Academic Council Meeting No. and Date: 11 / June 27, 2025

Agenda Number: 2 **Resolution Number: 50, 51/ 2.1, 2.7**

Vidya Prasarak Mandal's
B. N. Bandodkar College of Science (Autonomous), Thane

Syllabus for

Programme: Bachelor of Science

Specific Programme: Biotechnology
[T.Y.B.Sc. Biotechnology]

Level 5.5

CHOICE BASED GRADING SYSTEM

Revised under NEP

From academic year 2025 - 2026

Preamble

Biotechnology is an applied branch of biology that includes the study of biological systems to develop or create different products for betterment of society. Microbiology, biochemistry, immunology, genetics, molecular biology, medicine (drug development and personalized therapies), agriculture, marine, industrial biotechnology are among many other fields that form a beautiful collage of Biotechnology.

The present revision is related to restructuring of syllabus under the National Education Policy 2020, which aims at the holistic development of learners. With Biotechnology and Microbiology as major and minor subjects respectively in earlier semesters, the students have learnt concepts in biophysics, biochemistry, tissue culture, medical microbiology, immunology and molecular techniques. This revised syllabus for semester V and VI would further build their concepts in biochemistry, molecular biology, pharmacology, drug discovery, virology, analytical techniques and recombinant DNA technology. Based on their inclination, the student would also be able to opt for dairy Biotechnology and Bioprocess Technology or environmental biotechnology in semester V; and agri or marine biotechnology in semester VI. Generic courses include cell biology. On-job training or field project that provide practical exposure for 60 hours, is also a mandate. The revised curriculum aims to impart basic knowledge with emphasis on its applications to make the students research and industry-ready.

This syllabus is implemented from the academic year 2025–26, with a total of 132 credits required for graduation, ensuring a balanced blend of discipline-specific knowledge, interdisciplinary learning, vocational training and research exposure.

Prof. Dr. Jayashree Pawar
HOD, Biotechnology
VPM's B.N.Bandodkar College of Science (Autonomous), Thane

PROGRAMME OUTCOMES (POs) OF BACHELOR OF SCIENCE (B.Sc.)

The Undergraduate Programmes of Science are intended to cater quality education and attain holistic development of learners through the following programme outcomes:

PO1 - Disciplinary Knowledge
Lay a strong foundation of conceptual learning in science. Instil ability to apply science in professional, social and personal life.

PO2 - Inculcation of Research Aptitude
Ignite spirit of inquiry, critical thinking, analytical skills and problem-solving approach which will help learners to grasp concepts related to research methodology and execute budding research ideas.

PO3 - Digital Literacy
Enhance ability to access, select and use a variety of relevant information e-resources for curricular, co-curricular and extracurricular learning processes.

PO4 - Sensitization towards
Environment Build a cohesive bond with nature by respecting natural resources, encouraging eco-friendly practices and creating awareness about sustainable development.

PO5 - Individuality and Teamwork
Encourage learners to work independently or in collaboration for achieving effective results through practical experiments, project work and research activities.

PO6 - Social and Ethical Awareness
Foster ethical principles which will help in developing rational thinking and becoming sociallyawarecitizens. Build an attitude of unbiased, truthful actions and avoid unethical behaviour in all aspects of life.

Eligibility: Learnt S. Y. B.Sc. in Biotechnology
Degree Programme: B.Sc. Duration: 1 Year (includes SEM V and SEM VI)
Level: 5.5
Duration: 3 years (Syllabus for Third Year semester V & VI)
Mode of Conduct: Offline Laboratory Practicals / Offline lectures / Online lectures
Discipline/Subject: Biotechnology
Specific Programme: B.Sc. Biotechnology
Qualification Title: UG certificate

Discipline/Subject: **BIOTECHNOLOGY**

Program Specific Outcomes

1	Recall and define fundamental concepts of biomolecules, cells, genes, enzymes, recombinant DNA technology, and basic molecular and cellular mechanisms underlying biotechnology.	L1
2	Explain the principles, workflows, and biosafety practices involved in standard biotechnological, molecular biology, biochemical, microbiological, and	L2

	bioinformatics techniques.	
3	Apply biotechnological principles to industrial, medical, agricultural, environmental, and pharmaceutical contexts, demonstrating how biological systems are engineered for specific biotechnological applications.	L3
4	Analyze and interpret biological and experimental data related to health and disease, including diagnostic, immunological, genomic, and therapeutic aspects of clinical and biomedical biotechnology.	L4
5	Evaluate biotechnological problems using critical thinking, data interpretation, and bioinformatic tools to propose feasible, evidence-based, and ethically sound solutions.	L5
6	Design and propose innovative biotechnological approaches to address societal, industrial, and environmental challenges, with emphasis on sustainability, public health, and community welfare.	L6

Specific Programme: T.Y.B.Sc. (Biotechnology -Major/ Minor) Theory 40% 60%		
Assessment: Weightage for assessments (in percentage) For Major and Minor		
Type of Course	Formative Assessment / IA	Summative Assessment
Theory	40 %	60 %

VPM's B. N. Bandodkar College of Science (Autonomous), Thane

T.Y.B.Sc. (Biotechnology)

Structure of Programme

Semester V				
	Course Code	**Course Title**	**No. of lectures**	**Credits**
Major	25BUBT5T01	Biochemistry III	**30**	**2**
	25BUBT5T02	Molecular Biology II	**30**	**2**
	25BUBT5T03	Pharmacology and Basics of Drug Discovery	**30**	**2**
	25BUBT5P01	Practicals based on 25BUBT5T01	**60**	**2**
	25BUBT5P02	Practicals based on 25BUBT5T02	**60**	**2**
	25BUBT5P03	Practicals based on 25BUBT5T03	**60**	**2**
DSE	25BUBT5TE1	Dairy Biotechnology and Bioprocess Technology	**30**	**2**
	25BUBT5PE1	Practicals based on 25BUBT5TE1	**60**	**2**
	OR			
	25BUBT5TE2	Environmental Biotechnology IV	**30**	**2**
	25BUBT5PE2	Practicals based on 25BUBT5TE2	**60**	**2**
Minor	25BUBT5TMN	Cell Biology	**30**	**2**
VSC	25BUBT5VSC	Biostatistics	**15**	**1**
		Practicals based on 25BUBT5VSC	**30**	**1**
FP or OJT	25BUBT5OJT	On Job Training in Biotechnology I	**60**	**2**
	OR			
	25BUBT5FPR	Field Project in Biotechnology IV	**60**	**2**
		Total	**495**	**22**

Semester VI				
	Course Code	**Course Title**	**No. of lectures**	**Credits**
Major	25BUBT6T01	Biochemistry IV	**30**	**2**
	25BUBT6T02	Analytical techniques	**30**	**2**
	25BUBT6T03	Virology and Regulation of Gene Expression	**30**	**2**
	25BUBT6T04	Recombinant DNA technology	**30**	**2**
	25BUBT6P01	Practicals based on 25BUBT6T01	**60**	**2**
	25BUBT6P02	Practicals based on 25BUBT6T02 and 25BUBT6T04	**60**	**2**
	25BUBT6P03	Practicals based on 25BUBT6T03 and 25BUBT6T04	**60**	**2**
DSE	25BUBT6TE1	AgriBiotechnology	**30**	**2**
	25BUBT6PE1	Practicals based on 25BUBT6TE1	**60**	**2**
	OR			
	25BUBT6TE2	Marine Biotechnology	**30**	**2**
	25BUBT6PE2	Practicals based on 25BUBT6TE2	**60**	**2**
VSC	25BUBT6VSC	Bioinformatics	**15**	**1**
		Practicals based on 25BUBT6VSC	**30**	**1**
FP or OJT	25BUBT6OJT	On Job Training in Biotechnology II	**60**	**2**
	OR			
	25BUBT6FPR	Field Project in Biotechnology V	**60**	**2**
		Total	**495**	**22**

Semester V

Course Code 25BUBT5T01	Course Title Biochemistry III	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

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

CO1	Understand the regulation and interconnection of major carbohydrate metabolic pathways in bacterial and animal systems.	L2
CO2	Outline the steps and regulation of lipid metabolic pathways, including transport, oxidation, and synthesis of fatty acids.	L2
CO3	Illustrate the process of electron transport in mitochondria, including the roles of ETC complexes, electron acceptors, electron carriers, and regulatory molecules.	L2
CO4	Explain the fundamental concepts of metabolism, energy-rich compounds, various ways of generating ATP, ATP synthase, and various terms related to energy generation.	L2

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	0	0	0
CO2	3	1	1	0	0	0
CO3	3	1	1	0	0	0
CO4	3	0	1	0	0	0

Units	Description	No of lecture
Unit I: Carbohydrate and lipid metabolism	1. Quick brush up on metabolism learnt in SY, Reciprocal regulation of metabolic pathways (Glycolysis & Gluconeogenesis) 2. Interconnections of metabolic pathways 3. Biosynthesis & regulation of Peptidoglycan in Bacteria 4. Metabolism & Regulation of Glycogen in Animals 5. Lipids: Digestion, Mobilization, and Transport 6. Catabolism: Oxidation of fatty acids: Beta, alpha, and omega oxidation, Oxidation of unsaturated fatty acids, Oxidation of odd-chain fatty acids 7. Anabolism: Synthesis of saturated (fatty acyl synthase complex, synthesis of palmitic acid from acetyl-CoA). Unsaturated fatty acids synthesis	**15**
Unit II: Bioenergetics	1. Introduction to metabolism: Metabolic pathways: Metabolites, Catabolism, Anabolism, Principal characteristics of metabolic pathways. 2. Energy Rich Compounds: ATP as Energy Currency, Structure of ATP, Hydrolysis, Other Energy Rich Compounds other than ATP like PEP, Creatine Phosphate, etc. 3. Biochemical mechanism of generating ATP: Substrate-Level-Phosphorylation, Oxidative Phosphorylation & Photophosphorylation. 4. Electron transport chain: a. Universal Electron acceptors that transfer electrons to E.T.C,.Carriers in E.T.C. b. Hydrogen carriers – NADH, Flavoproteins, Quinones. c. Electron carriers – Iron Sulphur proteins, Cytochromes. 5. Mitochondrial ETC: a. Biochemical anatomy of mitochondria. b. Complexes in Mitochondrial ETC. 6. Explanation of terms – Proton motive force, Proton pump, Coupling sites, P:O ratio, Redox potential (definition of Standard reduction potential). 7. Chemiosmotic theory. 8. Structure & function of Mitochondrial ATP synthase and Mechanism by Rotational catalysis. 9. Inhibitors of ETC, ATPase and uncouplers.	**15**

Course Code 25BUBT5T02	Course Title Molecular Biology II	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Explain the process of translation, the difference between prokaryotic and eukaryotic systems.	L2
CO2	Explain the genetic code, components of translation machinery (tRNA and ribosomes), the role of inhibitors in translation, and the process of protein sorting in cells.	L2
CO3	Explain the types, mechanisms, and biological significance of genetic mutations.	L2
CO4	Compare the effects of different mutagens and analyze the mechanisms cells use to repair and recombine damaged DNA.	L4

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	0	1	0	0	0
CO2	3	0	1	0	0	0
CO3	3	1	1	0	0	0
CO4	3	1	1	0	0	0

Units	Description	No of lecture
Unit I: Translation	1. Nature of Genetic Code: a. Overlapping Vs non- overlapping code (1L) b. Deciphering the genetic code; concept of 'reading frame' (1L) c. Characteristics of the genetic code; evidence: the genetic code is a	**15**

	triplet code 2. Transfer RNA, structure of tRNA, tRNA genes (3L) 3. Translation: Process of Protein Synthesis (Initiation, Elongation, Translocation, Proofreading on the ribosome, Termination) (4L). 4. From an RNA World to a Protein World (4L): a. Ribozyme in protein synthesis b. The Wobble Hypothesis c. The significance of GTP in protein synthesis 5. Protein synthesis in eukaryotes (1L) 6. Inhibitors and modifiers of protein synthesis in prokaryotes and eukaryotes (1L) 7. Protein sorting in the cell (1L)	
Unit II: Mutation, repair and recombination	1. Mutations (10L) a. Definition and Types of Mutations. b. Mutation rate and mutation frequency. c. Types of Point Mutations: transition, transversion, missense, nonsense, neutral, silent, frameshift, leaky mutations d. Reverse Mutations and Suppressor Mutations: Induced Variation in the Genetic Code: Nonsense Suppression. e. Spontaneous Vs Induced mutations; Mutagenesis and Mutagens (Examples of Physical, Chemical and Biological Mutagens); mutator genes and mutational hotspots f. loss-of-function and gain-of-function mutation. h. Conditionally expressed mutants 2. DNA Repair (4L) Photo-reversal, Base Excision Repair, Nucleotide Excision Repair, Mismatch Repair, SOS Repair and Recombination Repair, NHEJ 3. Molecular mechanism of Homologous Recombination (Holliday model) (1L)	**15**

Course Code 25BUBT5T03	Course Title Pharmacology and Basics of Drug Discovery	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Recall conventional processes of drug discovery and different assays used in the process	L1
CO2	Relate newer methods of drug discovery, presubmission process, approval of new drugs and post-approval research	L1
CO3	Explain the phases of clinical investigation and related aspects	L2
CO4	Explain drug response w.r.t. Therapeutic index, ED, LD, Equations derived from drug receptor interaction, potency and intrinsic activity, drug antagonism	**L3**

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	1	1
CO2	2	3	1	0	0	1
CO3	3	2	1	0	2	3
CO4	3	2	0	0	1	1

Units	Description	No of lecture
Unit I: Basics of drug discovery	1. Introduction 2. Conventional processes of drug discovery 3. Cell based assays, receptor binding assays, enzyme assays 4. Newer methods : computer aided drug design, combinatorial chemistry, genomic methods 5. Search of drugs among unculturable microorganisms 6. Approval of new antibiotic and other drugs by regulating agency	**15**

	7. Pre submission of the new drug to FDA 8. Post approval research.	
Unit II: Pharmacology	1. Clinical testing of drugs 2. Phases of clinical investigation, special population, Adverse reaction surveillance 3. Receptors, drug receptors and biological responses 4. Second messenger systems 5. The chemistry and Dynamics of drug receptor binding 6. Dose response relationship 7. Therapeutic index, ED, LD 8. Equations derived from drug receptor interaction 9. Potency and intrinsic activity 10. Drug antagonism	**15**

Course Code 25BUBT5P01	Course Title Practicals based on 25BUBT5T01	Credits (02)	No. of Lectures in Hours: 60

COURSE OUTCOME

On completion of this course, students will be able to: **25BUBT5P01**

CO1	Perform quantitative biochemical estimations such as Bartlett's phospholipid method or cholesterol estimation	L3
CO2	Carry out and interpret analytical techniques such as thin layer chromatography (TLC) of fatty acids or HbA1c estimation	L4
CO3	Explain the principles, procedures, and applications of biochemical experiments including lipoprotein estimation, phospholipid analysis, mitochondrial isolation, ETC demonstration, lecithin and cholesterol extraction.	L2
CO4	Analyze experimental observations, calculations, and results obtained from biochemical estimations of cholesterol, phospholipids, HbA1c and separation techniques of fatty acids by TLC, and answer theoretical questions related to all prescribed practicals with appropriate biochemical principles, reactions, and clinical or physiological relevance.	L4

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	1	0
CO2	3	2	1	0	1	0
CO3	3	1	1	0	1	0
CO4	3	1	1	0	1	0

Practical No.	Name of experiment	Number of hours
Practical 1	Determination of HbA1c in human blood	10
Practical 2	Estimation of phospholipid by Bartlette's method (Lecithin/Cephalin)	10
Practical 3	Separation of fatty acids by TLC	10

Practical 4	Isolation of Mitochondria and Demonstration of ETC using a Marker Enzyme	12
Practical 5	Extraction of Lecithin and Cholesterol from egg yolk and its quantification	8
Practical 6	Estimation of cholesterol (HDL and total)	10

Course Code 25BUBT5P02	**Course Title Practicals based on 25BUBT5T02**	**Credits (02)**	**No. of Lectures in Hours: 60**

COURSE OUTCOME

On completion of this course, students will be able to: **25BUBT5P02**

CO1	Perform replica plating or UV mutagenesis–based isolation of mutants or gradient plate technique for dye-resistant mutants	L3
CO2	Plot the UV survival curve, calculate and determine D_{90}, and interpret the effect of UV exposure on microbial survival.	L4
CO3	Explain the principles, methodology, and applications of translation (virtual lab), genetic code decoding, UV mutagenesis, mutant isolation, and selection and characterization of mutants.	L2
CO4	Analyze experimental observations, survival data, and mutant phenotypes, and answer theoretical questions related to all prescribed practicals using appropriate genetic concepts and molecular mechanisms.	L2

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1	0	1	0
CO2	3	2	1	0	1	0
CO3	3	2	1	0	1	0
CO4	3	1	2	0	1	0

Practical No.	**Name of experiment**	**Number of hours**
Practical 1	Virtual lab for translation	5
Practical 2	Puzzle based decoding of the genetic code	5

Practical 3	UV survival curve – determination of D90	15
Practical 4	Isolation of mutants using UV mutagenesis	15
Practical 5	Gradient plate technique (dye resistant mutants)	10
Practical 6	Replica plate technique for selection & characterization of mutants – auxotroph & antibiotic resistant	10

Course Code 25BUBT5P03	**Course Title Practicals based on 25BUBT5T03**	**Credits (02)**	**No. of Lectures in Hours: 60**

COURSE OUTCOME

On completion of this course, students will be able to: **25BUBT5P03**

CO1	Perform microbiological assays such as agar cup method, ditch plate method, synergistic interaction assay, crowded plate technique, or Wilkins' overlay method to detect, screen, or evaluate antibiotic activity.	L3
CO2	Plot and analyze dose–response or standard curves obtained from bioassay of antibiotics and LD_{50} / ED_{50} evaluation, and interpret the biological effectiveness or toxicity of antimicrobial compounds.	L4
CO3	Explain the principles, methodology, and applications of chemical estimation of penicillin, bioassays, AST for water-insoluble antibiotics, screening of antibiotic producers, and toxicity testing models.	L2
CO4	Analyze experimental observations, inhibition zones, assay results, and calculated values, and answer theoretical questions related to all prescribed practicals using appropriate microbiological, pharmacological, and biochemical justification.	L4

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1	0	1	0
CO2	3	2	1	0	1	0
CO3	3	2	1	0	1	0
CO4	3	1	2	1	1	1

Practical No.	Name of experiment	Number of hours
Practical 1	To detect the levels of antibiotics in body fluids using agar cup method.	10
Practical 2	LD 50, ED 50 evaluation using suitable models e.g.,*Daphnia*	8
Practical 3	Chemical estimation of penicillin	8
Practical 4	Bioassay of antibiotic	10
Practical 5	Antibiotic sensitivity testing by ditch plate method	8
Practical 6	Primary screening of antibiotic producers by Wilkin's overlay	8
Practical 7	Determination of Synergistic Activity	8

Course Code 25BUBT5TE1	Course Title Dairy Biotechnology and Bioprocess Technology	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Explain the microbiological quality parameters of milk and milk products, methods of preservation and the role of microorganisms in various dairy fermentations.	L2
CO2	Summarize the role of microorganisms in dairy fermentation, the diversity of cheese types based on microbial activity, and current diagnostic methods for identifying milk-borne pathogens	L2
CO3	Discuss the principles of fermentation scale-up and scale-down, the role of computer-based control systems and the significance of economic considerations in industrial fermentation processes.	L2
CO4	Explain the fundamental concepts, types, and applications of bioassays used in fermentation-based processes.	L2

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	0	1	3
CO2	3	1	1	0	1	3
CO3	3	1	1	0	1	3
CO4	3	1	1	0	1	3

Units	Description	No of lecture
Unit I: Dairy Biotechnology	1. Normal flora of milk, Changes in raw milk, Microbiological Quality of Milk & Milk Products: SPC, coliform count, LPC, thermophilic, psychrophilic counts and DMC. 2. Raw and fluid milk products Pasteurization & Ultra-pasteurization, Preservation methods (drying, evaporation, condensation).	**15**

	3. Microbiology of butter, Yogurt, cultured buttermilk, dry milk and whey (flowsheet). 4. Cheese: Cheddar, Cottage, Processed Cheese, Cheese Defects. Enlist other cheese and associated microorganisms. 5. Rapid detection of milk borne pathogens- Nucleic acid based methods, immunological assays, biosensors.	
Unit II: Bio process Technology	1. Scale up and scale down of fermentation 2. Computer control 3. Fermentation economics 4. Bioassay a. Introduction b. Types: Diffusion, End Point, Turbidimetric, Metabolic Response, Enzymatic	**15**

Course Code 25BUBT5PE1	Course Title Practicals Based on 25BUBT5TE1	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Apply biochemical techniques such as Pyne's method to estimate milk protein and perform direct microscopic count (DMC) and phosphatase test to assess milk quality.	L3
CO2	Perform and interpret standard plate count (SPC), laboratory pasteurized milk count (LPC), thermophilic count, psychrophilic count, and coliform count to determine the total microbial load and hygienic quality of milk samples.	L3
CO3	Explain the principles, procedures, and significance of milk protein estimation (Pyne's method), direct microscopic count, phosphatase test, and isolation of normal microbial flora from milk and curd.	L2
CO4	Analyze and justify the principles, methodology, results, and quality implications of plate count techniques (SPC, LPC, thermophilic, psychrophilic, and coliform counts) and normal flora analysis, using appropriate microbiological standards.	L4

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	1	0
CO2	3	2	1	0	1	0
CO3	3	1	1	0	1	0
CO4	3	2	1	0	1	0

Practical No.	Name of experiment	Number of hours
Practical 1	Estimation of milk protein- Pyne's method	10
Practical 2	DMC of milk sample	7
Practical 3	Isolation of Normal flora from Milk and curd	6
Practical 4	Phosphatase test	7
Practical 5	Plate counts (SPC, LPC, Thermophilic and psychrophilic and coliform counts for provided milk sample	30

Course Code 25BUBT5TE2	Course Title Environmental Biotechnology IV	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Explain the components, significance, and productivity of aquatic ecosystems, along with basic microbiology of water and common drinking water purification methods.	L2
CO2	Describe the nature and ecology of wastewater, and explain the stages of modern sewage treatment, including sludge processing and disposal methods.	L2
CO3	Explain the causes, impacts, and control measures of major environmental issues such as pollution, eutrophication, soil degradation, and sea level rise, along with the concept of a circular economy.	L2
CO4	Explain the concept of bioindicators and their role in monitoring environmental pollution using various organisms and biochemical markers.	L2

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	1	0	0
CO2	3	1	1	2	0	0
CO3	3	1	1	2	0	0
CO4	3	1	1	2	0	0

Units	Description	No of lecture
Unit I: Aquatic ecosystems	**The aquatic ecosystem (5L)** 1. Natural waters: Atmospheric, surface, stored and ground waters 2. Factors affecting the aquatic environment 3. Fauna and flora of aquatic environment	**15**

	4. Techniques to study aquatic environment 5. Role and importance of aquatic ecosystem 6. Productivity of aquatic ecosystem **The microbiology of Domestic water and sewage** **Drinking water purification treatment processes (4L):** Preventive treatment, Sedimentation, Flocculation and osmosis, Disinfection: Chlorine, Ozone treatment and UV disinfection **Domestic sewage treatment (6L)** **1.** Ecology of wastewater 2. Nature of wastewater 3. Modern Wastewater treatment: Primary, Secondary and Tertiary Treatment 4. Oxidation Ponds and Septic tanks 5. Sludge Processing; Disposal of treated wastewater and Biosolids	

Unit II: Current global environmental issues	**Current global environmental issues and possible solutions** 1. Noise pollution: Sources, weighting networks, measurement of noise indices (Leq, L10, L90, L50, LDN, TNI). Noise dose and Noise Pollution standards. Noise control and abatement measures: Active and Passive methods. Vibrations and their measurements. Impact of noise and vibrations on human health. (3L) 2. Electronic waste (E-waste): Sources and types and constituents of E-wastes and its environmental consequences, measures to control (2L) 3. Plastic pollution: Sources, environmental consequences (terrestrial animals and humans, flora and fauna of waterbodies, effect on food web), Measures to control (2L) 4. Eutrophication and restoration of lakes and algal blooms; problem and consequences; Measures to control and resolve (1L) 5. Melting Ice Caps and Sea Level Rise: consequences, Measures to control (1L) 6. Ocean Acidification & pollution: problem, consequences (marine ecosystem and food web); Measures to control (1L) 7. Concept of circular economy (1L) **Monitoring pollution:** (4L) Bioindicators: Tolerance index, Types: plant, animal (earthworms, frogs, toads, insects, Freshwater Mussels), microbial (bacterial, algal, fungal, lichens), planktons, Enzymes as bioindicators Bat as Bioindicator of Environment Health Assessment Honey Bee as Bioindicator of Environment Quality Lichen as Bioindicator of Metal Pollution Phytoplankton as Bioindicator for Water Quality	**15**

Course Code 25BUBT5PE2	Course Title Practicals Based on 25BUBT5TE2	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Apply standard analytical techniques to determine organic and inorganic load in sewage samples through TOC, TS/TDS/TSS, BOD, and COD estimations.	L3
CO2	Apply microbiological techniques to detect and confirm the presence of coliforms in water using presumptive, confirmed, completed, and Eijkman tests and perform routine microbiological analysis using plate count techniques.	L3
CO3	Explain the standard ecological methods to determine the primary productivity of pond water.	L2
CO4	Discuss the microbial composition of sewage and the procedures used to detect fecal indicator organisms such as *Streptococci* and *Clostridia*.	L2

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	1	1	0
CO2	3	2	1	1	1	1
CO3	3	2	1	1	1	1
CO4	3	1	0	1	1	1

Practical No.	Name of experiment	Number of hours
Practical 1	Determination of Primary productivity of pond water	10
Practical 2	Routine analysis of water: a. Standard Plate Count	05
Practical 3	b. Detection of Coliforms in water: Presumptive Test,	15

	Confirmed Test and Completed Test	
Practical 4	Determination of TOC, TS/TDS/TSS, BOD, COD of sewage sample	20
Practical 5	Study of microbial flora in raw and treated sewage	05
Practical 6	Detection of fecal Streptococci	05

Course Code 25BUBT5TMN	Course Title Cell Biology	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

Students will be able to learn OR on completion of this course, students will be able to learn:

CO1	Outline the phases of the eukaryotic cell cycle and explain the roles of cyclins, Cdks and checkpoints in regulating cell cycle progression and mitosis.	L2
CO2	Differentiate between mitosis and meiosis, and examine the mechanisms of fertilization and programmed cell death in eukaryotic cells.	L4
CO3	Identify major components of cell signaling systems and describe the mechanism of signal transmission through G protein-coupled receptors and second messengers.	L2
CO4	Examine receptor tyrosine kinase, JAK-STAT, and TGF-β/SMAD signaling pathways, and explain how feedback and crosstalk contribute to the integration of cellular signaling networks.	L4

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	0	0	2	1
CO2	3	2	0	0	2	1
CO3	3	0	1	0	0	0
CO4	3	0	1	0	0	0

Units	Description	No of lecture
Unit I: Cell Cycle	**1. The eukaryotic cell cycle (3L)** Phases of cell cycle (no experiments to be discussed) Regulation of the cell cycle by cell growth and extracellular	**15**

	signals Cell cycle checkpoints Restricting DNA replication to once per cell cycle **2. Regulators of cell cycle progression (3L)** Protein kinases and cell cycle progression (no discussion of yeast and sea urchin experiment) Families of cyclins and cyclin dependent kinases (only animal cell, no CKIs to be discussed) Growth factors and the regulation of G1 Cdks (No discussion of Rb and E2F) DNA damage checkpoints **3. The events of M phase (3L)** Stages of Mitosis Cdk1/ Cyclin B and progression to metaphase (No fragmentation of Golgi apparatus to be discussed) The spindle assembly checkpoint and progression to anaphase Cytokinesis **4. Meiosis and fertilization (3L)** The process of meiosis Regulation of oocyte meiosis (No discussion of CSF and Mos) Fertilization **5. Apoptosis (Programmed Cell Death) (3L)** Programmed cell death versus accidental cell death: Apoptosis versus Necrosis The Extrinsic Pathway of Apoptosis The Intrinsic Pathway of Apoptosis	
Unit II: Cell Signalling	1. The basic elements of cell signaling systems (2L) 2. A survey of extracellular messengers and their receptors (1L) 3. G protein-coupled receptors and their second messengers (signal transduction by G protein-coupled receptors, second messengers) (6L) 4. Protein-tyrosine phosphorylation as a mechanism for signal transduction (3L) 5. JAK STAT and TGF beta/SMAD pathways (1L) 6. Signaling networks: (feedback and crosstalk, networks of cellular signal transduction) (2L)	**15**

Course Code 25BUBT5VSC	Course Title Biostatistics	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Justify statistical claims by applying hypothesis testing procedures and interpreting outcomes related to population means using appropriate statistical tools.	L5
CO2	Explain the principles of experimental design and summarize the characteristics and applications of binomial, Poisson, normal probability distributions and Student's t distribution.	L2
CO3	Apply statistical tools in MS Excel or R to analyze normal distributions and perform hypothesis testing on a single mean using Z.	L3
CO4	Evaluate differences between single mean/ two independent/ paired samples using appropriate hypothesis testing methods in MS Excel or R-software.	L5

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	1	1
CO2	3	2	1	0	1	1
CO1	3	2	3	0	1	1
CO2	3	2	3	0	1	1

Units	Description	No of lecture
Unit I: Biostatistics	1. Design of experiments (3L) 2. Introduction to Binomial distribution and Poisson distribution (2L) 3. Normal distribution: Overview, standard normal distribution, Application of normal distribution (2L) 4. Student t distribution (1L) 5. Basics of hypothesis testing (2L) 6. Testing a claim about a mean (5L)	**15**

Practical No.	Name of experiment	Number of hours
Practical 1	Study of normal distribution of data using MS Excel/ R-software	8
Practical 2	Testing a claim about mean (Z test, t test) using MS Excel/ R-software	10
Practical 3	Testing a claim about two means (independent samples) MS Excel/ R-software	6
Practical 4	Testing a claim about matched pairs MS Excel/ R-software	6

Course Code 25BUBT5OJT	On Job Training in Biotechnology I	Credits 02	No. of Hours. 60

COURSE OUTCOMES

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

CO1	Demonstrate practical, hands-on skills directly applicable to their roles defined by the organization.	L2
CO2	Relate the direct impact of good laboratory practices with quality standards.	L2
CO3	Build a professional skill set, including soft skills.	L3
CO4	Explain outcomes clearly through written reports, visual displays, or oral presentations.	L5

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	3	2
CO2	3	2	2	1	3	2
CO3	3	2	2	1	3	2
CO4	3	2	3	1	3	2

Description

In this course, the learner is required to get engaged in ‘On job training’ at a professional institute/ organization from the field related to Biotechnology. The learner is expected to acquire field-based skills, professional planning and execution of activities undertaken by the organization. The learner needs to complete 60 hrs. of training.

The learner would be required to qualify the assessment where he /she would be required to communicate outcomes clearly, interpret findings logically through written report, and visual oral presentation and viva.

Course Code 25BUBT5FPR	Field Project in Biotechnology IV	Credits 02	No. of Hours. 60

COURSE OUTCOME		
On completion of this course, students will be able to learn:		
CO1	Demonstrate practical, hands-on competence in essential laboratory techniques	L2
CO2	Develop analytical skills like designing experiment, data collection, statistical analysis and interpretation of results	L3
CO3	Experiment with basic knowledge integration from allied fields like molecular biology, bioinformatics, and biotechnology to address complex, multidisciplinary challenges	L3
CO4	Build written and oral communication skills through report writing, presentations	L3

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	1	3	2
CO2	3	3	3	1	3	2
CO3	3	3	3	1	3	2
CO4	3	3	3	1	3	2

Description
The learner can undertake the field project to apply knowledge of core topics of basic biotechnology to solve a real-world problem in areas such as healthcare, environmental sustainability, food safety, agriculture etc. The learner would be required to qualify the assessment where he /she would be required to communicate outcomes clearly, interpret findings logically through written report, visual displays, or oral presentations and viva.

Semester VI

Course Code 25BUBT6T01	Course Title Biochemistry IV	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Classify amino acids based on their R groups & describe the primary and secondary levels of protein structure and the implications of misfolding in human genetic disorders.	L2
CO2	Explain the tertiary and quaternary structure of protein alongwith process of protein folding	L2
CO3	Describe the need for enzyme isolation, identification of enzyme sources, and explain common methods such as ammonium sulfate precipitation, dialysis and basic purification techniques.	L2
CO4	Analyze advanced concepts in enzyme biochemistry including the choice of purification methods, enzyme immobilization, non-canonical enzymes (abzymes, synzymes, ribozymes), and enzyme engineering.	L4

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	0	1	0	0	0
CO2	3	0	1	0	0	0
CO3	3	1	1	0	0	0
CO4	3	1	1	0	0	0

Units	Description	No of lecture
Unit I: Protein Biochemistry	1. Four orders of Protein structure ● Amino acids can be classified by R groups (2L) ● Primary structure: The function of protein depends on its amino acid sequence (1L) ● Secondary structure: Peptide bonds restrict possible secondary conformations, Alpha helix, Beta sheets, Loops and bends (3L) ● Tertiary and Quaternary structure: Fibrous proteins (Collagen, Alpha keratin) Globular proteins (Myoglobin and hemoglobin) (5L) 2. Protein folding (2L) 3. Defects in Protein Folding Provide the Molecular Basis for a Wide Range of Human Genetic Disorders (2L)	**15**
Unit II: Advanced Enzymology	1. Need for isolation of enzymes, Identification of enzyme sources 2. Methods of Isolation of enzyme 3. Ammonium sulphate precipitation and dialysis 4. Methods of purification (Tabulation) 5. Some representative techniques employed initially for enzyme isolation 6. Choice of methods of purification, Terms related to enzyme purification 7. Enzyme immobilization 8. Non-canonical enzymes: abzymes, synzymes, ribozymes 9. Concept of enzyme engineering	**15**

Course Code 25BUBT6T02	Course Title Analytical techniques	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Explain the principles, working and biological applications of fluorescence spectroscopy, luminometry, atomic absorption, and flame spectrometry.	L2
CO2	Explain the working principles and biological significance of IR and Raman spectroscopy, imaging techniques, and isotope-based methods, including safety aspects.	L2
CO3	Explain the principles, instrumentation, and applications of partition and adsorption chromatography, ion exchange, and size exclusion chromatography.	L2
CO4	Summarize the working principles and biological applications of affinity, hydrophobic interaction, and gas-liquid chromatography.	L2

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	0	0
CO2	3	2	1	0	0	0
CO3	3	2	1	0	0	0
CO4	3	2	1	0	0	0

Units	Description	No of lecture
Unit I: Spectroscopy, imaging techniques and Isotopes in Biology	1. Spectroscopy Revision of basics (1L) Principle, working and applications related to biological science of: a. Fluorescence spectroscopy (3L) b. Luminometry (1L) c. IR and Raman spectroscopy (For Raman only intro and difference) (2L) d. Atomic absorption and Flame spectrometry (3L) 2. Introduction to imaging techniques: PET scan, CT scan (2L) 3. Isotopes in Biology (3L) a. Nature of radioactivity b. Detection Techniques using GM counter, Scintillation counter c. Autoradiography d. Applications of Tracer technique in Biology e. Safety aspect	**15**
Unit II: Chromatography	1. Introduction to chromatography (1L) 2. Partition Vs Adsorption chromatography 3. Column chromatography- Principle, Instrumentation and applications of the following: (10L) i. Ion exchange chromatography ii. Size exclusion-gel filtration iii. Affinity chromatography. Chromatography for Nucleic acids and DNA binding proteins (DNA cellulose chromatography), use of oligo-dT columns for eukaryotic mRNA isolation iv. Hydrophobic interaction chromatography (2L) 3. Gas Liquid Chromatography (2L)	**15**

Course Code 25BUBT6T03	Course Title Virology and Regulation of gene expression	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Describe the structure, classification, and taxonomy of viruses, including unique forms like satellite, helper, and giant viruses.	L2
CO2	Illustrate the life cycles, transmission, and methods for purification, cultivation, enumeration, and detection of viruses.	L2
CO3	Describe fundamental aspects of gene regulation in prokaryotes and eukaryotes, including operon models, transcriptional control mechanisms, regulation of the lac operon and riboswitches	L2
CO4	Analyze regulatory strategies in bacteria including the trp operon, lambda phage pathways, sigma factor control and post-transcriptional regulation by sRNAs	L4

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	0	0	0
CO2	3	1	1	0	0	0
CO3	3	1	1	0	0	0
CO4	3	1	1	0	0	0

Units	Description	No of lecture
Unit I: Virology	1. Revision of general properties & structure of Viruses learnt in FY, Baltimore classification & Taxonomy (ICTV), Concept of satellite and helper viruses, largest virus Mimivirus 2. Viral Life cycle: Influenza, HIV, Bacteriophage T4, TMV 3. Transmission of Virus 4. Purification, Cultivation, Enumeration, Detection, Cytocidal infections and cell damage 5. Cancer Biology: development and causes of cancer, concept of retro-oncogene, oncogene and tumor suppressor gene 6. Role of viruses in cancer: Viral oncogenes, Examples of viruses involved in cancer: EB, HPV, HBV, Kaposi's Sarcoma 7. Viroids and Prions	**15**
Unit II: Regulation of gene expression	1. Introduction (2L): Aspects of gene regulation (similarities and differences in bacteria and eukaryotes): Genes and regulatory elements, Levels of gene regulation, DNA binding proteins 2. Control of transcription in bacteria: Operon structure, Negative and positive control- Inducible and repressible operons 3. Lac operon: Mutations and regulation (4L) 4. Trp operon (2L) 5. Regulation of lytic and lysogenic pathway of lambda phage (3L) 6. Regulation of Sigma factor during growth: Sigma factor control by RNA thermometers and proteolysis (1L) 7. Regulatory RNAs: Intro, Mechanism of sRNA function, sRNA molecules expand the reach of regulatory proteins (2L) 8. Riboswitches (1L)	**15**

Course Code 25BUBT6T04	Course Title Recombinant DNA technology	Credits (02)	No. of Lectures in Hours. 30

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Summarize the properties and functions of enzymes used in recombinant DNA technology, including polynucleotide kinase, alkaline phosphatase and T4 DNA polymerase and analyze the mechanisms of DNA cutting and joining using restriction enzymes and DNA ligases.	L2
CO2	Discuss the features and applications of different cloning vectors and gene transfer methods in prokaryotes, such as transformation, electroporation and in vitro packaging.	L2
CO3	Describe the construction and screening of genomic, chromosomal, and cDNA libraries, and the role of probes and hybridization techniques in gene identification.	L2
CO4	Apply molecular techniques such as PCR, restriction mapping, in situ hybridization, and complementation to analyze gene location, function, and expression.	L3

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	0	0
CO2	3	2	1	0	0	0
CO3	3	2	1	0	0	0
CO4	3	2	1	0	0	0

Units	Description	No of lecture
Unit I: Enzymes and vectors	1. Enzymes in RDT: TDT, polynucleotide kinase, alkaline phosphatase, T4 phage polymerase: properties and applications 2. Cutting and joining DNA: Restriction enzymes: Types, properties,	**15**

	nomenclature, blunt Vs. sticky end cutters, rare Vs frequent cutters, Calculation of probability of cutting a given piece of DNA, isoschizomers and neoschizomers, star activity, partial and complete digestion of DNA 3. DNA ligase: definition, mode of action, sources and properties, temperature for ligation, use of linkers 4. Cloning vectors-Plasmids (pUC series), lambda phage replacement vectors, cosmids, phagemids M13, shuttle vectors, YAC vectors, expression vectors (introduction) 5. Methods of gene transfer in prokaryotes: transformation, electroporation, *in vitro* packaging followed by transduction	
Unit II: Recombinant libraries	1. Genomic, chromosomal and cDNA libraries: definition and construction 2. Radioactive and non- radioactive probes, synthesis of probe (random primer, nick translation, end labelling), autoradiography Screening of libraries: 3. PCR 4. Southern hybridization (RE digestion, denaturation, neutralization, blotting, baking/ crosslinking, pre-hybridization, hybridization, post-hybridization washes, detection) 5. Northern and Western hybridization for library screening 6. Restriction mapping 7. FISH, *in situ* hybridization: pros and cons 8. Advantages and drawbacks of PCR Vs. hybridization 9. Complementation of mutants 10. Chromosome walking	**15**

Course Code 25BUBT6P01	Course Title Practicals based on 25BUBT6T01	Credits (02)	No. of Lectures in hours: 60

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Analyze protein profiles by interpreting SDS-PAGE results to evaluate the molecular weight and purity of extracted proteins.	L4
CO2	Carry out protein estimation using the Bradford method, assess phosphatase enzyme activity, and perform yeast cell immobilization for invertase production.	L3
CO3	Explain the principles and procedures involved in protein extraction from bacterial and plant cells and the theoretical basis of yeast cell immobilization for invertase production.	L3
CO4	Describe the theoretical basis and steps involved in protein fractionation using ammonium sulphate precipitation followed by dialysis.	L2

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	1	0
CO2	3	2	1	0	1	0
CO3	3	2	1	0	1	0
CO4	3	1	1	0	1	0

Practical No.	Name of experiment	Number of hours
Practical 1	Protein extraction from bacterial & plant cells	60
Practical 2	Separation of extracted proteins using SDS-PAGE	
Practical 3	Ammonium sulphate precipitation and dialysis (demonstration)	
Practical 4	Monitoring protein purification: protein estimation by Bradford method	

Practical 5	Comparison of crude and purified enzyme activity	
Practical 6	Estimation of phosphatase enzyme activity	
Practical 7	Immobilization of yeast cells for invertase production	

Practical No.	**Name of experiment**	**Number of hours**
Practical 1	Introduction of Chromatography: Size exclusion Chromatography	60
Practical 2	Radioisotopes (half-life)	
Practical 3	Genomic DNA Extraction from Animal cells and agarose gel electrophoresis	
Practical 4	Extraction of a suitable plasmid vector (pUC18) and agarose gel electrophoresis	
Practical 5	RE digestion	
Practical 6	Restriction mapping	
Practical 7	Concept and preparation of MW marker (demonstration)	
Practical 8	Ligation	

Course Code 25BUBT6P02	**Course Title Practicals based on 25BUBT6T02 and 25BUBT6T04**	**Credits (02)**	**No. of Lectures in Hours: 60**

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Apply and analyze molecular biology techniques to extract genomic and plasmid DNA, perform restriction enzyme digestion, and interpret agarose gel band patterns to assess DNA quality and fragment size.	L3
CO2	Explain the principles, procedures, and expected band patterns of genomic and plasmid DNA extraction, restriction enzyme digestion, and agarose gel electrophoresis.	L2
CO3	Analyze DNA fragment data to interpret restriction maps and infer molecular weight marker preparation strategies.	L4

CO4	Analyze biochemical data to solve problems related to radioisotope decay, enzyme purification efficiency, and selection of appropriate chromatographic techniques.	L4

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	1	0
CO2	3	2	1	0	1	0
CO3	3	2	1	0	1	0
CO4	3	1	1	0	1	0

Course Code 25BUBT6P03	**Course Title Practicals based on 25BUBT6T03 and 25BUBT6T04**	**Credits (02)**	**No. of Lectures in Hours: 60**

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Interpret transformation outcomes and evaluate transformation efficiency to assess the effectiveness of competent cell preparation	L4
CO2	Explain the principles, methods, calculations, and significance of nucleic acid quantification	L2
CO3	Discuss the concept of blue-white screening and the expression and activity measurement of β-galactosidase.	L2
CO4	Apply quantitative methods to analyze diauxic growth curves and bacteriophage assay.	L3

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	1	0
CO2	3	2	1	0	1	0
CO3	3	2	1	0	1	0

CO4	3	1	1	0	1	0

Practical No.	Name of experiment	Number of hours
Practical 1	Study of Diauxic Growth Curve (Lactose and Glucose)	60
Practical 2	Expression of β-galactosidase and measurement of activity	
Practical 3	Bacteriophage assay	
Practical 4	Quantification of NAs	
Practical 5	Preparation of competent cells and Transformation in E. coli; Calculation of transformation efficiency	
Practical 6	Blue -white selection	
Practical 7	Southern Hybridization (demonstration)	

Course Code 25BUBT6TE1	Course Title AgriBiotechnology	Credits 2	No. of lectures

COURSE OUTCOME

On completion of this course, students will be able to learn:		
CO1	List the types, structure, glazing materials, agroclimatic factors, and environmental controls essential for greenhouse cultivation.	L4
CO2	Describe the use of advanced greenhouse technologies, precision cultivation, sustainable practices, and traditional organic methods in modern agriculture.	L2
CO3	Describe the effects of various abiotic stresses (water, temperature, light, salt, and heavy metals) on plant physiology and explain associated protective mechanisms and stress-sensing responses.	L2
CO4	Analyze plant responses to biotic stress, including beneficial and harmful interactions with microorganisms and herbivores, and evaluate the signaling and defense mechanisms involved.	L4

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	2	0	0
CO2	3	1	1	2	0	0
CO3	3	1	1	1	0	0
CO4	3	1	1	1	0	0

Units	Description	No of lecture
Unit I: Modern agricultural systems	1. Introduction to greenhouse and it importance 2. Agroclimate: factors important for greenhouse cultivation (2L) 3. Types of glazing materials 4. Types of greenhouse: Based on cost investment, shape, construction, covering materials (2L)	**15**

	5. Greenhouse Environmental Control: Ventilation, Cooling, Heating, Humidity (2L) 6. Phytotrons, Fertigation (1L) 7. Advanced Greenhouse Technologies: Hydroponics, Aeroponics (2L) 8. Precision Cultivation- Intro, Core principles, Key technologies, benefits and limitations. (2L) 9. Sustainable practices in greenhouse agriculture: Energy, Water and Waste management (2L) 10. *Bacillus thuringiensis* (BT) as biopesticide: pros and cons (1L) 11. Reviving Organic and natural farming: Beejamrit, Jeevamrit, Panchgavya, Neemastra (Organic pesticide) (1L)	
Unit II: Plant stress Biology	**1. Abiotic stress (10L)** ● Water stress: (3L) Water deficit [Consequences: membrane damage, photosynthesis, ABA accumulation, Stomatal response; Physiological and cellular responses: Osmoprotection (only examples of compatible solutes and aquaporins), LEA proteins]; Flooding [Role of aerenchyma in the growth of rice and other plants undergoing waterlogging (no discussion of ethylene pathway), ROS] ● Temperature stress: Low and high temperature ● Light stress ● Salt stress ● Heavy metal stress, mineral nutrient deficiencies ● Stress-sensing mechanisms and activation of signalling pathways in response to abiotic stress in plants **2. Biotic stress: (5L)** ● Beneficial interactions between host plants and microorganisms (nitrogen fixation, phosphate solubilization) ● Harmful interactions between plants, pathogens and herbivores ● Responses to pathogen invasion or plant defences against pathogens	**15**

Course Code 25BUBT6PE1	Course Title Practicals Based on 25BUBT6TE1	Credits 2	No. of lectures in hrs. 60

COURSE OUTCOME

On completion of this course, students will be able to learn:		
CO1	Apply microbiological techniques to isolate beneficial rhizospheric microorganisms such as Azospirillum and phosphate-solubilizing bacteria.	L3
CO2	Analyze the impact of abiotic stress on plants using rapid screening tests and interpret physiological parameters through quantitative assessment.	L4
CO3	Evaluate antioxidant defense responses in plants under stress by estimating ascorbate levels and antioxidant enzyme activities.	L5
CO4	Summarise the layout, function and significance of greenhouse facilities through observation and documentation.	L2

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	1	1	0
CO2	3	2	1	1	2	0
CO3	3	2	1	1	1	0
CO4	3	1	1	1	1	0

Practical No.	Name of experiment	Number of hours
Practical 1	Isolation of *Azospirillum*	5
Practical 2	Isolation of Phosphate solubilizing bacteria	5
Practical 3	Study of effect of abiotic stress on plants	6
Practical 4	Rapid screening tests for abiotic stress tolerance	6

Practical 5	Estimation of antioxidant - Ascorbate	8
Practical 6	Estimation of antioxidant enzyme activity a. Catalase b. Peroxidase	12
Practical 7	Visit to greenhouse facility and submission of field visit report	8

Course Code 25BUBT6TE2	Course Title Marine Biotechnology	Credits 2	No. of lectures

COURSE OUTCOME

On completion of this course, students will be able to learn:		
CO1	Explain the structure and functioning of various marine ecosystems including intertidal zones, estuarine regions, coral reefs, and deep-sea environments.	L2
CO2	Explain marine microbial habitats, bioprospecting methods, and the biotechnological importance of bioactive compounds from marine organisms.	L2
CO3	Identify and categorize marine-derived biomolecules such as bacteriocins, pigments, enzymes, and pharmaceuticals, and relate their properties to potential biotechnological applications.	L3
CO4	Explain the role of marine-derived nutraceuticals and biomaterials, and their applications in health and biomedical fields such as anticancer therapy, drug delivery, and tissue engineering.	L2

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	0	0	0
CO2	3	1	1	1	0	1
CO3	3	1	1	1	0	1
CO4	3	1	1	1	0	1

Units	Description	No of lecture
Unit I: Introduction to Marine Biotechnology	1. **Introduction to Marine Biotechnology** 2. **The marine ecosystem and its functioning:** Intertidal (Rocky intertidal, Sandflats and Mudflats, Salt marshes and Mangroves, Estuarine, Neritic Environments, coastal	**15**

and bioprospecting	sedimentary environments, coral reef), Open-ocean environments (Oceanic, deep sea, hydrothermal vents and seeps) 3. **Bioprospecting,** Marine Microbial Habitats and Their Biotechnologically relevant Microorganisms, Methods for microbial bioprospecting in Marine environments 4. **Biotechnological Potential of Marine Microbes-** Bioactive compounds from Marine Organisms: fungi, Microalgae, Seaweeds, Actinomycetes, sponges	
Unit II: Applications of marine biotechnology	1. Bacteriocins 1L 2. Pigments (carotenoids) 1L 3. Enzymes (polysaccharide degrading, agarases, proteases, cellulases, extremozymes with importance) 2L 4. Pharmaceuticals (antimicrobial peptides, lipids, proteins, secondary metabolites with significance) 4L 5. Nutraceuticals (functional carbohydrates, polyunsaturated fatty acids, soluble calcium, selenium collagen and gelatin, marine probiotics) 5L 6. Biomaterials and their applications in anticancer, antiviral, drug delivery, tissue engineering 2L	**15**

Course Code 25BUBT6PE2	Course Title Practicals Based on 25BUBT6TE2	Credits 2	No. of lectures in hrs. 60

COURSE OUTCOME

Students will be able to learn OR on completion of this course, students will be able to learn:		
CO1	Identify key morphological and taxonomic features of selected marine bacteria, algae (macro and micro), shrimps, and sponges.	L2
CO2	Perform antioxidant and pigment analysis using DPPH assay and spectrophotometric determination of absorption maxima from marine biological extracts.	L2
CO3	Execute extraction of gelatin, collagen and marine alkaloids and separate alkaloids using thin-layer chromatography.	L3
CO4	Explain the principles behind the extraction, estimation, and separation techniques used for gelatin, collagen, and alkaloids from marine organisms.	L2

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	0	1	0
CO2	3	2	1	0	1	0
CO3	3	2	1	0	1	0
CO4	3	1	1	0	0	0

Practical No.	Name of experiment	Number of hours
Practical 1	Study of any 5 marine bacteria and algae (Macro and micro)	6
Practical 2	Identification of Shrimp/ sponges	6
Practical 3	DPPH assay for antioxidant extracted from marine algae	10
Practical 4	Extraction of carotenoids from marine algae/Bacteria/Fungi	10
Practical 5	Extraction and estimation of Gelatin	10
Practical 6	Extraction and estimation of Collagen	8
Practical 7	Extraction of alkaloids from marine organisms and their separation by	10

	TLC	

Course Code 25BUBT6VSC	Course Title Bioinformatics	Credit 1	No. of lectures

COURSE OUTCOME

Students will be able to learn OR on completion of this course, students will be able to learn:		
CO1	Classify biological databases and file formats, and explain the scope, applications, and limitations of bioinformatics with reference to major nucleic acid sequence repositories.	L2
CO2	Compare protein structure and sequence databases, and use structural visualization and classification tools to interpret protein architecture and analyze metabolic pathways using KEGG.	L2
CO3	Identify and make use of biological file formats (GenBank, FASTA), and utilize NCBI and UniProt databases to retrieve and interpret sequence and annotation data and use CATH and SCOP databases for classification of proteins.	L3
CO4	Visualize protein structures using Rasmol and interpret metabolic pathways using the KEGG database.	L4

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	0	1	0
CO2	3	2	3	0	1	0
CO3	3	3	3	0	1	0
CO4	3	3	3	0	1	0

Units	Description	No of lecture
Unit I: Bioinformatics	1. Definition, Aims, Scope, Applications, and limitations of bioinformatics (1L) 2. Biological databases (1L): Primary, Secondary, Specialized databases; Interconnection between	**15**

	biological databases 3. Various File Formats for Biomolecular Sequences: FASTA format, GenBank sequence flatfile format (2L) 4. Biological Databases (12L): a. Nucleic acid sequence databases: NCBI, EMBL, DDBJ b. Protein structure database: PDB c. Protein sequence database: PIR, SWISS-PROT d. Protein structural visualization: Rasmol, Swiss-PDB viewer e. Protein structure classification: CATH and SCOP f. Metabolic pathway database - KEGG	

Practical No.	Name of experiment	Number of hours
Practical 1	File formats: GenBank, FASTA	3
Practical 2	Familiarization with NCBI databases	6
Practical 3	Familiarization with UniProt database	3
Practical 4	Classification of proteins using CATH and SCOP	6
Practical 5	Visualization of PDB molecules using Rasmol	8
Practical 6	Metabolic pathway database - KEGG	4

Course Code 25BUBT6OJT	On Job Training in Biotechnology II	Credits 02	No. of Hours. 60

COURSE OUTCOMES

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

CO1	Demonstrate practical, hands-on skills directly applicable to their roles defined by the organization.	L2
CO2	Relate the direct impact of good laboratory practices with quality standards.	L2
CO3	Build a professional skill set, including soft skills.	L3
CO4	Explain outcomes clearly through written reports, visual displays, or oral presentations.	L5

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	3	2
CO2	3	2	2	1	3	2
CO3	3	2	2	1	3	2
CO4	3	2	3	1	3	2

Description

In this course, the learner is required to get engaged in ‘On job training’ at a professional institute/ organization from the field related to Biotechnology. The learner is expected to acquire field-based skills, professional planning and execution of activities undertaken by the organization. The learner needs to complete 60 hrs. of training.

The learner would be required to qualify the assessment where he /she would be required to communicate outcomes clearly, interpret findings logically through written report, and visual oral presentation and viva.

Course Code 25BUBT6FPR	Field Project in Biotechnology V	Credits 02	No. of Hours. 60

COURSE OUTCOME

On completion of this course, students will be able to learn:

CO1	Demonstrate practical, hands-on competence in essential laboratory techniques	L2
CO2	Develop analytical skills like designing experiment, data collection, statistical analysis and interpretation of results	L3
CO3	Experiment with basic knowledge integration from allied fields like molecular biology, bioinformatics, and biotechnology to address complex, multidisciplinary challenges	L3
CO4	Build written and oral communication skills through report writing, presentations	L3

Grading will be as 3: High (>60%), 2: Moderate (40%-60%), 1: Low (<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	1	3	2
CO2	3	3	3	1	3	2
CO3	3	3	3	1	3	2
CO4	3	3	3	1	3	2

Description

The learner can undertake the field project to apply knowledge of core topics of basic biotechnology to solve a real-world problem in areas such as healthcare, environmental sustainability, food safety, agriculture etc.

The learner would be required to qualify the assessment where he /she would be required to communicate outcomes clearly, interpret findings logically through written report, visual displays, or oral presentations and viva.

REFERENCES

Semester V

25BUBT5T01 Major - Biochemistry

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Lehninger, principles of biochemistry	David Nelson and Michael Cox	W.H. Freeman and Company, New York.	4th	2005
2.	Fundamentals of Biochemistry	D. Voet and J. Voet	Wiley plus	5th	2011
3.	Illustrated Biochemistry	Harper	Lange Medical Books/McGraw-Hill	26th	2003
4.	The Physiology and Biochemistry of Prokaryotes	White, D.,	Oxford University Press	3rd	1995
5.	Biochemistry	Satyanarayana and Chakrapani	Books & Allied (P) Ltd	4th	2017

25BUBT5T02 Major - Molecular Biology

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	iGenetics	Peter Russell	Pearson Education India	3rd	2009
2.	Molecular Biology	Friefelder		2nd	
3.	Genetics: A Conceptual Approach	Benjamin A. Pierce	WH Freeman	4th	2012
4.	Principles of Biochemistry	Nelson and Cox	WHFreeman	4th	2004
5.	General Microbiology	Stanier, Ingraham, Wheelis & Painter	McMillan Press Ltd.	5th	1987

25BUBT5T03 Major - Pharmacology and Basics of Drug Discovery

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Modern Pharmacology with clinical applications	Charles R. Craig and Robert E.	Lippincott Williams And Wilkins	5th	2003

		Stitzel			
2.	Clinical Pharmacology	Bennet P.N, Brown M.J, Sharma.P	Elsevier	11th	2016

DSE - I: Dairy Biotechnology and Bioprocess Technology

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Applied Dairy Microbiology	Elmer.H. Marth, James. L. Steele	Mercel Dekker Inc.	2nd	2001
2.	Comprehensive Dairy Microbiology	Yadav and Grower	Metropolitian Book Co.	1st	1993

DSE -II: Environmental Biotechnology

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Microbiology	Michael J Pelczar Jr. E. C. S Chan Noel R. Krieg	Tata McGraw-Hill	5th	1993
2.	Fundamental Principles of Bacteriology	A.J. Salle	Tata Mc Graw Hill	7th	1984
3.	https://earth.org/the-biggest-environmental-problems-of-our-lifetime/				
4.	Principles and Applications of Environmental Biotechnology for a Sustainable Future	Ram Lakhan Singh	Springer	-	2017
5.	Global Environmental Issues and Human Wellbeing	Li Jianping, Li Minrong, Wang Jinnan, Li Jianjian, Su Hongwen & Huang Maoxing	Springer	-	2014
6.	https://www.tandfonline.com/doi/pdf/10.1080/21553769.2016.1162753				
7	https://link.springer.com/content/pdf/10.1186/s42269-020-00385-x.pdf				
8	https://jpoll.ut.ac.ir/article_64336_74b42781d6d3416bc0845a587ed1dcda.pdf				

Minor - Cell Biology

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	The Cell: A Molecular Approach	Geoffrey N. Cooper	Sinauer Associates Inc	4th	2007
2.	Cell Biology	Thomas Pollard	Elsevier	3rd	2017
3.	Cell and Molecular Biology	Karp	John Wiley & Sons, Inc	8th	2016

VSC - Biostatistics

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Biostatistics for the Biological and Health sciences with Statdisk	Marc M. Triola and Mario F. Triola	Pearson Education Limited	1st	2012
2.	Biostatistics	P.N. Arora	Himalaya Publishing House	1st	2012

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Semester VI
Major - Biochemistry

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Biochemistry	U. Satyanarayana and Chakrapani	Elsevier	4th	2013
2.	Lehninger, Principles of Biochemistry	Nelson and Cox	W. H. Freeman & Co. Ltd.	4th	2004
3.	Harper's Illustrated Biochemistry	Robert K. Murray	McGraw Hill	26th	2003
4.	General Enzymology	Dr. N .S.Kulkarni	Himalaya publishing house	1st	2007
5.	Understanding Enzymes: An Introductory Text	Dr. Aditya Arya	Drawing Pin Publishing, New Delhi, India	1st	2019
6.	Enzyme Engineering: Performance Optimization, Novel Sources, and Applications in the Food Industry	Shucan Mao, Jiawen Jiang, Ke Xiong, Yiqiang Chen, Yuyang Yao, Linchang Liu, Hanbing Liu andXiang Li	Foods Journal	-	2024

Major - Analytical techniques

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Biophysical Chemistry Principles and Techniques	Upadhyay, Upadhyay and Nath	Himalaya Publication	1st	2016
2.	Principles and Techniques of Biochemistry and Molecular Biology	Keith Wilson and John Walker	Cambridge University Press	7th	2010
3.	Radiology book chapter on Fundamentals of PET and PET/CT Imaging	Ronald B. Workman	Springer	1st	2006

4.	Biomedical Imaging Techniques	SS Ilangovan	IGI Global Publisher	1st	2017

Major - Virology and Regulation of gene expression

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Understanding Viruses	Teri Shors	Jones & Bartlett Learning	3rd	2016
2.	Principles of Virology	Flint, Racaniello, Rall, Skalka, Enquist	ASM Press	4th	2015
3.	Virology: Principles and Applications	Carter & Saunders	John Wiley & Sons	1st	2007
4.	iGenetics	Peter Russell	Pearson Education Inc.	3rd	2010
5.	Genetics: A Conceptual Approach	Benjamin A. Pierce	WH Freeman	3rd	2007
6.	Microbiology- An evolving science	John W. Foster, Joan L. Slonczewski	W. W. Norton & company Ltd.	4th	2017

Major - Recombinant DNA technology

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	iGenetics: A Molecular Approach	Peter J. Russell	Pearson Education, Inc., publishing	3rd	2010
2.	Principles of gene manipulation and genomics	Sandy B. Primrose, Richard Twyman, Bob Old	John Wiley and Sons Ltd	7th	2006

DSE - I: AgriBiotechnology

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Plant Physiology - Theory and Applications	S.L. Kochhar and Sukhbir Kaur Gujral	Cambridge University Press	2nd	2020
2.	Polymicrobial Multi-functional Approach for Enhancement of Crop Productivity	Chilekampalli A. Reddy1, Ramu S. Saravanan	Elsevier	-	2013
3.	Sustainable Crop Protection under Protected Cultivation	P. Parvatha Reddy	Springer	-	2016
4.	Precision agriculture: Revolutionizing farm management (https://www.bhumipublishing.com/wp-content/uploads/2024/07/Farming-the-Future-Advanced-Techniques-in-Modern-Agriculture-Volume-I.pdf)	Devkar A. et.al	-	-	-
5.	The Role of Greenhouse Technology in Streamlining Crop Production	Singh et.al	Journal of Experimental Agriculture International, Vol.46, Issue 6	-	-
6.	Fertigation https://www.fao.org/4/a1336e/a1336e16.pdf	-	In: Protected Cultivation and Smart Agriculture edited	-	-
7.	Sustainable Agriculture Practices: Promoting Environmentally Friendly Farming Systems (In book: Advances in Agriculture Extension Vol.1)	Saikia et.al	Elite Publishing House	-	2023
8.	Green-houses: Types and Structural Components (In: Protected Cultivation and Smart Agriculture edited)	Dalai et.al	New Delhi Publishers	-	2020
9.	Overview of organic farming (https://www.bhumipublishing.com/wp-content/uploads/2024/07/Farming-the-Future-Advance	Priyanka Dhalwani	Farming-the-Futu e-Advanced-Tech niques-in-Modern	-	-

	d-Techniques-in-Modern-Agriculture-Volume-I.pdf)		-Agriculture-Volume-I		

DSE - II: Marine Biotechnology

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Springer Handbook of Marine Biotechnology	Se-Kwon Kim (Ed.)	Springer	1st	2015
2.	Blue biotechnology: Marine bacteria bioproducts. *Microorganisms*, *12*(4), 697..	Maldonado-Ruiz, K., Pedroza-Islas, R., & Pedraza-Segura, L.	-	-	2024
3.	Marine Natural Products: A New Wave of Drugs? Future Med Chem 3(12):1475-89. https://www.ncbi.nlm.nih.gov/pubmed/21882941.	Montaser, R and H Luesch	-	-	2011
4.	Cultivating Blue Food Proteins: Innovating Next-Generation Ingredients from Macro and Microalgae. *Biocatalysis and Agricultural Biotechnology*, 103278 https://nopr.niscpr.res.in/bitstream/123456789/7759/1/IJBT%205(3)%20263-268.pdf	Thakur, A., Sharma, D., Saini, R., Suhag, R., & Thakur, D.	-	-	2024

VSC - Bioinformatics

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Essential Bioinformatics	Xiong Jin	Cambridge University Press, USA.	1st	2006
2.	Introduction to bioinformatics (Cell and molecular biology in action series)	Attwood T.K., Parry-smith DJ	Pearson education Asia	-	2001
3.	Bioinformatics for Beginners_ Genes, Genomes, Molecular Evolution, Databases and Analytical Tools	Choudhuri Supratim	Elsevier Inc.	1st	2014
4.	Bioinformatics: A practical guide to the analysis of genes and proteins, New York.	Baxevanis, A. D. and Ouellette, B. F. F.	Wiley Interscience	2nd	2001

VPM's B.N. Bandodkar College of Science (Autonomous), Thane

Curriculum Structure for the Undergraduate Degree Programme T.Y.B.Sc Biotechnology

	SEMESTER – V	Course imparts Employability (EM), Entrepreneurship (EN), Skill Development (SD)			Course integrates with Professional Ethics (PE), Gender Equity (GE), Human Value (HV), Environmental Sustainability (ES)			
Course Code	**Major Course Title**	**EM**	**EN**	**SD**	**PE**	**GE**	**HV**	**ES**
25BUBT5T01	Biochemistry III	-	-	-	-	-	-	-
25BUBT5T02	Molecular Biology II	-	-	-	-	-	-	-
25BUBT5T03	Pharmacology and Basics of Drug Discovery	-	-	✔	✔	-	-	-
25BUBT5P01	Practical-I based on 25BUBT5T01	✔	✔	✔	-	-	-	-
25BUBT5P02	Practical-II based on 25BUBT5T02	✔	✔	✔	-	-	-	-
25BUBT5P03	Practical-II based on 25BUBT5T03	✔	✔	✔	-	-	-	-
25BUBT5TE1	Dairy Biotechnology and Bioprocess Technology	-	-	✔	-	-	-	-
25BUBT5PE1	Practicals based on 25BUBT5TE1	✔	✔	✔	-	-	-	-
25BUBT5TE2	Environmental Biotechnology IV	-	-	-	-	-	-	✔
25BUBT5PE2	Practicals based on 25BUBT5TE2	✔	✔	✔	-	-	-	✔
25BUBT5TMN	Cell Biology	-	-	-	-	-	-	-
25BUBT5VSC	Biostatistics	✔	✔	✔	-	-	-	-
25BUBT5OJT	On Job Training in Biotechnology I	✔	✔	✔	✔	✔	✔	✔

25BUBT5FPR	Field Project in Biotechnology IV	✔	✔	✔	✔	✔	✔	✔

	SEMESTER – VI	Course imparts Employability (EM), Entrepreneurship (EN), Skill Development (SD)			Course integrates with Professional Ethics (PE), Gender Equity (GE), Human Value (HV), Environmental Sustainability (ES)			
Course Code	**Major Course Title**	**EM**	**EN**	**SD**	**PE**	**GE**	**HV**	**ES**
25BUBT6T01	Biochemistry IV	-	-	✔	-	-	-	-
25BUBT6T02	Analytical techniques	-	-	✔	-	-	-	-
25BUBT6T03	Virology and Regulation of Gene Expression	-	-	-	-	-	-	-
25BUBT6T04	Recombinant DNA technology	-	-	✔	-	-	-	✔
25BUBT6P01	Practicals Based on 25BUBT6T01	✔	✔	✔	-	-	-	-
25BUBT6P02	Practicals Based on 25BUBT6T02 and 25BUBT6T04	✔	✔	✔	-	-	-	-
25BUBT6P03	Practicals Based on 25BUBT6T03 and 25BUBT6T04	✔	✔	✔	-	-	-	✔
25BUBT6TE1	Agri Biotechnology	-	-	-	-	-	-	✔
25BUBT6PE1	Practicals based on 25BUBT6TE1	✔	✔	✔	-	-	-	✔
25BUBT6TE2	Marine Biotechnology	✔	✔	✔	-	-	-	✔
25BUBT6PE2	Practicals based on 25BUBT6TE2	✔	✔	✔	-	-	-	-
25BUBT6VSC	Bioinformatics	✔	✔	✔	✔	-	-	-

25BUBT6OJT	On Job Training in Biotechnology II	✔	✔	✔	✔	✔	✔	✔
25BUBT6FPR	Field Project in Biotechnology V	✔	✔	✔	✔	✔	✔	✔