaelis-Menten equation, Enzyme inhibitors.	10	CO2 CO5	K2, K3,K4 & K5
V	Lipids, classification, chemical nature, properties. Biosynthesis of fatty acids-Triglycerides, phospholipid, sterols, Steroid hormones, Oxidation of fatty acids. Nucleic acid chemistry, Purines and pyrimidines biosynthesis.	10	CO5	K3,K4 & K6

Reference Books:

- Lehninger C (2021), Principles of Biochemistry, International edition, W.H.Freeman & Co Ltd,
- John Tymoczko, Jeremy M. Berg Lubert Stryer, Gregory Gatto, (2015) Biochemistry,9th Edition, W.H.Freeman & Co Ltd,
- Philip W. Kuchel, Gregory B. Ralston, Audrey M. Berstein, (1997) Schaum's Outline of Theory and Problems of Biochemistry, Int. Ed., McGraw-Hill Book Co.
- W B Wood; J H Wilson; R M Benbow; L E Hood. (1974). Approaches in Biochemistry. Benjamin-Cummings Publishing Company
- Donald Voets. D. Judith G Voet (2018) Principles Of Biochemistry 5Ed Global Edition, John Wiley,

**Core paper-III
MICROBIOLOGY**

Paper-			
Title of the paper	Microbiology		Subject Code: 26PBT03
Category of the course	Year	Semester	Credits
Core Paper	Ist	1	5

Learning Outcome:

This course provide knowledge on microorganism and its diversity, taxonomy, growth characteristics, microbial culture techniques and microbes and host interaction (disease and beneficial functions).

Course Outcomes:

CO-1	Providing basic information on microbes and staining techniques
CO-2	Overview of techniques used in microbiology
CO-3	Bacterial taxonomy and its classification
CO-4	Gives knowledge on microbial growth properties and its nutrition
CO-5	Understanding of bacterial – host interaction and disease formation

SYLLABUS Core Paper-III MICROBIOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	History and scope of microbiology, definition of microbes, diversity of microbes – archebacteria (Halophiles, Thermophils, Barophils) & eubacteria, fungi, virus, microalgae, protozoa, yeast). Basic structure of microbes, Beneficial microbes (bacteria, fungi, microalgae, etc) Sterilization methods (wet, dry & Chemical methods). Staining techniques - Principles and types of staining (simple, differential staining, acid fast staining & endospore staining), Acellular microorganisms (Viruses, Viroids, Prions).	10	CO1 CO2	K1,K2 & K3
II	Microscopy - Principles and applications of light microscopes (bright field, dark field, phase contrast, fluorescent microscopes and electron microscopes (transmission and scanning electron microscopes). Bacteriological techniques, pure culture isolation: streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic	10	CO1 CO2 CO3	K1,K2 & K5

	bacteria, and accessing. Microbiological media: Nutrient Agar and Potato Dextrose Agar preparation.			
III	Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches: evolutionary chronometers, rRNA oligonucleotide sequencing. Differences between eubacteria and archaeobacteria. Difference between prokaryotic and eukaryotic microorganisms	10	CO1 CO2 CO5	K4 & K5
IV	Definitions of growth and generation time, measurement of microbial growth and specific growth rate, Batch and Continuous culture, Phases and types of growth curve and its industrial application, Factors affecting microbial growth (temperature, pH, solute and water activity, oxygen, pressure and radiation), photosynthetic pigments and apparatus in bacteria, Mode of nutrition - hydrogen and nitrifying bacteria, purple sulfur bacteria, non-sulfur bacteria and green sulfur bacteria, methylotrophs and methanogens, mechanism of nitrogen fixation, Symbiotic and non symbiotic nitrogen fixation.	10	CO3 CO5	K2, K3,K4 & K5
V	Classification of infectious diseases; reservoirs of infection; emerging infectious diseases; mechanism of microbial pathogenicity; nonspecific defense of host; antigens and antibodies; Humoral and cell mediated immunity; vaccines; Immune deficiency; Diseases caused by viruses, bacteria and pathogenic fungi in human.	10	CO4	K3,K4 & K6

Reference Books:

- Alcamo IE. 2001. Fundamentals of Microbiology, sixth edition, Addison wesley Longman, Inc. California.
- Dubey RC and Maheswari DK. 2010. A Text Book of Microbiology. S Chand, New Delhi.
- Madigan MT, Martinko JM, and Parker J. 2009. Biology of Microorganisms, 12th Edition, MacMillan Press, England.
- Pelczar MJ, Chan ECS and Kreig NR. 2009. Microbiology, 5th Edition. McGraw- Hill. Book Co.Singapore.

Core Practical-I
Practical-I
(Cell and Developmental Biology, Biochemistry and Microbiology)

PRACTICAL-I			
Title of the paper	Practical-I (Cell And Developmental Biology, Biochemistry and Microbiology)		Subject Code: 26PBTP01
Category of the course	Year	Semester	Credits
Core Paper	1st	1	4

Learning Outcome:

This practical course help the students to gain hand on experience in basic techniques related to cell biology, biochemistry and microbiology and improve practical knowledge.

Course Outcomes:

CO-1	To handle basic light microscope and visualize objects
CO-2	Illustrate basic cell biology techniques
CO-3	Study the methods used of estimation of biomolecules
CO-4	To learn good laboratory practice in microbiology, cell biology, biochemistry
CO-5	Hands on training on microbiological growth techniques

SYLLABUS Practical Paper-1 (Cell and Developmental Biology, Biochemistry and Microbiology)				
Unit	Contents	Hours	COs	Cognitive level
A	Cell And Developmental Biology: 1. Light microscopy – Principles and instrumentation 2. Measurement of cell size by micrometry 3. Observation of Mitosis cell division in Onion 4. Meiotic cell division in Onion flower 5. Barr body observation in the buccal smear 6. Blood cells identification in human blood	15	CO1 CO2 CO3 CO4 CO5	K3& K4
B	Biochemistry: 7. Estimation of glucose (DNS method) 8. Estimation of DNA (Diphenylamine) 9. Estimation of RNA (Orcinol) 10. Estimation of Protein (Lowry's Method) 11. Thin Layer Chromatography – amino acids separation	15	CO1 CO2 CO3 CO4 CO5	K5 & K6

	12. Separation of protein (SDS-PAGE)			
C	Microbiology: 13. Good Laboratory practice in microbiology 14. Simple staining, Gram's staining, Acid fast staining & Endospore staining 15. Isolation of bacteria, fungi from the soil sample using serial dilution technique 16. Pure culture preparation by streak plate and pour plate method 17. Growth measurement of bacteria using turbidometric method 18. Motility test by hanging drop method	15	CO1 CO2 CO3 CO4 CO5	K4, K5& K6
Reference Books: • Saxena, J., M. Baunthiyal, I. Ravi (2015) Laboratory Manual of Microbiology, Biochemistry and Molecular Biology, Scientific Publishers, New Delhi. • Keith Wilson and John Walker. (2010) Practical Biochemistry- principles and techniques; Cambridge University press, London, UK. • David T Plummer, (2019), An introduction to practical biochemistry, Tata McGraw- Hill publishing company limited, New Delhi. • James H. Jorgensen, Karen C. Carroll, Guido Funke, Michael A. Pfaller, Marie Louise Landry, Sandra S. Richter, David (2015), W. Warnock, Manual of Clinical Microbiology, Wiley Publication • Rina Majumdar, Rama Sisodia (2018), Laboratory Manual of Cell Biology, Prestige publishers				

Elective-I
BIOINSTRUMENTATION

Paper-			
Title of the paper	Bioinstrumentation		Subject Code: 26PBTE01
Category of the course	Year	Semester	Credits
Core Paper	1st	1	3

Learning Outcome:

This course help the students to gain knowledge on instruments used in the field of biology to identify, investigate, analyze biological samples.

Course Outcomes:

CO-1	Give the knowledge on histology and centrifugation techniques
CO-2	Gain the information on spectroscopic techniques
CO-3	Provide principles and application on chromatographic techniques
CO-4	Illustrate the biomedical techniques in the field
CO-5	To evaluate quality and purity of nucleic acids and protein molecules

SYLLABUS Elective Paper-1 BIOINSTRUMENTATION				
Unit	Contents	Hours	COs	Cognitive level
I	Fixation, Cryofixation, Fixative agents, Microtome, negative staining, shadow casting, freeze fracture, freeze etching. Cell fractionation techniques: Cell lysis, homogenization, extraction, Centrifugation: Principles, types of centrifuges, types of rotors, differential and density gradient centrifugation, application, etc.	8	CO1 CO2	K1,K2 & K3
II	Principle involved in Spectrophotometer; Spectrophotometric techniques, Colorimeter, UV-Visible spectroscopy, IR spectroscopy, Atomic absorption spectroscopy, NMR Spectroscopy, ESR Spectroscopy, Flame photometer, Mass Spectrophotometer, Flow cytometry, Circular dichroism	8	CO3 CO4 CO5	K1,K2 & K5
III	Technique of handling micropipettes, Chromatographic techniques: Principle and applications – Column - thin layer – paper, affinity and gas chromatography - Gel filtration - Ion exchange and high performance liquid chromatography, Partition chromatography, Ion exchange chromatography, Permeation chromatography.	8	CO1 CO2 CO5	K4 & K5

IV	Basic principles of electrophoresis - Gel Electrophoresis - AGE and PAGE and Paper Electrophoresis). X-ray, CAT-SCAN, ECG, EEG, Autoradiography, X ray crystallography, ultrasound, Angiography.	10	CO3 CO5	K2, K3,K4 & K5
V	Northern, Southern and Western Hybridization, Chromosome banding, FISH, chromosome painting, Radio isotopic techniques Measurement of radioactivity- GM Counter, Liquid scintillation.	10	CO2 CO3	K3,K4 & K6

Reference Books:

- Keith Wilson and John Walker. (2010) Practical Biochemistry- principles and techniques; Cambridge University press, London, UK.
- David T Plummer, (2019), An introduction to practical biochemistry, Tata McGraw- Hill publishing company limited, New Delhi.
- C.R. Kothari, 2nd Edition, (2004). Research methodology- methods and techniques. New Age International (P) limited publishers, New Delhi.
- P.K. Sharma (2005) Instrumental methods of chemical analysis – Krishna Prakasan media (P) limited Ed. Manjula sharma
- Williams. (2015) Handbook of Biomedical Instrumentation – Tata McGraw Hill

Elective-I
ENZYMOLGY

Paper-			
Title of the paper	Enzymology		Subject Code: 26PBTE02
Category of the course	Year	Semester	Credits
Core Paper	1st	1	3

Learning Outcome:

This course brings knowledge on the fundamentals of enzyme structure, classification, kinetics and other components involved in enzyme function. This subject also provides information on commercial enzymes used in industry..

Course Outcomes:

CO-1	Gives the overview of enzymes and its nomenclature and associated components
CO-2	Understanding the order of reaction and enzyme kinetics
CO-3	Provide knowledge on isolation and purification of enzymes
CO-4	Overview of application of enzymes
CO-5	Commercial use of enzymes in industries

SYLLABUS Elective Paper-1 ENZYMOLGY				
Unit	Contents	Hours	COs	Cognitive level
I	Enzymes – definition, enzyme nomenclature, concepts of coenzymes, cofactors, holoenzymes, apoenzyme, activators, inhibitors, regulatory enzymes. Specificity of enzyme (active site) and models for enzyme specificity (Lock and key, induced-fit and transition-state stabilization hypothesis). Metal-activated enzymes and metalloenzymes (alkali metal cations, alkaline earth metal cations and transition metal cations).	10	CO2 CO4	K2 & K3
II	Concept of activation energy for uncatalyzed and catalyzed (chemical and enzyme) reaction. Type of reaction (zero-order, first-order and second order). Unisubstrate enzyme kinetics; factors affecting the rate of enzyme catalyzed reactions forms and derivation of Michaelis-Menten equation; significance of V _{max} , K _m and different plots (Lineweaver-Burk, EadieHofstee and Hanes plots). Enzyme inhibition and kinetics – type of inhibition (reversible and irreversible), competitive, non competitive, uncompetitive, mixed, partial, substrate,	10	CO3 CO4 CO5	K1 & K5

	and allosteric.			
III	Methods for homogenization of tissue, Method for enzyme (protein) purification depend on size, Method for enzyme purification depend on polarity, (isoelectric focusing, hydrophobic interaction chromatography), Method for enzyme purification depend on changes in solubility (change in pH, change in ionic strength, decrease in dielectric constant), Method for enzyme purification depend on possession of specific binding sites or structural features (affinity chromatography, affinity elution, dye-ligand chromatography, immunoabsorption chromatography and covalent chromatography)	10	CO2 CO3 CO5	K4 & K5
IV	Advantages of enzymes vs. chemical catalysts, Immobilized enzymes and cells: Methods of immobilization, use of immobilized enzymes, advantage and disadvantage of immobilized enzymes. Type of isoenzymes and clinical significance (eg. lactate dehydrogenase, creatine phospho kinase, alkaline phosphatase)	8	CO4 CO5	K4 & K5
V	Industrial enzymes, selection criteria for industrial enzymes, advantage and disadvantage of industrial enzymes, methods of enzyme assay, source of industrial enzymes, microbial enzyme production for industry, manipulation of enzyme biosynthesis	8	CO1 CO2	K1,K4& K6

Reference Books:

- Lehninger C (2021), Principles of Biochemistry, International edition, W.H.Freeman & Co Ltd,
- John Tymoczko, Jeremy M. Berg Lubert Stryer, Gregory Gatto, (2015) Biochemistry,9th Edition, W.H.Freeman & Co Ltd,
- Philip W. Kuchel, Gregory B. Ralston, Audrey M. Berstein, (1997) Schaum's Outline of Theory and Problems of Biochemistry, Int. Ed., McGraw-Hill Book Co.
- W B Wood; J H Wilson; R M Benbow; L E Hood. (1974). Approaches in Biochemistry. Benjamin-Cummings Publishing Company
- Donald Voets. D. Judith G Voet (2018) Principles Of Biochemistry 5Ed Global Edition, John Wiley,

Skill Enhancement Course-I
FOOD SCIENCE AND TECHNOLOGY

Paper			
Title of the paper	Food Science and Technology		Subject Code: 26PBTSE01
Category of the course	Year	Semester	Credits
SEC paper	1st	1	2

Learning Outcome:

This course impart knowledge on the fundamentals of food science and quality of food and its controlling measures.

Course Outcomes:

CO-1	Provide the basics of food, meal plan, components of food and its classification
CO-2	Illustrate the quality control measures in variety of foods
CO-3	Analysis of microbial flora of foods
CO-4	Information on food processing and preservation techniques
CO-5	Nutrition and its requirement to different age groups

SYLLABUS SEC Paper-1 FOOD SCIENCE AND TECHNOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	Food – definition, types of meal, meal plan; Food chemistry - carbohydrates, amino acids and proteins, lipids, vitamins and minerals. Classification of food, sources, functions, deficiencies, nutritional significance, digestion, absorption and metabolism.	6	CO1	K2 & K3
II	Quality control in cereals & millets, pulses & legumes, milk & milk products, egg & fleshy foods, vegetables & fruits, sugar & sugar products, fats & oils – composition, nutritive value, methods of processing, nutrient losses, uses & storage, anti-nutritional factors. Food adulteration, food laws and food safety.	6	CO1 CO2	K1 & K2
III	Introduction to microbiology and its relevance to everyday life-General morphology of microorganisms – General characteristics of bacteria, fungi, virus, protozoa, algae present in food. Microbiology of foods-cereals based products, meat, poultry, eggs, fruits, vegetables, milk, milk products, salts sugars etc. Role of microorganisms in fermented foods-bread, malt beverages, wine, vinegar, butter and cheese etc. Food	6	CO3 CO4	K3 & K5

	poisoning and their causative organisms, food borne infections.			
IV	General principles of food processing, preservation by high and low temperature, drying irradiation, sugar, salt etc. Preparation of jams, jellies, marmalades, juices, squashes, ketchup, pickles and chutneys. Preparation of milk products- cheese condensed and evaporated milk, whole and skim milk powder and ice cream.	6	CO2 CO4	K4 & K6
V	Balanced diet, RDA, Food groups, Food Pyramid, Food exchange list, Nutritional requirements for different age groups. Disorders of malnutrition, GIT disorders, Obesity, hypertension, renal diseases, cardiovascular diseases, Diabetes, Cancer & Inborn errors of metabolism – Etiology, symptoms and dietary management.	6	CO1 CO5	K3 & K5

Reference Books:

- Pomeranz Y and Meloan C.E (1996) Food analysis: Theory and Practice”. 3rd ed. CBS Publishers, New Delhi.
- Nielsen S.S., (1994), Introduction to the chemical analysis of foods, Jones and Bartlett Publishers, London.
- Nielson S S. (2003). “Food analysis laboratory manual”. Chips Ltd, USA.
- AOAC, (1990) “Official methods of analysis. Association of Official Analytical Chemist. Vol. 01, Arunton, Virginia, USA.
- Lawless H T and Heymann H. (1998) Sensory Evaluation of Foods Principles and Practices”, Chapman and Hall, New York, Arlington 1995.

SEMESTER II

Core paper-IV
MOLECULAR BIOLOGY

Paper-			
Title of the paper	Molecular biology		Subject Code: 26PBT04
Category of the course	Year	Semester	Credits
Core Paper	1st	2	5

Learning Outcome:

- To study the central dogma of molecular biology.
- To study the structure and function of DNA and RNA and the mechanism by which genetic information is translated into proteins.

Course Outcomes:

CO-1	Describe the genetic structure and genome complexity.
CO-2	Elucidate the types of chromatin and importance of methylation.
CO-3	Understand the concept of DNA Replication and transcription in prokaryotes and eukaryotes.
CO-4	Explicate the mechanism of translation and gene expression regulation.
CO-5	Understand the concept of mutation and recombination.

SYLLABUS Core Paper-IV MOLECULAR BIOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	Nucleic acid structure and function: Chemical nature of the genetic material and experiments that proved DNA and RNA as genetic material. DNA double helix: endo- and exo sugars, syn- and anti-conformation of N-bases (W-C and Non-W-C base pairing), roll, slide and twist in DNA. DNA supercoiling: super helical density, TOPOLOGY OF DNA(Lk, Wr and Tw,) topoisomerases, Genome complexity: DNA re-association kinetics, Cot curve, C-value paradox, Chemistry and types of RNA.	10	CO1 CO3	K1 & K3
II	DNA to Chromosome: Genomes of bacteria, eukaryotes, organelle and viruses: linear and circular chromosomes, single stranded and double stranded DNA/RNA viral genome, Organization of DNA into chromosomes: DNase I sensitive regions, heterochromatin and euchromatin, DNA methylation (e.g. X chromosome inactivation), repetitive and unique	10	CO2 CO4	K2 & K4

	sequences. Special Types Of Chromosome - Sex Chromosomes, B-Chromosome, Polytene and Lamp brush Chromosomes			
III	DNA Replication In Prokaryotes and Eukaryotes: Mechanism Of Replication, Transcription: Initiation, Elongation And Termination (Rho-Dependent And Independent) of RNA Synthesis; Eukaryotic Promoters, Enhancers, Transcription Factors, RNA Polymerases; Various Protein Motifs Involved In DNA-Protein Interactions During Transcription.	10	CO3 CO4 CO5	K4 & K5
IV	Genetic Code, Translation: Prokaryotes and Eukaryotes, Translation and their Regulation, Involvement of different translational factors at different stages of translation. Regulation of Gene Expression in Prokaryotes And Eukaryotes: Promoters and enhancers. Transcriptional regulation in bacteria: regulation of <i>lac</i> , <i>ara</i> and <i>trp</i> operons, two component regulatory system in bacteria. Concept of eukaryotic gene regulation, RNA in gene regulation: RNA binding proteins, RNA stability, UTR mediated gene regulation, Riboswitch.	10	CO2 CO4 CO5	K2, K3,K4 & K6
V	Gene Mutation And Its Mechanism; Types Of Mutation: Forward; Reverse; Intragenic Suppressor; Extragenic Suppressor; Point Mutations; Missense; Nonsense; Somatic Versus Germinal Mutation. Mutagenesis-Spontaneous and Induced. DNA Repair Mechanisms- Direct Reversal and Excision Repair. Recombination - Models; Rec A, Rec BCD, Ruv Abc, and Molecular Mechanism of Recombination. Conjugation, transformation and transduction. Transposons.	10	CO3 CO4	K2,K5 & K6

Reference Books:

- Cooper, Geoffrey M, and Robert E. Hausman. The Cell: A Molecular Approach. Sunderland, MA: Sinauer Associates, 2013.
- Maniatis, Tom, Edward F. Fritsch, and Joseph Sambrook. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor: Cold Spring Harbor Laboratory, 1982.
- Lodish,H., Berk, A., Zipursky, S.L., Matsudaira, P., Kaiser, A., Krieger, Scott and
- T.A. Brown, 2010. Gene cloning and DNA analysis: An introduction, 6th edition, Wiley-Blackwell.
- Sandy B.Primrose and Richard Twyman, 2006. Principles of Gene Manipulation and
- genomics, 7th edition, Wiley-Blackwell.
- Lewin, 2009. Genes X, 10th edition, Jones & Barlett Publishers

Core paper-V
GENETIC ENGINEERING

Paper-			
Title of the paper	Genetic Engineering		Subject Code: 26PBT05
Category of the course	Year	Semester	Credits
Core Paper	1st	2	5

Learning Outcome:

Design recombinant DNA-based approaches to address problems in medicine, agriculture, and industry

Course Outcomes:

CO-1	Receipt the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.
CO-2	Detailed knowledge of gene transfer methods and identifying suitable hosts for cloning. K2
CO-3	Acquire theoretical knowledge in the techniques, tools, and application and safety measures of genetic engineering K3
CO-4	Describe the genome mapping and sequencing and methods for gene therapy. K4
CO-5	Elucidate different techniques involved in genetic engineering

SYLLABUS Core Paper-V GENETIC ENGINEERING				
Unit	Contents	Hours	COs	Cognitive level
I	DNA manipulating enzymes- Exo and endonucleases, Restriction enzymes, types, DNA ligases and RNA ligases. DNA modifying enzymes, Terminal transferases, Alkaline phosphatases, Polynucleotide kinase, Methylases; DNA dependent DNA polymerases, DNA dependent RNA polymerases, RNA dependent DNA polymerases.	10	CO1 CO5	K1,K2 & K3
II	E. coli vectors: pBR322, pUC18/19, Cosmids, PHAGEMIDS, Lambda and M13 phage vectors Expression vectors: Yeast vectors. Shuttle vectors. Artificial chromosomes – BAC, YAC, HAC. Inteins (Protein introns) Exteins. Ti plasmids and Ri plasmids Plant binary vectors for transformation, Plant Viruses and Animal Viruses as vectors for transfection-Artificial Gene Transfer Methods	10	CO1 CO2 CO5	K1,K2 & K5
III	Screening and Selection of Recombinants- Nucleic acid hybridization techniques; Molecular probes (Types of probes and its	10	CO1 CO3 CO5	K4 & K5

	construction); probe labeling. Nick translation, End labeling and Random primer labeling. Polymerase chain reaction and its variants; DNA fingerprinting and Site Directed Mutagenesis- Transgenics and GMO's.			
IV	Sequencing Methods: Sanger sequencing, Next-Generation Sequencing (NGS), and Third-Generation Sequencing (TGS). Transcript Analysis: Microarrays, RNA-Seq, and quantitative PCR (qPCR). Proteomics: 2D-Gel electrophoresis, Mass Spectrometry (MALDI-TOF) and protein-protein interactions (Yeast Two-Hybrid). Gene silencing techniques: siRNA and miRNA. Gene Therapy: <i>in-vivo</i> vs. <i>ex-vivo</i> therapies, and antisense technology.	10	CO4 CO5	K2, K3, K4 & K5
V	Introduction to Advanced Gene Editing Technologies , Therapeutics and Mechanism- CRISPR- Origins of CRISPR, CRISPR Knockout basics (Experimental Design, Guide RNA design, Delivery into Genome), CRISPR Editing in Animal Models (Knockout and Knockin Strategies in Mice), CRISPR Interference (dCas9 Fusions Inhibition or Activation), CRISPR to target RNA and Other Cas Proteins, CRISPR-Based Gene Therapy (Gene editing, Clinical Applications). Other Editing Tools: TALENs and Zinc Finger Nucleases (ZFNs).	10	CO5	K3, K4 & K6

Reference Books:

- Genetic Engineering and Biotechnology: Concepts, Methods, and Applications - G. Padmanaban, C. Shanmugam; published in 2023 by Springer Nature.
- CRISPR-Cas Systems: RNA-Mediated Adaptive Immunity in Bacteria and Archaea — Rodolphe Barrangou, John van der Oost (Editors); 2024; Springer.
- Genome Editing and Engineering: From TALENs, ZFNs and CRISPRs to Molecular Surgery — Krishnarao Appasani (Editor); Cambridge University Press, 2018,
- Principles of Gene Manipulation and Genomics (7th Edition) — Sandy B. Primrose, Richard Twyman; Wiley-Blackwell, e-book edition 2013; still extensively used in genetic engineering and recombinant DNA courses.
- Gene Cloning and DNA Analysis: An Introduction (9th Edition) — Terry A. Brown; 2024; Wiley-Blackwell.

**Core paper-VI
IMMUNOLOGY**

Paper-			
Title of the paper	Immunology		Subject Code: 26PBT06
Category of the course	Year	Semester	Credits
Core Paper	1st	2	5

Learning Outcome:

The students will be able to understand the fundamental concepts of Immunology and learn the applications of immunological techniques.

They will learn about the properties of antigen and antibodies, mechanism involved in immune response and techniques.

Course Outcomes:

CO-1	To present an overview on types of immunity & immunological responses and to illustrate about different cells and organs involved in immune system.
CO-2	To demonstrate the properties and role of antigens and antibodies in immune system, the principle of antibody diversity, Ag-Ab interactions and its diagnostics and applications.
CO-3	To display the role of MHC in antigen processing and presentation and the elaborate the process of T cell and B cell activation during the course of CMI and HMI and Vaccines
CO-4	To elucidate on the properties and functions of hypersensitivity reactions, Autoimmunity and different types of vaccines
CO-5	To interpret the mechanism of immune response -Transplantations and Cancers- Immunoinformatics and Elucidation of response.

SYLLABUS Core Paper-VI IMMUNOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	History of Immunology, Types of Immunity-Innate and Acquired-Phagocytosis; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); - Overview of Lymphoid System, Hematopoiesis, Cells and Organs of the Immune System, Primary and Secondary Lymphoid Organs, Tertiary Lymphoid Tissues. Physiology of Acquired Immune Response – Various Phases of HI, CMI – Cell Mediated Cytotoxicity.	10	CO1 CO5	K1,K2 & K3
II	Antigen and Antibodies : Antigen Concept, Criteria of Antigens, Immunogen, Nature and biology of antigens, epitopes, haptens, adjuvants. Immunoglobulins- structure,	10	CO1 CO2 CO5	K1,K2 & K5

	specificity, distribution and function-Immunoglobulin super family -Isotypic, Allotypic and Idiotypic variants, generation of antibody diversity-Gene Rearrangement- Concepts and Characteristics of Antigen - Antibody Interactions and their types. Complement System – Classical, Lectin and Alternative pathway			
III	T and B Cell Activation, Differentiation and Memory, Receptors and Signaling : T-Cell and B-Cell Receptors, Receptor Ligand Interaction, Signaling in T-Cell and B-Cell, Antigen Processing and Presentation: Major Histocompatibility Complex, MHC Restriction, Stem cells development and differentiation, Role Of Cytokines, Lymphokines And Chemokines.- Production of Mono and Polyclonal Antibodies-Monoclonal antibody production and its applications. Humanized antibodies and catalytic antibodies. Types of vaccine and vaccination schedule.	10	CO1 CO3 CO5	K4 & K5
IV	Hypersensitivity, Inflammation and Transplantation Immunology Type I (Allergy), Type II (Antibody Mediated) and Type III (Immune Complex Mediated) and Type IV (Delayed Type) Hypersensitivity Reaction. Autoimmunity, Immune Regulation Mechanisms: Immuno-Induction, Suppression, Tolerance and Immuno-Potentiation.	10	CO4 CO5	K2, K3,K4 & K5
V	Transplantation Immunology-immunological basis of graft rejection, clinical transplantation and Immunosuppressive therapy. Tumor Immunology - Tumor antigen, Immune response to tumors. Artificial immune system, Vaccine immunology, Introduction to AI/ML Modelling Immune responses and Structural Immunoinformatics, Immuno-metabolism and Neuroimmunology, Brief of Immunological Disease Management.	10	CO5	K3,K4 & K6

Reference Books:

- Ivan M. Roitt, J. Brostoff and D. K. Male, Immunology, Gower Medical Publishing, London.1993.

- Clark WR, The Experimental Foundations of Modern Immunology. John Wiley and Sons Inc. New York. 1991.
- Janis Kuby, Immunology, II edition. W. H. Freeman and Company, New York. 1993.
- Janeway Travers, Immunobiology- The Immune System in Health and Disease. Current Biology Ltd. London, New York. 3rd ed.,1997.
- Peter J. Delves, Ivan M. Roitt, Encyclopedia of Immunology; Academic Press. 2nd Ed., 1998.
- Abul K Abbas, Andrew H. Lichtman, Shiv Pillai, Cellular and Molecular Immunology, 9th edition 2017.

Core Practical-II
Practical-II
(Lab in Molecular Biology, Genetic Engineering and Immunology)

PRACTICAL-II			
Title of the paper	Practical-II (Molecular Biology, Genetic Engineering and Immunology)		Subject Code: 26PBTP02
Category of the course	Year	Semester	Credits
Core Paper	1st	2	4

Learning Outcome:

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

Course Outcomes:

CO-1	Examine Plant tissue preparation and their functions
CO-2	Study the Animal tissue culturing and trypsinization techniques
CO-3	Learn the Bioinformatics tools for sequence retrieval and alignment
CO-4	Apply the learned tools for various applications
CO-5	Study upstream and downstream techniques

SYLLABUS Practical Paper-2 Practical-II (Lab in Molecular Biology, Genetic Engineering and Immunology)				
Unit	Contents	Hours	COs	Cognitive level
A	Molecular Biology: 1. Isolation of Plasmid DNA by Alkaline Lysis Method 2. Purification and Elution of DNA from Agarose Gel 3. Restriction Enzyme Digestion of DNA 4. DNA Ligation Using DNA Ligase	15	CO3 CO4 CO5	K4, K5 & K6
B	Genetic Engineering: 5. Preparation of Competent <i>Escherichia coli</i> Cells 6. Bacterial Transformation and Screening of Recombinant Clones by Blue-White Screening 7. Random Amplified Polymorphic DNA (RAPD) Analysis 8. DNA Amplification by Polymerase Chain Reaction (PCR)	15	CO3 CO4 CO5	K3, K4 & K6
C	Immunology: 9. Study on Blood Cells a. Identification of blood cells b. Differential count of white blood	15	CO1 CO2 CO3 CO4	K2, K3, K4, K5 & K6

	cells c. Separation of mononuclear cells from Human peripheral blood 10. Preparation of specimen for Immunology a. Preparation of serum b. Preparation of plasma c. Preparation of blood antigens 11. Agglutination test a. ABO Blood grouping b. Widal test for typhoid fever (qualitative and quantitative test) c. Haemagglutination test 12. Passive agglutination test a. Anti - Streptolysin O (ASO) test b. C-reactive protein (CRP) test c. Rheumatoid arthritis (RA) test 13. Agglutination inhibition test - Pregnancy test for detection of HCG 14. Flocculation test - Rapid Plasma Reagin Test (RPR) 15. Precipitation test a. Ouchterlon's Double Immunodiffusion Technique (ODD) b. Counter Current Immunoelectrophoresis (CIE) c. Immuno Electrophoresis (IE) d. Radial Immuno Diffusion (RID) e. Rocket Immuno Electrophoresis (RIE) 16. Demonstration of laboratory animal handling, Route of inoculation, bleeding 17. IgG separation by affinity chromatography 18. ELISA		CO5	
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Elective-II
PHARMACEUTICAL BIOTECHNOLOGY

Paper-			
Title of the paper	Pharmaceutical Biotechnology		Subject Code: 26PBTE03
Category of the course	Year	Semester	Credits
Core Paper	1st	II	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	Explains the fundamentals of pharmaceutical and biotechnology industry and explain the methods and applications of biomarkers and biosensors.
CO-2	Describes the scientific and technical aspects of rDNA technology and vaccine production and purification methods.
CO-3	Describes the basic concepts of preclinical screening and standardization requirements of herbal and folklore medicinal preparations
CO-4	Describes the criteria for evaluation of prepared drugs and various formulation methods of biopharmaceutical products
CO-5	Explains the molecular mechanism of drug action and adverse drug reactions

SYLLABUS Elective Paper-II PHARMACEUTICAL BIOTECHNOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	Fundamentals of pharmaceutical biotechnology in modern medicine and its industrial applications, Importance of Ethanopharmacology, Biomarkers as a diagnostic tools. Biosensors and its types. Brief introduction to Protein Engineering. Use of microbes in production of industrially important enzymes-Penicillinase, Pectinase, Amylases, Protease.	8	CO1 CO5	K1,K2 & K3
II	Recombinant DNA technology and its applications-Production, isolation and purification of enzymes-Microbial production of therapeutic enzymes-Immobilized enzyme technology: Design and operation of immobilized enzyme. Technical and economic aspects of vaccines-Production and purification of viral vaccines- Polio, Rabies, Influenza and Covaxin, storage conditions and stability of vaccines, Production and purification of	8	CO1 CO2 CO5	K1,K3 & K4

	Hormones – Insulin			
III	General Principles of preclinical screening- Simple, Blind and Programmed Screening, Natural products- derived combinatorial libraries and their significance in drug discovery programmes- Methods for documentation and preservation of crude drugs and their products-Shelf life study-protocols to study stabilization of herbal based products. Assessment of physical, physico-chemical and chemical parameters at different stages- Bioavailability and pharmacokinetic significance for herbal drugs with examples of clinically used herbal drugs- Standardization requirements of herbal medicines, traditional and folklore remedies and preparations- USP guidelines for GAMP laboratory	8	CO1 CO2 CO5	K4 & K5
IV	Pharmacological activity of Plant drugs, Criteria for pharmacological evaluation of drugs. Formulation of biopharmaceutical products- emulsions, elixirs, granules, linctus, powders, solutions, suppositories, suspensions and syrups. Biological standardization: General principles, scope and limitations of bioassays, Bioassays of some official drugs. Bioavailability, Bioequivalence, FDA guidelines: drug approval.	8	CO4 CO5	K2, K3,K4 & K5
V	Clinical Pharmacology: Mechanism of drug action- Drug therapy-benefits and risk of use of drugs, Therapeutic efficacy, Therapeutic index, tolerance, dosage forms and routes of drug action , factors affecting drug action; Adverse Drug reactions and drug poisoning classification and causes of ADR; principle clinical manifestations and treatment of ADR.	8	CO3 CO4	K3,K4 & K6

Reference Books:

- Harbanslal, 2011. Pharmaceuticals biochemistry. CBS Publishers and distributors Pvt. Ltd.
- 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

Elective-II
GENOMICS & PROTEOMICS

Paper-			
Title of the paper	Genomics & Proteomics		Subject Code: 26PBTE04
Category of the course	Year	Semester	Credits
Core Paper	1st	II	3

Learning Outcome:

To provide better knowledge of molecular profiling of genes and proteins for its analysis and applications

Course Outcomes:

CO-1	To familiarize the students with various type of genomes, analysis, markers for genetic analysis and gene expression profiling and tools for the analysis
CO-2	To gain insight into different sequencing methods, comparative and functional genomic analysis which enables the students to understand about sequence and structure based approaches for gene prediction and function determination.
CO-3	To have better understanding about proteomics and learn about protein profiling and analysis of data generated through mass spectrometry and to be aware of various bioinformatics proteomic tools for drug modelling and targeting.
CO-4	To study about protein interactions and proteome analysis
CO-5	To understand well about Human Genome Analysis, ADMA analysis, Pharmaceutical applications and to have a case study.

SYLLABUS Elective Paper-II GENOMICS & PROTEOMICS				
Unit	Contents	Hours	COs	Cognitive level
I	Computational Analysis of sequences, Gene Annotation, Phylogenomics, Tools for Genome Analysis– PCR, RFLP, DNA fingerprinting, RAPD, FISH-Physical Mapping - In situ hybridization, Sequence Tagged Sites Mapping. DNA sequencing methods: Chemical degradation & Sanger's methods, Shot gun sequencing, Clone Contig method, Next Generation sequencing.	8	CO1 CO5	K1,K2 & K3
II	Construction of genetic maps, FISH to identify chromosome landmarks. Functional genomics: Sequence based & structure based approaches to assign gene function. DNA microarray: Databases and tools; SAGE databases; Gene expression omnibus (GEO). Gene Editing - Crispr Cas9. Omics Databases: Genome databases – ENSEMBL - VISTA – FlyBase – OMIM	8	CO1 CO2 CO5	K1,K2 & K5

III	Protein profiling; 2D gel electrophoresis, Quantitative Mass spectrometry: Peptide mapping, N & C terminal sequencing and analytical protein chips – Computational pattern, recognition of proteomes: protein network and pathways. Principle of protein microarrays, Mass spectrometry analysis for proteomic analysis, Bioinformatics based tools for analysis of proteomic data. Application of proteomics in disease diagnosis: Biomarker, drug development and their target identification.	8	CO1 CO3 CO5	K4 & K5
IV	UNIT IV Peptide fingerprinting/mapping; Determination of 3D structure of protein by X-ray diffraction and NMR spectroscopy. Isotope-coded affinity tag (ICAT) method for quantitative proteome analysis; Various approaches for determining the function of a protein; Protein-protein interaction using two hybrid system, complementation, tandem affinity purification (TAP) tag method; Protein- protein interaction mapping; Protein microarrays Analytical, reverse phase, functional.	8	CO4 CO5	K2, K3,K4 & K5
V	Applications of Genomics and Proteomics: Analysis of human genome, application of proteome analysis- drug development and toxicology, pharmaceutical applications, proteomics in drug discovery in humans, Capstone project on genomics and proteomics, Gene/Protein function prediction using neural network, Phage antibodies as tools for proteomics	8	CO2 CO5	K3,K4 & K6

Reference Books:

- Wilson and Walker, Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 8th edition, 2018.
- S. B. Primrose and R.M. Twyman - Principles of Genome Analysis and Genomics, 7th Edition, Blackwell Publishing, 2006.
- S. Sahai - Genomics and Proteomics, Functional and Computational Aspects, Springer Publication, 2009.
- Campbell AM & Heyer LJ, Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition, 2007.
- Primrose S & Twyman R, Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell, 2006.
- Hubert Rehn. (2006). Protein Biochemistry and Proteomics, Academic Press
- Liebler Humana. (2002). Introduction to proteomics: Tools for new Biology, W.CBS
- Twyman RM. (2004). Principles of proteomics, York: Garland Science/ Bios Scientific

SEMESTER III

Core paper-VII
PLANT AND ANIMAL BIOTECHNOLOGY

Paper-			
Title of the paper	Plant And Animal Biotechnology		Subject Code: 26PBT07
Category of the course	Year	Semester	Credits
Core Paper	2nd	3	5

Learning Outcome:

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

Course Outcomes:

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

SYLLABUS Core Paper-VII PLANT AND ANIMAL BIOTECHNOLOGY				
Unit	Contents	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 in plants - Glycosides and Flavonoids; Anthocyanins and Coumarins - Lignans, Terpenes, Volatile oils and Saponins; Carotenoids and Alkaloids: biogenesis, therapeutic applications.	10	CO1 CO5	K1,K2 & K3
II	Plant Transformation Direct transformation by electroporation and particle gun bombardment. Agrobacterium, Ti plasmid vector. Theory and techniques for the development of new genetic traits, conferring resistance to biotic and abiotic. Plant engineering towards the development of enriched food products, plant growth regulators; Molecular Marker aided breeding; RFLP maps, Linkage analysis,	10	CO1 CO2 CO5	K1,K2 & K5

	RAPD markers, STS Mirco satellite, SCAR, SSCP, QTL, Map based cloning and Molecular marker assisted selection.			
III	Animal health disease diagnosis, hybridoma technique, monoclonal antibodies, application of probes for disease diagnosis of existing and emerging animal diseases. Prophylaxis - Vaccines, Oral vaccines DNA Vaccines in animal disease. Cell culture: primary and established culture; organ culture; tissue culture.	10	CO1 CO3 CO5	K4 & K5
IV	Disaggregation of tissue and primary culture; cell separation, Slide and coverslip cultures, flask culture, test tube culture techniques, cell synchronization, cryopreservation. Scaling up of animal cell culture, cell line and cloning micromanipulation and cloning, somatic cell cloning. Karyotyping; measuring parameters for growth, measurement of cell death, apoptosis and its determination, cytotoxicity assays	10	CO4 CO5	K2, K3,K4 & K5
V	Application of animal cell culture for in vitro testing of drugs in production of human and animal viral vaccines and pharmaceutical proteins. Culture Scale up and mass production of biologically important compounds. Harvesting of products, purification and assays. Transgenic animals: Production and application; transgenic animals in livestock improvement, transgenic animals as model for human diseases	10	CO5	K3,K4 & K6

Reference Books:

- Razdan. M. K., 2011. Plant tissue culture. Oxford and IBH publishing Company Pvt. Ltd, New Delhi.
- Chawla. H. S., 2010. Introduction to plant biotechnology. Oxford and IBH publishing company pvt. Ltd, New delhi.
- Ian Freshney, 2010. Culture of animal cells. 6th edition, Wiley-Blackwell publishers. 39
- Slater, 2008. Plant Biotechnology: The Genetic manipulation of plants, Second Edition, Oxford University Press, USA.
- W.H.Freeman. 26 K. Dass. 2005, Text book of Biotechnology, Second Edition, Wiley Dreamtech, India (P) Ltd.
- H.Kreuzer & A.Massey. 2001. Recombinant DNA and Biotechnology: A guide for teachers Second Edition. ASM press, Washington.
- M.Sudhir. 2000. Applied Biotechnology & Plant Genetics. Dominant publishers & Distributors.

Core paper-VIII
BIOINFORMATICS AND AI TOOLS

Paper			
Title of the paper	Bioinformatics And AI Tools		Subject Code: 26PBT08
Category of the course	Year	Semester	Credits
Core Paper	2nd	3	5

Learning Outcome:

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

Course Outcomes:

CO-1	To get introduced to the basic concepts of Bioinformatics and its significance in Biological data analysis.
CO-2	Describe the history, scope and importance of Bioinformatics and role of internet in Bioinformatics.
CO-3	Explain about the methods to characterize and manage the different types of Biological data.
CO-4	Classify different types of Biological Databases.
CO-5	Introduction to the basics of AI tools

SYLLABUS Core Paper-VIII BIOINFORMATICS AND AI TOOLS				
Unit	Contents	Hours	COs	Cognitive level
I	Database concepts, Introduction to internet and its application, Introduction to bioinformatics, Protein and nucleotide databases, Information retrieval from biological databases, Sequence alignment and database searching-similarity searches using BLAST and FASTA. Big data analysis - DNA/RNA/protein sequence or structure data, gene expression data, protein-protein interaction (PPI) data, pathway data and gene ontology (GO) data.	10	CO1	K1 & K2
II	Sequence alignment basics, match, mismatch, similarity, scoring an alignment, gap penalty, protein vs DNA alignments, Dot-matrix alignment, pairwise alignment. Global and local alignment algorithms, multiple sequence alignment-progressive alignment and Iterative alignment algorithms, consensus sequence, patterns and profiles, Database searching: Pairwise alignment based rigorous algorithm (Smith and Waterman).	10	CO2	K2,K3 & K5
III	Bioinformatics for genome sequencing, EST Clustering and analyses, Finding	10	CO3	K2 & K5

	genes in prokaryotic and eukaryotic genomes, Regulatory sequence analysis, Bioinformatics for Genome maps and markers, Bioinformatics for understanding Genome variation, Protein structure-X-ray crystallography, The protein databank and the PDBSum-SCOP, CATH, DALI and HSSP ;Visualization of molecular structures-RasMol and Pymol; Protein secondary structure prediction.			
IV	Medical application of Bioinformatics. Disease genes, Drug Discovery. History. Steps in drug discovery. Target Identification. Target Validation. QSAR. Lead Identification. Preclinical pharmacology and toxicology. ADME. Drug designing. Rational drug design. Computer aided drug design. Ligand based approach. Target based approach.	10	CO4	K4 & K5
V	Molecular visualization tools. Rasmol, Chime and Spdb viewer. Structure analysis tools. VAST and DALI. Protein and engineering- Alpha fold, Drug design, Atomwise, RFDiffusion, Arzeda. Genomics and Gene Editing- CRISPR-ML tools. Commercial AI tools- DeepVariant, Tensor Flow, PyTorch, Deepcell, Research Rabbit, Scite, Benevolent AI and Elicit.	10	CO5	K3,K4 & K6

Reference Books:

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

Core paper-IX
BIOPROCESS TECHNOLOGY

Paper			
Title of the paper	Bioprocess Technology		Subject Code: 26PBT09
Category of the course	Year	Semester	Credits
Core Paper	2nd	3	5

Learning Outcome:

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

Course Outcomes:

CO-1	Outline the basis of Bioprocess Engineering
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-9 BIOPROCESS TECHNOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	Introduction to fermentation. General requirements of fermentation. Microbial growth kinetics of batch and continuous culture. Solid substrate, slurry fermentation and its application. Microbial cell culture. Immobilization of cells and enzymes	10	CO1	K1 & K2
II	Types of bioreactors: Submerged reactors, surface reactors, mechanically agitated reactors, non-mechanically agitated reactors. Design of fermenters, body construction. Isolation and improvement of Industrially important Microorganisms, Media for Industrial fermentation and Sterilization. Production of citric acid, penicillin and insulin.	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. Extraction Principles, Liquid-	10	CO3	K2 & K5

	liquid extraction, aqueous two-phase extraction, supercritical fluid extraction.			
IV	Down Stream Processing: Chromatography Techniques, Membrane separation, ultrafiltration. Drying.Principles and operation of vacuum dryer, shelf dryer, rotary dryer, freezer and spray dryer. Crystallization and Whole broth processing.	10	CO4	K4 & K5
V	Aerobic and anaerobic fermentation processes and their application in the field of biotechnology industry. Production of commercially important primary and secondary metabolites, Effluent Treatment and Fermentation Economics.	10	CO5	K3,K4 & K6
Reference Books: • Min-tzeLiong, 2011. Bioprocess Sciences and Technology. NovaScience Pub Inc. • Michael L.Shuler, FikretKargi. 2003. Bioprocess Engineering. PHIpublishers. • P.A.Belter, E.L.Cursler, and W.S.Hu. 1988.Bioseparation: Downstream processing for Biotechnology. John Wiley and sons. • R.G. Harrison, P.Todd, SR.Rudge and D.P. Petrides. 2003.Bioseparation science And engineering. Oxford Press.				

Core Practical-III
(Lab in Plant and Animal Biotechnology, Bioinformatics and AI tools & Bioprocess technology)

PRACTICAL-III			
Title of the paper	Practical-III (Plant and Animal Biotechnology, Bioinformatics and AI tools & Bioprocess technology)		Subject Code: 26PBTP03
Category of the course	Year	Semester	Credits
Core Paper	2nd	3	4

Learning Outcome:

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

Course Outcomes:

CO-1	Examine Plant tissue preparation and their functions
CO-2	Study the Animal tissue culturing and trypsinization techniques
CO-3	Learn the Bioinformatics tools for sequence retrieval and alignment
CO-4	Apply the learned tools for various applications
CO-5	Study upstream and downstream techniques

SYLLABUS Practical Paper-3 Practical-III (Plant and Animal Biotechnology, Bioinformatics and AI tools & Bioprocess technology)				
Unit	Contents	Hours	COs	Cognitive level
A	Plant and Animal Biotechnology: 1. Plant tissue culture media preparation 2. Plant tissue culture sterilization techniques. 3. Generation of Callus from leaf, root, bud and shoot apex 4. Maintenance of callus culture. 5. Suspension culture of Cell, Anther, Pollen and Embryo 6. Isolation of plant protoplast and viability test. Preparation of sera for animal cell culture 7. Preparation of single cell suspension from chicken liver (Primary cell culture). 8. Trypsinization of established cell culture. 9. Cell counting and viability - staining of cells (a) Vital Staining (Trypan blue, Erythrosin (b) Giemsa staining.	15	CO1 CO2 CO3 CO4 CO5	K1, K2, K3. K4, K5 & K6

B	Bioinformatics and AI Tools: 10. Sequence retrieval from Genbank. 11. Sequence identity search- Sequence similarity search using BLAST. 12. Sequence similarity search using FASTA. 13. Sequence similarity search using PSI BLAST. 14. ORF gene Search –Genscan. 15. Sequence translation using ExPASy translate tool. 16. Multiple sequence alignment using EBI-CLUSTALW2. 17. PHYLOGENY- Phylogenetic tree. 18. Molecular visualization of proteins using RASMOL. 19. Docking of small molecule with protein structure using LeadIT software.	15	CO1 CO2 CO3 CO4 CO5	K1, K2, K3. K4, K5 & K6
C	Bioprocess Technology: 20. Parts and design of fermenter. 21. Solid state fermentation. 22. Submerged fermentation. 23. Foaming and antifoaming agents. 24. Production and estimation of amylase. 25. Production of wine using grapes. 26. Production and determination of penicillin activity 27. Citric acid production. 28. Use of alginate for cell immobilization. 29. Cell disruption (Sonication).	15	CO1 CO2 CO3 CO4 CO5	K1, K2, K3. K4, K5 & K6

Elective-III
NANOBIOTECHNOLOGY

Paper			
Title of the paper	Nanobiotechnology		Subject Code: 26PBTE05
Category of the course	Year	Semester	Credits
Elective paper	2nd	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	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-III NANOBIOTECHNOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	Introduction to Nanotechnology- Scientific revolution, Feynman's vision, Classification of nanobiomaterials -Types of nanomaterials – nanoparticles, nanotubes, nanowires, Nanofibers, Size dependent variation in the properties of Nanomaterials, Nature's Nanophenomena.	07	CO1	K1
II	Preparation of Nanomaterials, Top down and bottom up approaches, Biosynthesis, Nanobiomaterials- Polymer, Ceramic, Metal based Nanobiomaterials, Carbon based Nanomaterials, DNA based Nanostructures, Protein based Nanostructures, Quantum dots, Magnetic Nanoparticles, Nanofibres, Hydrogels, Films and Scaffolds.	07	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.	07	CO3	K1 & K5
IV	Nanomaterials for diagnosis and therapy,	07	CO4	K2

	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.			
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.	07	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. pte. ltd. 2011.
- OdedShoseyov (Editor), Ilan Levy, 2010. NanoBioTechnology: BioInspired Devices andMaterials of the Future, Humana Press.
- K.K.K.Jain 2006. Nanobiotechnology in Molecualr Diagnostics: Current Techniques and Applications Horizon Bioscience
- Nanomaterials for medical diagnosis and therapy, Challa Kumar, Wiley-VCH, 2007.
- Nanotechnology for cancer therapy, Mansoor M. Amiji, CRC Press, 2007.
- K.K.Jain, Nano Biotechnology, Horizons Biosciences, 2006
- Nanomaterials: An introduction to synthesis, properties and application, Dieter Vollath, WileyVCH, 2008
- Cato T. Laurencin and Lakshmi S. Nair, Nanotechnology and Tissue Engineering The Scaffold, CRC Press taylor& Francis Group.
- Introduction to Nanoscience and Nanotechnology, Gabor .L et al, Fundamentals 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

Elective-III
BIOENTREPRENEURSHIP

Paper			
Title of the paper	Bioentrepreneurship		Subject Code: 26PBTE06
Category of the course	Year	Semester	Credits
Elective paper	2nd	3	3

Learning Outcome:

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

Course Outcomes:

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

SYLLABUS Elective Paper-III BIOENTREPRENEURSHIP				
Unit	Contents	Hours	COs	Cognitive level
I	Introduction to bioentrepreneurship – Biotechnology in a global scale, Scope in Bioentrepreneurship, Importance of entrepreneurship. Meaning of entrepreneur, function of an entrepreneur, types of entrepreneur, and advantages of being entrepreneur. Innovation – types, out of box thinking, opportunities for Bioentrepreneurship. Entrepreneurship development programs of public and private agencies (MSME,DBT, BIRAC, Startup and Make in India).	07	CO1	K1 & K2
II	Business plan preparation: business feasibility analysis by SWOT, socio-economic costs benefit analysis, Sources of financial assistance – making a business proposal, approaching loan from bank and other financial institutions, budget planning and cash flow management. Collaborations and partnerships,	07	CO2	K2,K3 &K4

	information technology for business administration and expansion.			
III	Knowledge centers - Universities, innovation centre, research institutions and business incubators. R&D - technology development and upgradation, assessment of technology development, managing technology transfer, industry visits to successful bio-enterprises, regulations for transfer of foreign technologies, quality control, technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO,NBA, GLP, GCP & GMP)	07	CO3	K3,K4 &K5
IV	Definition, characteristics, need and rationale, objectives, scope and advantages of small scale industries. Types of bioindustries – Pharma, Agri and Industry. Biofertilizers production - Azospirillum, Azolla, Cyanobacteria and its applications. Biopesticides production - Bacterial, fungal, viral and plant insecticides. Sericulture. Apiculture. Dairy farming. Single Cell Protein Production and applications. Vermicomposting and its applications. Mushroom cultivation and its application. Ancillary and tiny industries	07	CO4	K4,K5 & K6
V	Assessment of market demand for potential product(s) of interest, Market conditions, segments, prediction of market changes, identifying needs of customers. Branding issues, developing distribution channels – franchising policies, promotion, advertising, branding and market linkages. Marketing of agro products. Recruitment and selection process, leadership skills, managerial skills, organization structure, training, team building and teamwork.	07	CO5	K4,K5 & K6

Reference Books:

- Entrepreneurship Ideas in Action—South-Western,
- Principles of Management, PC Tripathi, PN Reddy,–Tata Mc Graw Hill
- Dynamics of Entrepreneurial Development & Management, Vasant Desai Himalaya Publishing House
- Management Fundamentals, Robert Lusier – Concepts, Application, Skill Development, Thomson
- Entrepreneurship Development, S SKhanka, S Chand & Co

**Skill Enhancement Course-II
STEM CELL TECHNOLOGY**

Title of the paper	Stem Cell Technology		Subject Code: 26PBTE07
Category of the course	Year	Semester	Credits
SEC paper	2nd	3	2

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:

CO-1	Understand the major discoveries of stem cell biology
CO-2	Provide basic knowledge about stem cell niche and functions
CO-3	Enlighten the students on stem cell isolation and culture techniques
CO-4	Update the knowledge on stem cell cycle
CO-5	Assess and appraise applications of embryonic stem cells.

SYLLABUS SEC Paper-3 STEM CELL TECHNOLOGY				
Unit	Contents	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.	06	CO1	K1 & K3
II	Stem cell niche, Niche specification - Drosophila germ line stem cells. Receptors, genes and markers of stem cells. Stem cell isolation and culture techniques. Characterization of stem cells.	06	CO2	K2 & K4
III	Stem cell cycle. Chromatin modification and transcriptional regulation, chromatin modifying factors, Chromosomal inactivation. JAK -STAT pathway, Ras/Raf pathway, PI3K cell signaling, p53 check points, Role of LIF pathway in cell cycle control.	06	CO3	K1 & K5
IV	Therapeutic applications of stem cells- Gene therapy. History and evolution of gene therapy, Optimal disease target, failures and success with gene therapy and future prospects.	06	CO4	K4 & K5

V	Applications of embryonic stem cells, Bone marrow stem cells, Adipose derived stem cells and Hematopoietic stem cells. Ethics in human stem cell research.	06	CO5	K3 & 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.				

SEMESTER IV

Core paper-X
RESEARCH METHODOLOGY AND BIOSTATISTICS

Paper			
Title of the paper	Research methodology and Biostatistics		Subject Code: 26PBT10
Category of the course	Year	Semester	Credits
Core Paper	2nd	4	5

Learning Outcome:

Apply the principles of research methodology to identify research problems, design experiments, collect data, and prepare scientific reports following ethical guidelines.

Analyze and interpret biological data using descriptive and inferential statistical methods and utilize statistical software tools for biotechnology research and decision making.

Course Outcomes:

CO-1	Understand the principles, ethics, and process of scientific research.
CO-2	Design research studies using appropriate sampling and data collection methods.
CO-3	Prepare scientific reports, dissertations, and research publications using proper citation practices.
CO-4	Apply descriptive statistical methods to analyze and present biological data.
CO-5	Use biostatistical tools and software to interpret research data and draw valid conclusions.

SYLLABUS Core Paper-X RESEARCH METHODOLOGY AND BIOSTATISTICS				
Unit	Contents	Hours	COs	Cognitive level
I	Introduction to Research: Meaning, objectives, significance and types of research. Research process, identification and formulation of research problems, literature survey, hypothesis formulation, research ethics, and characteristics of good research.	10	CO1	K2 & K3
II	Research Design and Sampling: Research design and its importance, experimental design, sampling design, probability and non-probability sampling methods, sample size determination, methods of data collection, questionnaire design, and data processing techniques.	10	CO2	K4 & K5
III	Scientific Writing and Data Management: Data organization, data interpretation, presentation of results, preparation of	10	CO3	K1,K2 & K5

	research reports, thesis and dissertation writing, referencing and citation methods, plagiarism, scientific publication, and communication of research findings.			
IV	Descriptive Statistics and Data Presentation: Types of biological data, classification and tabulation of experimental data, frequency distribution, graphical representation of biological data (bar diagrams, histograms and pie charts frequency), measures of central tendency (mean, median and mode), measures of dispersion (range, variance, standard deviation and coefficient of variation), skewness and kurtosis, and their applications in biological research.	10	CO4	K4 & K5
V	Statistical Inference and Data Analysis: Correlation and regression, Chi-square test, goodness of fit, test of independence, hypothesis testing, level of significance, one-tailed and two-tailed tests, Student's t-test, analysis of variance (ANOVA), interpretation of experimental data using SPSS and applications of biostatistics in biotechnology research.	10	CO5	K3,K4 & K6

Reference Books:

- C.R. Kothari and Gaurav Garg, Research Methodology: Methods and Techniques (4th Revised Edition), New Age International Publishers, New Delhi, 2019.
- B.K. Mahajan, Methods in Biostatistics for Medical Students and Research Workers (9th Edition), Jaypee Brothers Medical Publishers, New Delhi, 2021.
- P.S.S. Sundar Rao and J. Richard, An Introduction to Biostatistics (5th Edition), PHI Learning Private Limited, New Delhi, 2022.
- S.C. Gupta and V.K. Kapoor, Fundamentals of Applied Statistics (5th Edition), Sultan Chand & Sons, New Delhi, 2020.
- R. Panneerselvam, Research Methodology (3rd Edition), PHI Learning Private Limited, New Delhi, 2021.

Core paper-XI
ENVIRONMENTAL BIOTECHNOLOGY

Paper			
Title of the paper	Environmental Biotechnology		Subject Code: 26PBT11
Category of the course	Year	Semester	Credits
Core Paper	2nd	4	5

Learning Outcome:

Demonstrate knowledge of environmental biotechnology principles and apply biotechnological methods for pollution control, waste management, and environmental sustainability.

Course Outcomes:

CO-1	Explain the principles and significance of environmental biotechnology in pollution control and sustainability.
CO-2	Describe the role of microorganisms in biogeochemical cycles and environmental processes.
CO-3	Apply biotechnological approaches for waste management and bioremediation of contaminated sites.
CO-4	Evaluate the use of biotechnology in environmental monitoring and pollution management.
CO-5	Assess renewable energy technologies and sustainable strategies for environmental protection.

SYLLABUS Core Paper-XI ENVIRONMENTAL BIOTECHNOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	Introduction to Environmental Biotechnology: Scope and importance of environmental biotechnology, environmental pollution and its types (air, water, soil and noise pollution), sources and effects of pollution, environmental monitoring, environmental regulations and sustainable development.	10	CO1	K1 & K2
II	Microbial Ecology and Biogeochemical Cycles: Microbial ecology, microbial interactions, role of microorganisms in the environment, carbon cycle, nitrogen cycle, phosphorus cycle, sulfur cycle, biodegradation of organic compounds, and microbial diversity in environmental systems.	10	CO2 CO3	K2,K3 & K5
III	Waste Management and Bioremediation: Types of wastes, solid waste management, sewage and wastewater treatment, activated sludge process, anaerobic digestion, composting, bioremediation, bioaugmentation, biostimulation, and phytoremediation of contaminated	10	CO3	K2 & K5

	environments.			
IV	Environmental Biotechnology Applications: Microbial treatment of industrial effluents, biotreatment of agricultural wastes, biodegradation of xenobiotics, bioleaching, biosorption, biofertilizers, biopesticides, and applications of biotechnology in pollution control.	10	CO3 CO4	K4 & K5
V	Renewable Energy: Biofuels and their production, biogas technology, bioethanol, biodiesel, microbial fuel cells, waste-to-energy technologies, environmental impact assessment, climate change mitigation, carbon sequestration, and sustainable environmental management.	10	CO4 CO5	K3,K4 & K6
sReference Books: • M.H. Fulekar, Environmental Biotechnology (2nd Edition), Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2022. • A.K. Chatterji, Introduction to Environmental Biotechnology (Revised Edition), PHI Learning Pvt. Ltd., New Delhi, 2022. • S.N. Jogdand, Environmental Biotechnology (Revised Edition), Himalaya Publishing House, Mumbai, 2023. • P.D. Sharma, Ecology and Environment (14th Edition), Rastogi Publications, Meerut, 2023.				

Non Major Elective-I
AN INTRODUCTION TO BIOTECHNOLOGY

Title of the paper	An Introduction to Biotechnology		Subject Code:
Category of the course	Year	Semester	Credits
NME paper	2nd	2	2

Learning Outcome:

Understand the fundamental concepts, principles, and applications of biotechnology in agriculture, medicine, industry, and environmental management.

Course Outcomes:

CO-1	Explain the basic concepts, scope and applications of biotechnology.
CO-2	Describe the structure and functions of cells, genes and genetic material.
CO-3	Discuss the applications of biotechnology in agriculture and food production.
CO-4	Explain the role of biotechnology in medicine and healthcare.
CO-5	Illustrate the applications of biotechnology in environmental protection and industrial processes.

SYLLABUS NME Paper-1 AN INTRODUCTION TO BIOTECHNOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	Basics of Biotechnology: Definition, scope and importance of biotechnology, history and development of biotechnology, branches of biotechnology (red, green, white and blue biotechnology), contributions of biotechnology to society.	6	CO1 CO3	K1 & K3
II	Cell and Molecular Biology : Structure and functions of cells, DNA and RNA, genes and chromosomes, genetic code, protein synthesis, introduction to recombinant DNA technology and genetic engineering.	6	CO2	K2 & K4
III	Agricultural and Food Biotechnology: Applications of biotechnology in agriculture, genetically modified crops, plant tissue culture, biofertilizers, biopesticides, biotechnology in food production and food preservation.	6	CO3	K1 & K5
IV	Medical Biotechnology: Role of biotechnology in healthcare, vaccines, antibiotics, recombinant therapeutic proteins, diagnosis of diseases, gene therapy, stem cells and their applications.	6	CO4	K4 & K5
V	Environmental and Industrial Biotechnology: Environmental	6	CO5	K3 & K4

	biotechnology and pollution control, bioremediation, waste management, industrial production of enzymes and biofuels, applications of biotechnology in sustainable development.			
Reference Books: • Gupta, P.K. Elements of Biotechnology (3rd Edition), Rastogi Publications, Meerut, 2022. • Das, H.K. Textbook of Biotechnology (5th Edition), Wiley India, 2022. • Brown, T.A. Gene Cloning and DNA Analysis: An Introduction (9th Edition), Wiley-Blackwell, 2024. • Primrose, S.B. and Twyman, R.M. Principles of Gene Manipulation and Genomics (9th Edition), Wiley-Blackwell, 2023.				

Non Major Elective-II
AGRICULTURAL BIOTECHNOLOGY

Title of the paper	Agricultural Biotechnology		Subject Code:
Category of the course	Year	Semester	Credits
NME paper	2nd	3	2

Learning Outcome:

Evaluate modern biotechnological tools, biofertilizers, biopesticides, and genetically modified crops for enhancing agricultural productivity and food security.

Course Outcomes:

CO-1	Explain the principles and applications of agricultural biotechnology in crop improvement.
CO-2	Describe plant tissue culture techniques and their agricultural applications.
CO-3	Apply genetic engineering methods for the development of improved crop varieties.
CO-4	Analyze the role of biotechnology in enhancing agricultural productivity and sustainability.
CO-5	Evaluate the use of biofertilizers, biopesticides, and biosafety measures in modern agriculture.

SYLLABUS NME Paper-2 AN INTRODUCTION TO BIOTECHNOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	Introduction to Agricultural Biotechnology : Scope and importance of agricultural biotechnology, plant biotechnology, applications in crop improvement, conventional breeding versus modern biotechnology, and role of biotechnology in sustainable agriculture.	6	CO1 CO2	K1 & K2
II	Plant Tissue Culture : Laboratory organization and aseptic techniques, culture media and growth regulators, callus culture, cell suspension culture, micropropagation, somatic embryogenesis, synthetic seeds, and applications of plant tissue culture.	6	CO2	K3 & K4
III	Genetic Engineering in Plants : Recombinant DNA technology, gene transfer methods in plants, Agrobacterium-mediated transformation, direct gene transfer methods, transgenic plants, marker genes, and molecular farming.	6	CO3	K2 & K5

IV	Biotechnology for Crop Improvement : Development of insect-resistant, herbicide-resistant, disease-resistant, and stress-tolerant crops, biofortification, genetically modified crops, marker-assisted selection, and genome editing in agriculture.	6	CO1 CO4	K4 & K6
V	Biofertilizers, Biopesticides and Biosafety : Types and applications of biofertilizers, biopesticides and biocontrol agents, integrated pest management, biosafety regulations, environmental concerns of GM crops, intellectual property rights, and future prospects of agricultural biotechnology.	6	CO5	K1 & K2
Reference Books: • Kumar, H.D. Agricultural Biotechnology (Revised Edition), Vikas Publishing House, 2022. • B.D. Singh. Biotechnology: Expanding Horizons (5th Edition), Kalyani Publishers, 2023. • P.K. Gupta. Elements of Biotechnology (3rd Edition), Rastogi Publications, 2022. • Razdan, M.K. Introduction to Plant Tissue Culture (3rd Edition), CRC Press, 2022. • B.R. Glick, J.J. Pasternak and C.L. Patten. Molecular Biotechnology: Principles and Applications of Recombinant DNA (6th Edition), ASM Press, 2023.				

Non Major Elective-II
ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY

Title of the paper	Analytical Techniques in Biotechnology		Subject Code:
Category of the course	Year	Semester	Credits
NME paper	2nd	3	2

Learning Outcome:

Acquire knowledge of analytical principles and instrumentation used for the analysis of biomolecules and biological systems.

Course Outcomes:

CO-1	Understand the principles, instrumentation, and applications of analytical techniques used in biotechnology.
CO-2	Explain the working principles of spectroscopic, chromatographic, and electrophoretic techniques.
CO-3	Apply analytical methods for the separation, identification, and characterization of biological molecules.
CO-4	Analyze biological samples and interpret experimental data using modern analytical tools.
CO-5	Evaluate the suitability of advanced analytical techniques for research, diagnostics, and quality control in biotechnology.

SYLLABUS NME Paper-2 ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	Basics of Analytical Techniques :Principles and importance of analytical techniques in biotechnology, sampling methods, preparation of biological samples, accuracy, precision, sensitivity, specificity, calibration, validation, and quality control in analytical procedures.	6	CO1	K1 & K3
II	Spectroscopic Techniques :Principles, instrumentation and applications of UV-Visible spectroscopy, fluorescence spectroscopy, infrared (IR) spectroscopy, atomic absorption spectroscopy (AAS), and mass spectrometry in biological analysis.	6	CO2 CO3	K2 &K4
III	Chromatographic Techniques :Principles and applications of paper chromatography, thin-layer chromatography (TLC), column chromatography, gas chromatography (GC), high-performance liquid chromatography (HPLC), ion-exchange chromatography, and affinity chromatography.	6	CO3	K1 & K5
IV	Electrophoretic and Microscopic	6	CO4	K2 &K3

	Techniques : Principles and applications of agarose gel electrophoresis, SDS-PAGE, isoelectric focusing, two-dimensional electrophoresis, light microscopy, fluorescence microscopy, electron microscopy, and confocal microscopy.			
V	Advanced Analytical Techniques : Principles and applications of PCR, real-time PCR, ELISA, Western blotting, biosensors, flow cytometry, DNA sequencing, protein characterization techniques, and bioanalytical instrumentation in biotechnology research.	6	CO4 CO5	K3 & K4

Reference Books:

- Keith Wilson and John Walker, Practical Biochemistry: Principles and Techniques (9th Edition), Cambridge University Press, 2024.
- R. O. Duda and P. E. Hart, Analytical Techniques in Biotechnology (Latest Edition), Springer, 2022.
- Upadhyay, A., Upadhyay, K. and Nath, N., Biophysical Chemistry: Principles and Techniques (6th Edition), Himalaya Publishing House, 2022.
- Plummer, D.T., An Introduction to Practical Biochemistry (6th Edition), McGraw Hill Education, 2022.
- R. M. Patel, Analytical Biochemistry and Instrumentation (Latest Edition), CBS Publishers & Distributors, 2023.

Non Major Elective-III
BIOENERGY TECHNOLOGY

Title of the paper	Bioenergy Technology		Subject Code:
Category of the course	Year	Semester	Credits
NME paper	2nd	4	2

Learning Outcome:

Acquire knowledge of analytical principles and instrumentation used for the analysis of biomolecules and biological systems.

Course Outcomes:

CO-1	Explain the principles and significance of bioenergy and biomass resources.
CO-2	Describe various biomass conversion technologies used for bioenergy production.
CO-3	Apply methods for the production of biofuels and biogas from renewable resources.
CO-4	Analyze bioenergy systems and waste-to-energy technologies for sustainable energy generation.
CO-5	Evaluate the environmental, economic, and sustainability aspects of bioenergy technologies.

SYLLABUS NME Paper-3 BIOENERGY TECHNOLOGY				
Unit	Contents	Hours	COs	Cognitive level
I	Introduction to Bioenergy : Energy resources and global energy demand, renewable and non-renewable energy sources, concept and importance of bioenergy, biomass resources, biomass characterization, and environmental impacts of conventional energy sources.	6	CO1 CO3	K1 & K3
II	Biomass Conversion Technologies : Biochemical and thermochemical conversion of biomass, anaerobic digestion, fermentation technology, combustion, gasification, pyrolysis, and production of value-added products from biomass.	6	CO2	K2 & K4
III	Biofuels and Their Production : Classification of biofuels, bioethanol production from lignocellulosic biomass, biodiesel production from plant oils and microalgae, biobutanol, biohydrogen production, and factors affecting biofuel production.	6	CO3 CO5	K1 & K5
IV	Biogas and Bioenergy Systems : Biogas production technology, biogas plant design and operation, microbial aspects of biogas production, biogas purification and	6	CO4	K4 & K5

	utilization, microbial fuel cells, and waste-to-energy technologies.			
V	Bioenergy Applications and Sustainability : Applications of bioenergy, energy recovery from industrial and agricultural wastes, environmental and economic aspects of bioenergy, life cycle assessment, carbon footprint, bioenergy policies, and sustainable bioenergy development.	6	CO5	K3 & K6
Reference Books: • R.C. Dubey. A Textbook of Biotechnology (6th Edition), S. Chand Publishing, 2024. • C.Y. Wereko-Brobby and E.B. Hagan. Biomass Conversion and Technology, Wiley, 2022. • A. Pandey, C. Larroche, S.C. Ricke and C.G. Dussap. Biofuels: Alternative Feedstocks and Conversion Processes (3rd Edition), Academic Press, 2023. • S. Kumar. Bioenergy Technology, New India Publishing Agency, 2022. • M. Kaltschmitt, H. Hartmann and H. Hofbauer. Energy from Biomass (2nd Edition), Springer, 2023.				