Vidyasagar University

Dept. of Biotechnology & Bioinformatics

M.Sc. Biotechnology & Bioinformatics (NEP)

Effective from 2025-2026

Syllabus

www.vidyasagar.ac.in

Preamble

The M.Sc. program in Biotechnology and Bioinformatics under the NEP-2020 framework is designed to provide students with a broad and integrated understanding of modern biological sciences, biotechnological innovation, and computational biology. The curriculum blends molecular biology, genomics, proteomics, bioinformatics, and applied biotechnology with entrepreneurship, ethics, and sustainability. It emphasizes the development of conceptual understanding, practical proficiency, and analytical capability through laboratory training, project work, internships, and exposure to industrial and research environments. The program aims to nurture technically skilled, ethically conscious, and socially responsible biotechnologists capable of contributing to healthcare, agriculture, environment, and the bioeconomy sector.

Program Objectives (POs)

1. To impart comprehensive knowledge in modern areas of biotechnology, bioinformatics, and molecular biosciences.
2. To develop laboratory and computational skills for application in research, diagnostics, and industrial production.
3. To train students in data-driven biological analysis, including genomics, proteomics, and system biology using digital tools.
4. To promote entrepreneurial mindset and innovation in bioprocess, healthcare, agricultural, and environmental biotechnology.
5. To inculcate ethical values, biosafety practices, and intellectual property awareness in scientific research and innovation.
6. To build interdisciplinary competence for addressing real-world biological challenges through project-based learning.
7. To enhance communication, teamwork, and leadership skills for professional and societal engagement.
8. To align academic learning with sustainability, national development, and global biological research trends.

Program Outcomes (POs)

After successful completion of the program, students will be able to:

1. Demonstrate a deep understanding of biological principles governing cellular, molecular, and genetic processes.
2. Apply biotechnological and bioinformatics tools to analyze, interpret, and solve biological problems.
3. Design, conduct, and evaluate experimental research and data analysis using modern laboratory and computational techniques.
4. Develop biotechnological products, diagnostics, and processes relevant to industrial, agricultural, and healthcare sectors.
5. Exhibit ethical, safe, and sustainable research practices adhering to national and international biosafety and IPR standards.
6. Communicate scientific ideas effectively through technical reports, publications, and oral presentations.
7. Demonstrate critical thinking, problem-solving, and analytical reasoning skills relevant to professional biotechnology practice.
8. Engage in lifelong learning and adaptability to emerging areas such as synthetic biology, artificial intelligence in biology, and omics technologies.

Programme Specific Outcomes (PSOs)

PSO-1: Acquire theoretical and practical expertise in molecular biology, recombinant DNA technology, and bioinformatics tools.

PSO-2: Analyze and interpret genomic, transcriptomic, and proteomic data using computational biology approaches.

PSO-3: Apply biotechnological principles to develop sustainable solutions for agriculture, medicine, and environmental management.

PSO-4: Demonstrate proficiency in bioprocess optimization, fermentation technology, and product development.

PSO-5: Integrate digital, ethical, and entrepreneurial components for self-employment, start-up incubation, or industrial research.

PSO-6: Design and execute independent research projects, write scientific reports, and defend research findings effectively.

PSO-7: Contribute responsibly to biosafety, bioethics, and environmental conservation in the context of biotechnology applications.

Distinctive Features of the M. Sc. Biotechnology and Bioinformatics Program

Special Features	Course Number(s)	% of Total
Value-added content	BTI 101; 102; 202; 203; 205; 304; 305; 310	8.33
Employability / Entrepreneurship / Skill Development	BTI 106; 107; 108; 109; 201; 202; 204; 205; 206; 207; 209; 210; 211; 301; 302; 305; 306; 307; 308; 309; 310; 401; 404; 407	37.5
Digital content / ICT integration	BTI 102; 107; 203; 205; 210; 304; 309	6.25
Ethics, Gender, Human Values, Environment & Sustainability	BTI 103; 104; 202; 204; 303; 304; 401	16.67
New Courses Introduced	BTI 110; 111; 207; 305; 310; 407	8.33
Field & Industry Survey / Academic Excursions	BTI 211; 308; 404	6.25
Review Writing & Project Work	BTI 207; 406	6.25
Internships / Community Outreach / Start-up Proposal	BTI 211; 310; 407	8.33
Biosafety Norms & IPR / Research Proposal Design	BTI 202; 401; 407	4.17

[Several courses overlap across categories, reflecting the interdisciplinary nature of the NEP curriculum]

Dept. of Biotechnology and Bioinformatics Vidyasagar University					
Semester I					
Course Code	**Course Content**	**Credit**	**Marks**	**No. of Hours**	**Credit (L-T-P)**
BTIC401X1	Cell and Molecular Biology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC401X8	Cell and Molecular Biology	2	**25** (P25)	20	**2** (0-0-2)
BTIC402X0	Introduction to Bioinformatics and Programming Languages	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC403X9	Basic Bioinformatics, Computer Programming, and Operating System	2	**25** (P25)	20	**2** (0-0-2)
BTIC404X0	Research Methodology & Ethics	4	50	40	**4** (4-0-0)
BTIE405A1	Microbiology and Microbial Physiology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIE405A8	Microbiology and Microbial Physiology	2	**25** (P25)	20	**2** (0-0-2)
BTIE406A0	Biochemistry of Macromolecules & Secondary Metabolites	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIE407A9	Analytical Biochemistry	2	**25** (P25)	20	**2** (0-0-2)
BTIO408VC	Indian Knowledge System (IKS)	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIO409NC	Vidyasagar: Life and Philosophy	Compulsory Non-Credit Course			
	Total	**22**	**275**		
Semester II					
BTIC451X1	Genetic Engineering	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC451X8	Genetic Engineering	2	**25** (P25)	20	**2** (0-0-2)
BTIE452A0	Biosafety & Bioanalytical techniques	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIE456A9	Review Work & Seminar	2	**25** (P25)	20	**2** (0-0-2)
BTIE453A1	Biostatistics and R Programming	2	**25** (T20 + IA5)	40	**2** (2-0-0)
BTIE453A8	Biostatistics and R Programming	2	**25** (P25)	20	**2** (0-0-2)
BTIE454A1	Immunology & Medical Biotechnology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIE454A8	Diagnostic test & microbial pathology	2	**25** (P25)	20	**2** (0-0-2)
BTIC455X1	Advanced Bioinformatics	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC455X8	Advanced Bioinformatics	2	**25** (P25)	20	**2** (0-0-2)
BTIO457X9	Industry Visit & Internship	2	**25** (P25)	20	**2** (0-0-2)
	Total	**22**	**275**		
Semester III					
BTIO501X0	MOOC Course	4	50	40	**4** (4-0-0)
BTIC502X1	Plant and Animal Biotechnology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC502X8	Plant and Animal Biotechnology	2	**25** (P25)	20	**2** (0-0-2)
BTIC503X1	Food and Bioprocess Technology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC503X8	Food and Bioprocess Technology	2	**25** (P25)	20	**2** (0-0-2)
BTIC504X1	Agro-Enviro-Marine Biotechnology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC504X8	Agro-Enviro-Marine Biotechnology	2	**25** (P25)	20	**2** (0-0-2)
BTIC505X1	Omics Technology & Big Data Analysis	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC505X8	Big Data Analysis	2	**25** (P25)	20	**2** (0-0-2)
BTIO506X9	Community Out-reach Program and report preparation	2	**25** (P25)	20	**2** (0-0-2)
	Total	**22**	**275**		
Semester IV					
BTIC551X1	Structural Bioinformatics and Drug Design	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC551X8	Structural Bioinformatics and Drug Design	2	**25** (P25)	20	**2** (0-0-2)
BTIC552X0	Next-Generation Microbiotechnology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC554X9	Grand Viva	2	**25** (P25)	20	**2** (0-0-2)
BTIC555X9	Project Work	8	**100** (P100)	80	**8** (0-0-8)
BTIC556X9	Research/ Start-up Proposal Design	4	**50** (P50)	40	**4** (0-0-4)
BTIO553X0	Intellectual Property Right, Bioethics, & Entrepreneurship	2	**25** (T20 + IA5)	20	**2** (2-0-0)
	Total	**22**	**275**		
L: Lecture; **T:** Tutorial; **P:** Practical					

Semester I						
Course Code	**Course No.**	**Course Content**	**Credit**	**Marks**	**No. of Hours**	**Credit (L-T-P)**
BTIC401X1	BTI 101	Cell and Molecular Biology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC402X0	BTI 102	Introduction to Bioinformatics and Programming Languages	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC404X0	BTI 103	Research Methodology & Ethics	4	50	40	**4** (4-0-0)
BTIE405A1	BTI 104	Microbiology and Microbial Physiology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIE406A0	BTI 105	Biochemistry of Macromolecules & Secondary Metabolites	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC401X8	BTI 106	Cell and Molecular Biology	2	**25** (P25)	20	**2** (0-0-2)
BTIC403X9	BTI 107	Basic Bioinformatics, Computer Programming, and Operating System	2	**25** (P25)	20	**2** (0-0-2)
BTIE405A8	BTI 108	Microbiology and Microbial Physiology	2	**25** (P25)	20	**2** (0-0-2)
BTIE407A9	BTI 109	Analytical Biochemistry	2	**25** (P25)	20	**2** (0-0-2)
BTIO408VC	BTI 110	Indian Knowledge System (IKS)	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIO409NC	BTI 111	Vidyasagar: Life and Philosophy	Compulsory Non-Credit Course			
TOTAL			**22**	**275**		

BTI 101: Cell and Molecular Biology | Course: BTIC401X1 | 25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To provide fundamental knowledge of cell structure, organelles, in prokaryotes and eukaryotes.*
- *To develop an understanding of the molecular basis of inheritance, cell division, and genetic regulation.*
- *To familiarize students with the central dogma processes, DNA repair, and mechanisms of gene expression.*

Course Outcomes (COs):

- *Students will be able to explain the structure-function relationship of cells, and chromosomes.*
- *Students will demonstrate understanding of DNA replication, transcription, translation, and gene regulation in prokaryotes and eukaryotes.*
- *Students will analyse the significance of genetic variations, DNA repair, and epigenetic modifications in cellular processes and disease.*

Course Content:

Unit 1 - Basic Structure and Function of Cells: Differences in structure and composition of prokaryotic and eukaryotic (plant and animal) cells; Structure and function of eukaryotic cell organelles: nucleus, ER, Golgi apparatus, lysosomes, peroxisomes, mitochondria, chloroplasts, ribosomes, cytoskeleton, plasma membrane; Organization of bacterial genomes and nucleoid structure.

Unit 2 – Cell Cycle, Division, and Principles of Genetics: Cell cycle: phases, checkpoints, molecular regulation; Mitosis and meiosis: phases, regulation, and significance; Mendel's Laws; physical basis of inheritance; Multiple alleles, gene-gene interactions, complementation; Linkage, recombination, and genetic mapping; Extra-chromosomal inheritance; Chromosomal aberrations: numerical (euploidy, aneuploidy) and structural (deletion, duplication, inversion, translocation); Epigenetic modifications and gene imprinting; Transposable elements: types, mechanisms, significance.

Unit 3 – Central Dogma of Molecular Biology: DNA as the genetic material — experimental evidences (Griffith, Avery-MacLeod-McCarty, Hershey-Chase); Concept of the gene: split genes, overlapping genes, pseudogenes; Flow of genetic information: DNA → RNA → protein; Role of proteins, non-coding RNAs, and other biomolecules in cellular functions.

Unit 4 – DNA Replication, Repair, and Recombination: Structure and functions of bacterial DNA polymerases and eukaryotic DNA polymerase; Mechanisms of prokaryotic and eukaryotic replication — origins, replication forks, enzymes (helicases, topoisomerases, ligases, SSBs etc.); Telomerase mechanism and significance; DNA damage: alkylation, deamination, oxidation, UV radiation; Repair mechanisms: photoreactivation, excision repair, post-replication repair, mismatch repair, SOS repair; Homologous recombination; prokaryotic gene transfer — conjugation, transformation, transduction; Relevance to cell cycle, reproduction, cancer, and evolution.

Unit 5 – RNA Synthesis and Processing: Gene organization: promoters, exons, introns, regulatory elements; Mechanisms of transcription in prokaryotes and eukaryotes; Molecular control of transcription initiation: transcription factors, enhancers, silencers, RNA polymerases; Types of RNA: mRNA, rRNA, tRNA, non-coding RNAs; Post-transcriptional modifications: 5′-capping, polyadenylation; Splicing: types, mechanism, and significance; RNA editing.

Unit 6 – Protein Synthesis and Processing: Genetic code: reading frames, degeneracy, wobble hypothesis, codon bias; Structure and function of ribosomes; Mechanism of translation: amino acid activation, initiation, elongation, termination; Post-translational modifications and protein targeting; Role of microRNAs and RNA interference in eukaryotes.

Unit 7 – Regulation of Gene Expression: Prokaryotic gene regulation: operon models (lac and trp operon).

BTI 106: Cell and Molecular Biology	Course: BTIC401X8	25 Marks (P25)

Course Objectives (COBs):

- *To train students in fundamental molecular biology techniques such as DNA, RNA, and protein isolation.*
- *To develop skills in visualization, quantification, and characterization of nucleic acids and proteins.*
- *To introduce experimental methods for studying mutations and cellular organelles.*

Course Outcomes (COs):

- *Students will able to isolate, quantify, and analyse DNA, RNA, and proteins from different biological sources.*
- *Gain hands-on experience in molecular techniques like agarose gel electrophoresis and Ames test.*
- *Students will demonstrate competency in organelle separation and identification through experimental approaches.*

Course Content:

1. DNA isolation from animal and plant cell.
2. Isolation and quantification of DNA/RNA from microorganisms by spectrophotometric method.
3. Isolation of bacterial genomic DNA and visualization through Agarose gel electrophoresis.
4. Isolation of bacterial plasmid DNA and visualization through Agarose gel electrophoresis.
5. Isolation and quantification of total protein from microorganisms.
6. Study the Ames test for mutation analysis.
7. Separation and Identification of cell organelles.

BTI 102: Introduction to Bioinformatics and Programming Languages	Course: BTIC402X0	25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To introduce students to bioinformatics concepts, and computational tools for biological data analysis.*
- *To develop computational skills in sequence analysis, gene prediction, protein modelling, and phylogenetic studies.*
- *To train students in programming for solving bioinformatics problems and handling biological datasets.*

Course Outcomes (COs):

- *Students will be able to retrieve, analyse, and interpret biological data from major bioinformatics databases.*
- *Students will demonstrate proficiency in sequence alignment, phylogenetic analysis, and protein structure prediction.*
- *Students will apply C, Python, and Biopython tools to solve bioinformatics problems, manage biological data, and create visualizations.*

Course Content:

Unit 1 – Introduction to Bioinformatics: Definition, importance and applications of bioinformatics; History, aims and scope; Branches of bioinformatics; Biological tools and databases; Sequence and molecular file formats; Database conversion and sequence format tools.

Unit 2 – Biological Databases: Nucleotide sequence databases: NCBI, EMBL, DDBJ; Protein databases: UniProt, PIR, Swiss-Prot, TrEMBL; Structural databases: PDB, MMDB, SCOP, CATH, Gene3D; Specialized databases: GEO, OMIM, TCGA, Pfam, KEGG, UCSC, COSMIC, InterPro, Prosite; Tools for data retrieval and annotation (BLAST, PSI-BLAST, RPS-BLAST).

Unit 3 – Sequence Analysis and Gene Prediction: Concepts of sequence alignment (local and global); Scoring matrices (PAM, BLOSUM); Sequence alignment algorithms: Needleman-Wunsch, Smith-Waterman; Heuristic methods: FASTA, BLAST, PSI-BLAST; Multiple sequence alignment (MSA) and tools; Principles and computational approaches of gene prediction, challenges in gene annotation.

Unit 4 – Phylogeny and Protein Modelling: Concepts of molecular phylogeny, molecular clock hypothesis, validation and statistical evaluation; Phylogenetic tree construction methods: UPGMA, Neighbor Joining, Maximum Likelihood, Maximum Parsimony; Protein structure levels (primary, secondary, tertiary, quaternary); Approaches for structure prediction: secondary structure prediction, homology modelling, threading, ab initio methods; Model evaluation and refinement; Tools: SWISS-MODEL, PDB viewers.

Unit 5 - Computer Organization: Basic components of a modern computers, and how the computing speed depends on its components, e.g. specifications of processors, RAM, HDD types etc. Concept of parallel computing and cluster computing to handle large calculations in Bioinformatics. Concept of network, LAN, internet and IP address (local and global). Introduction to Big data storage and Cloud computing.

Unit 6 – Programming in C (Basics): Structure of a C program; Constants, variables, data types and operators; Compilation and execution; Decision control statements (if, else-if, switch-case); Looping constructs (for, while, do-while); Jump statements: break, continue, goto; Arrays and pointers; Structures and Unions; Functions: declaration, definition, types, recursion; Basic Input output and File handling.

Unit 7 – Python Programming Basics and Bioinformatics: Introduction to Python: syntax, variables, operators, expressions; Conditional and looping statements; Data structures: strings, lists, tuples, dictionaries; Functions: definition, arguments, scope, lambda functions; Pandas: Series and Data Frames; File handling (CSV, Excel, XML, JSON); NumPy arrays and operations; Biopython: sequence operations, alignments, annotations, bioinformatics applications; Data visualization with matplotlib; Regular expressions.

BTI 107: Basic Bioinformatics, Computer Programming, and Operating System	Course: BTIC403X9	25 Marks (P25)

Course Objectives (COBs):

- *To provide hands-on training in bioinformatics tools, databases, and sequence analysis methods for biological data interpretation.*
- *To develop computational skills using Linux, C programming, and Python for data handling, analysis, and problem-solving in life sciences.*

- *To integrate computational approaches with molecular biology concepts for applications in genomics, phylogenetics, and molecular modelling.*

Course Outcomes (COs):

- *Students will be able to retrieve, analyze, and interpret biological sequences using bioinformatics tools, databases, and algorithms.*
- *Gain practical experience in Linux, C, and Python programming for executing biological data analysis tasks and automating workflows.*
- *Students will demonstrate competence in applying computational biology techniques.*

Course Content:

1. **Bioinformatics Part**
   i. Use of public domain interfaces for downloading DNA & protein sequences.
   ii. Performing BLAST and interpretation of results.
   iii. Submission of biological sequences.
   iv. Study of Nucleotide/Genome, Protein Sequence, Structure, and Specialized databases.
   v. Pairwise sequence alignment.
   vi. Multiple sequence alignment.
   vii. PCR (in vitro DNA amplification).
   viii. Construction of phylogenetic tree using offline tools & visualization.
2. **Linux Part**
   i. Linux architecture and basic commands.
   ii. Linux file management, file system, and related calls.
   iii. Linux shell scripting, performing commands in loops, etc.
3. **C Programming Part**
   i. Syntax/style of C code.
   ii. main() function as the starting point of C code.
   iii. Important C library functions.
   iv. Basic data types & data structures.
   v. Arithmetic & logical operations.
   vi. Arrays: single & multi-dimensional, iterations, and looping.
   vii. Basic type pointers & user-defined data type pointers.
   viii. Functions and their utility in C.
   ix. File operations using C library functions.
4. **Python Programming Part**
   i. Installation of Python and IDE.
   ii. Decision-making & loop statements.
   iii. Regular expressions.
   iv. File operations in Python.
   v. Object-oriented programming in Python.
   vi. BioPython libraries.

BTI 103: Research Methodology & Ethics — Course: BTIC404X0 — 50 Marks (T40 + IA10)

Course Objectives (COBs):

- *To provide a foundation in the principles, process, and design of scientific research, including formulation of research problems, hypotheses, and objectives.*
- *To develop proficiency in literature review, data collection, analysis, and interpretation using appropriate statistical and experimental approaches.*

- *To inculcate skills in scientific writing, reporting, and adherence to research ethics, ensuring integrity and responsible conduct of research.*

Course Outcomes (COs):

- *Explain the theoretical basis, structure, and methodology of scientific research and distinguish among various research approaches.*
- *Design and execute research projects through proper problem identification, data handling, statistical analysis, and result interpretation.*
- *Demonstrate competence in preparing scientific reports and publications while maintaining ethical standards and integrity in research practices.*

Course Content:

Unit 1 - Foundation of Research: Definition, objectives and significance of research; scientific research and theory; conceptual and theoretical models; research process; problem definition; research questions; research design and approaches; role of reasoning in research.

Unit 2 - Review of Literature: Purpose and significance of literature review; selection and organization of literature; sources and search tools; note-taking and referencing; role of libraries, indexing, abstracting and citation databases.

Unit 3 - Research Formulation and Design: Selection and formulation of research problems; hypothesis development; measurement and variable identification; types and structure of research design.

Unit 4 - Experimental Research: Cause–effect relationships; hypothesis testing; measurement system analysis; error propagation; experimental validity; statistical design of experiments.

Unit 5 - Data Collection Methods: Types and sources of data; primary and secondary data; methods of data collection—survey, observation, simulation, and questionnaire techniques.

Unit 6 - Data Processing and Analysis: Editing, classification, coding, transcription and tabulation; graphical and numerical data analysis; sampling methods, sample size determination; sampling errors; descriptive and inferential statistics; data interpretation.

Unit 7 - Research Writing and Reporting: Structure and format of dissertation and research papers; principles of scientific writing; preparation of abstract, introduction, methodology, results, discussion, and conclusion; tables and illustrations; referencing and citation styles; journal types (Q1–Q4).

Unit 8 - Research Ethics and Integrity: Concept and importance of research ethics; intellectual honesty; research misconduct—plagiarism, fabrication, falsification, redundancy; authorship and contributorship; ethical committees and approvals; biomedical and animal research ethics; data ownership and privacy; environmental ethics.

BTI 104: Microbiology and Microbial Physiology	Course: BTIE405A1	25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To provide an understanding of the origin, diversity, and evolutionary history of microbial life forms.*
- *To study the classification, structural features, reproduction, and importance of major microbial groups.*
- *To develop knowledge of microbial physiology, stress responses, and methods for their cultivation and control.*

Course Outcomes (COs):

- *Able to explain the evolutionary origin and diversity of microbial life and their roles in ecosystems.*

- *Acquire knowledge of microbial morphology, physiology, growth, and stress adaptation strategies.*
- *Demonstrate the ability to apply microbial cultivation, preservation, and control methods.*

Course Content:

Unit 1 - Origin of Life: Abiotic synthesis of organic monomers and polymers; Concept of Oparin and Haldane; Experiment of Miller (1953); The first cell; Evolution of prokaryotes; Origin of eukaryotic cells; Evolution of unicellular eukaryotes.

Unit 2 – Bacteriology: General classification of bacteria with salient feature of major bacterial phyla according to Bergey's Manual of Systematic Bacteriology. Morphological Features.

Unit 3 – Archae & Cyanobacteria: Systematics, diversity, characteristics, potential application of Archea. General account of cyanobacteria.

Unit 4 – Mycology& Phycology: Structure, reproduction and general classification of fungi. Secondary metabolites from fungi: Terpenes, Non-ribosomal peptides, hydrophobins, peptaibols, detailed emphasis on polyketides. Micro algae: Diversity, mode of reproduction, ecological significance, economic importance including role in human affairs.

Unit 5 –Virology & Protozoology: Classification and structural features; Subviral particles: viroids, prions, satellite viruses. Principal events involved in replication; Structural organization of bacteriophage; Life cycle – lytic & lysogenic. Classification, structure, and reproduction of protozoa. Characteristics of Flagellates, Amoeboids, Sporozoans and Cilliates.

Unit 6 – Microbial Growth and control: Bacterial reproduction: binary fission, budding, fragmentation, sporogenesis; Growth physiology, kinetics, yields, batch and continuous cultures; Aerobic, anaerobic, facultative microbes; Pure culture techniques, nutritional types, culture media; Growth measurement (direct/indirect) and influencing factors; Control of microbial growth: physical & chemical methods, preservation techniques.

Unit 7 - Microbial Stress Responses: Adaptation to extreme environments; Responses to osmotic, oxidative, pH, thermal, and nutrient/starvation stress; Aerobic-anaerobic transitions and osmoregulation.

BTI 108: Microbiology and Microbial Physiology | Course: BTIE405A8 | 25 Marks (P25)

Course Objectives (COBs):

- *To familiarize students with laboratory safety protocols and biosafety levels essential for microbiological research.*
- *To provide hands-on training in isolation, cultivation, staining, and identification of microorganisms from different sources.*
- *To develop skills in microbial growth measurement, enrichment techniques, and antimicrobial assays.*

Course Outcomes (COs):

- *Demonstrate safe lab practices and proficiency in core techniques for handling diverse microorganisms.*
- *Isolate, enumerate, and characterize microbes from environmental samples and identify key algae, fungi, and protozoa.*
- *Quantify microbial growth and evaluate antibiotic efficacy using standard assays.*

Course Content:

1. Safety measures in laboratory, brief idea of bio-safety level.

2. Observation and Identification of important taxa of Algae, Fungi and Protozoa.
3. Enumeration of microorganisms [bacteria and fungi] from soil, water and air using selective media and isolation of pure culture.
4. Staining method: Simple staining, Gram staining, Endospore staining, Acid-fast staining, Flagella staining, Capsule staining.
5. Isolation and enumeration of bacteriophage from sewage sample.
6. Enrichment culture of Nitrogen fixer, Spore former, cellulose decomposer, sulphate reducing bacteria and phosphate solubilizer.
7. Bacterial (cell count, turbidometry, plate count) and fungal (spore count, biomass weight) growth measurement.
8. Microbiological assay of antibiotics using tube dilution and well diffusion methods.

BTI 105: Biochemistry of Macromolecules & Secondary Metabolites	Course: BTIE406A0	25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To provide foundational understanding of biomolecules and their chemical properties.*
- *To develop conceptual clarity on enzyme mechanisms, kinetics, and metabolic pathways in biological systems.*
- *To integrate biochemical knowledge with cellular functions, energy regulation, and applied biological processes.*

Course Outcomes (COs):

- *Able to explain the structure, function, and metabolism of major biomolecules.*
- *Students will gain analytical skills to interpret enzyme kinetics, thermodynamics, and metabolic regulations.*
- *Apply biochemical principles to understand cellular processes, health, and disease.*

Course Content:

Unit 1 – Physical Chemistry for Biologists: Chemical bonds, hydrogen bond, quantitative description of solutions, e g. molarity, normality, percentage. pH scale, pKa values, isoelectric pH. Chemical equilibrium and principles of buffer solutions. Laws of thermodynamics. Concepts of ΔG, ΔH and ΔS, in judging the feasibility of biochemical process.

Unit 2 – Carbohydrates: Monosaccharides, disaccharides and Polysaccharides; Concept of reducing and non-reducing sugars; Concept of store polysaccharides (starch and glycogen) and structural polysaccharides (cellulose, chitin and peptidoglycan).

Unit 3 – Proteins: Chemistry of amino acids, four level proteins structure, Ramachandan plot, domain, folds and motifs of protein. Chemical modification of protein. Denaturation and renaturation of proteins structure.

Unit 4 – Lipids: Fatty acids structure and properties; Lipid: classification and functions of lipid; Membrane structure; Artificial membrane: monolayers, bilayers; Bacterial membrane transport.

Unit 5 - Enzymes: Classification, Specific activity, and turnover number; Mechanism of action of enzymes; Enzyme kinetics: Michaelis-Menten equation and their transformations; Allosteric mechanism; Enzyme inhibition and its kinetics. Bi-substrate reaction kinetics.

Unit 6 – Nucleic acid: Physical properties, structure of DNA and RNA; DNA denaturation and renaturation; DNA super coiling and bonding pattern of DNA; Types of RNA.

Unit 7 - Vitamins: Characteristics of Vitamins with examples, sources and importance.

Unit 8 - Metabolism: Carbohydrate Metabolism- Glycolysis (EMP pathway), Gluconeogenesis, Pentose phosphate pathway, Entner–Doudoroff pathway, Regulation of carbohydrate metabolism; Lipid Metabolism- Fatty acid oxidation (β-oxidation); Fatty acid biosynthesis; Role of lipids in membranes and energy storage; Amino Acid and Nucleotide Metabolism- Biosynthesis and degradation of amino acids; transamination, deamination, and urea cycle connections; nucleotide biosynthesis (purines, pyrimidines); nucleotide degradation and salvage pathways.

BTI 109: Analytical Biochemistry	Course: BTIE407A9	25 Marks (P25)

Course Objectives (COBs):

- *To train students in preparation of biological buffers and quantitative estimation of biomolecules.*
- *To impart hands-on skills in chromatographic separation and enzyme kinetics, including factors affecting enzyme activity.*
- *To provide practical exposure to protein purification, molecular weight determination, and electrophoretic techniques.*

Course Outcomes (COs):

- *Students will acquire the ability to prepare buffers and accurately measure biomolecules using standard biochemical techniques.*
- *Develop practical skills in chromatographic separation, enzyme activity measurement, and evaluation of enzyme kinetics.*
- *Become skilled in protein isolation, characterization, and analysis through SDS-PAGE and native gel electrophoresis methods.*

Course Content:

1. Preparation of buffer (Acetate, Phosphate, Tris)
2. Estimation of total carbohydrate by Phenol Sulphuric acid method.
3. Quantification of reducing sugar by Dinitro Salicylic Acid method.
4. Quantification of Protein by Bradford and Lowry method.
5. Quantification of total lipids by Gravimetric Method.
6. Determination of saponification values of fat.
7. Quantification of DNA by DPA method.
8. Quantification of RNA by Orcinol method.
9. Separation of sugar and amino acids by Thin Layer and Paper Chromatography
10. Determination of activity of enzyme and inhibition study.
11. Effect of pH and temperature on enzyme activity.
12. Determination of *K*m and *V*max value of enzyme (i.e. amylase)
13. Demonstration on Purification of protein.
14. Determination of molecular weight of protein by SDS-PAGE followed by Coomassie brilliant blue and silver nitrate staining.
15. Study of enzyme by native gel electrophoresis (zymogram).

BTI 110: Indian Knowledge System	Course: BTIO408VC	25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To introduce the definition, characteristics, and historical evolution of Indian Knowledge Systems (IKS), including traditional education, governance, arts, sciences, medicine, and the impact of colonial interventions.*
- *To develop an understanding of ancient Indian contributions in mathematics, astronomy, health systems (Ayurveda), governance, arts, culture, and environmental sustainability, highlighting their scientific, philosophical, and cultural significance.*
- *To encourage the application and integration of IKS principles in modern contexts such as healthcare, administration, cultural preservation, and environmental conservation for sustainable and holistic development.*

Course Outcomes (COs):

- *Understand the philosophical foundations, historical evolution, and multidisciplinary contributions of Indian Knowledge Systems (IKS), and compare them with modern scientific approaches.*
- *Analyze the relevance of traditional Indian knowledge in addressing contemporary challenges related to sustainability, health, governance, and social well-being, and apply IKS principles to practical solutions.*
- *Demonstrate cultural awareness by integrating indigenous perspectives into academic and professional contexts, and create innovative ideas or projects extending IKS into modern research and lifelong learning.*

Course Content:

Unit 1 - Introduction to IKS: Definition and characteristics of Indian Knowledge Systems; Historical evolution from ancient times to the 18th century CE; Impact of colonial education policies and the need for revisiting traditional Knowledge; Traditional educational institutions - Gurukuls, Pathshalas, Takshashila, and Nalanda; Local heritage sites and their relevance.

Unit 2 - Introduction to ancient Indian mathematics and astronomy: Ancient numeral systems and mathematical concepts; Indian logic systems and epistemology; Overview of Indian astronomy; celestial coordinate systems and calendar systems; Astronomical Instruments (Yantras) - Application of Physics and Chemistry

Unit 3 - Introduction to health and medicine: In-depth study of Ayurveda, its diagnostic methods, and therapeutic practices; Understanding the holistic approach to health encompassing physical, mental, and spiritual well-being; Application of Ayurveda principles in contemporary healthcare systems; Ayurvedic perspectives on health, including dietary regimes, disease management, elements of wellness—and their intersections with botany and medical science

Unit 4 - Introduction to ancient governance and public administration: Analysis of ancient Indian governance models and administrative structures; Insights from texts like Arthashastra on statecraft and economics; Relevance of traditional governance principles in modern administrative; Practices; Concept of Kingship; duties and responsibilities of a monarch; Three-tier political system- Dharmadanda, Rajdanda, Nyāyadanda; Law & administration, crime suppression, defence systems, foreign policy; Concept of wealth, ownership, and distribution; Kautilya’s “Saptanga” model (seven sources of income); Taxation, savings, and expenditure in ancient Indian economy

Unit 5 - Introduction to Ancient Arts and Culture: Study of traditional Indian art forms, including sculpture, dance, and music; Understanding the cultural significance and philosophical underpinnings of these art forms; Promotion of cultural heritage through education and practice; Temple architecture overview; Cave and monolithic architecture; Architectural styles - Chalukya, Pallava, Chola, Hoysala, Mauryan, Vijayanagara; Buddhist and Jain art & architectural heritage

Unit 6 - Introduction to Ancient Environmental Sustainability: Traditional knowledge systems related to agriculture, water management, and ecological balance; Application of sustainable practices derived from ancient texts and practices; Integration of IKS in contemporary environmental conservation efforts.

BTI 111: Vidyasagar: Life and Philosophy	Course: BTIO409NC	Non-Credit

Course Objectives (COBs):

- *To familiarize students with the life, lineage, and educational journey of Pandit Iswar Chandra Vidyasagar.*
- *To understand Vidyasagar's pioneering role in the reformation of Indian education and social systems.*
- *To explore Vidyasagar's contributions toward women's emancipation, modernization, and their relevance to contemporary society.*

Course Outcomes (COs):

- *Students will be able to describe the major events and influences that shaped Vidyasagar's life and philosophy.*
- *Students will critically analyze Vidyasagar's educational and social reforms, especially in the context of women's rights and education.*
- *Students will appreciate and apply Vidyasagarian ideals of rationality, equality, and humanism to modern social and ethical challenges.*

Course Content:

Unit 1 – Early Life and Education: Birth and Lineage; A journey from Iswar Chandra Bandopadhaya to Iswar Chandra Vidyasagar.

Unit 2 – Vidyasagar and Indian Education: The then Indian Education system; Vidyasagar plan for reformation of Indian education- Vidyasagar as teacher, Vidyasagar as writer, planner and reformer of Indian education.

Unit 3 – Vidyasagar and Women Emancipation: Introduction of widow remarriage; Struggle to stop child marriage.

Unit 4 – Vidyasagar: Traditions and Modernity: Tradition; Modernity; Vidyasagar as traditional moderniser.

Unit 5 – Relevance of Vidyasagarian Thought and Values: Vidyasagar and the then Society of Bengal; Lesson for future generations.

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Semester II						
Course Code	**Course No.**	**Course Content**	**Credit**	**Marks**	**No. of Hours**	**Credit (L-T-P)**
BTIC451X1	BTI 201	Genetic Engineering	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIE452A0	BTI 202	Biosafety & Bioanalytical techniques	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIE453A1	BTI 203	Biostatistics and R Programming	2	**25** (T20 + IA5)	40	**2** (2-0-0)
BTIE454A1	BTI 204	Immunology & Medical Biotechnology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC455X1	BTI 205	Advanced Bioinformatics	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC451X8	BTI 206	Genetic Engineering	2	**25** (P25)	20	**2** (0-0-2)
BTIE456A9	BTI 207	Review Work & Seminar	2	**25** (P25)	20	**2** (0-0-2)
BTIE453A8	BTI 208	Biostatistics and R Programming	2	**25** (P25)	20	**2** (0-0-2)
BTIE454A8	BTI 209	Diagnostic test & microbial pathology	2	**25** (P25)	20	**2** (0-0-2)
BTIC455X8	BTI 210	Advanced Bioinformatics	2	**25** (P25)	20	**2** (0-0-2)
BTIO457X9	BTI 211	Industry Visit & Internship	2	**25** (P25)	20	**2** (0-0-2)
		TOTAL	**22**	**275**		

BTI 201: Genetic Engineering — Course: BTIC451X1 — 25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To introduce the principles and tools of recombinant DNA technology (RDT) and genetic engineering.*
- *To familiarize students with cloning vectors, transformation methods, and gene expression analysis techniques.*
- *To highlight applications of genetic engineering in medicine, agriculture, and food biotechnology.*

Course Outcomes (COs):

- *Students will be able to explain the role of enzymes, vectors, and molecular techniques in DNA manipulation and cloning.*
- *Students will gain proficiency in PCR-based methods, blotting, sequencing, and functional genomics tools.*
- *Students will apply knowledge of genetic engineering to design and evaluate applications in healthcare, food, and agriculture.*

Course Content:

Unit 1 - DNA Manipulation and Enzymes: General concept of RDT**,** Enzymes used in genetic engineering (nucleases, ligases, polymerases, modifying enzymes); Restriction endonucleases and restriction mapping; Formation of recombinant DNA (use of linkers, adaptors, and homopolymer tails)

Unit 2 - Polymerase Chain Reaction (PCR): Principle and components of PCR; Role of oligonucleotide primers and temperature cycling; Applications: chemical diagnostics, RT-PCR (for RNA), qRT PCR, RAPD analysis; Sequencing of PCR-amplified products.

Unit 3 - DNA Introduction into Host Cells: Methods of transformation: chemical ($CaCl_2$), physical (electroporation, microinjection), biological (vectors, viruses)

Unit 4 - Cloning Vectors: Bacterial vectors Plasmids (pBR322, pUC series), bacteriophages (λ, M13), cosmids, phasmids, BACs; Yeast vectors (YEP, YRP, YIP, shuttle vectors, YACs); Plant vector (*Agrobacterium tumefaciens*); Animal virus vectors (retroviruses, adenoviruses).

Unit 5 - Clone Identification and Libraries: Genomic and cDNA library construction; Screening of clones (probe hybridization, immunological screening); use of radioactive and non-radioactive probes

Unit 6 - Gene and Genome Structure Analysis: Southern blotting and northern blotting for gene localization; Pulse-field gel electrophoresis, in situ hybridization; Chromosome walking and automated DNA sequencing; RFLP, AFLP analysis and genetic fingerprinting, NGS vs. WGS.

Unit 7 - Gene Expression and Functional Analysis: Expression vectors for *E. coli* and other hosts; Challenges of expressing eukaryotic genes in prokaryotes; Regulatory studies (gel retardation, DNase footprinting); Site-directed mutagenesis and protein engineering. DNA Microarray.

Unit 8 - Applications of Genetic Engineering: Medical (insulin, hepatitis B vaccine); Food: (Single Cell Protein, Single Cell Fat); Agriculture (transgenic, disease-resistant crops). DNA chip.

BTI 206: Genetic Engineering — Course: BTIC451X8 — 25 Marks (P25)

Course Objectives (COBs):

- *To familiarize students with molecular techniques such as PCR, restriction digestion, and electrophoretic analysis.*
- *To provide hands-on experience in genetic transfer mechanisms including transformation, transduction, and conjugation.*
- *To expose students to experimental approaches for studying gene regulation and microbial genetic diversity.*

Course Outcomes (COs):

- *Able to amplify, digest, and analyse nucleic acids using molecular biology techniques.*
- *Demonstrate competence in bacterial genetic manipulation through transformation, transduction, and conjugation.*
- *Acquire skills in analysing gene expression and genetic variation using assays.*

Course Content:

1. Amplification of DNA/RNA by PCR.
2. Restriction digestion of bacterial DNA and analysis of restriction fragments.
3. Induction of β−galactosidase in *E. coli*.
4. Transformation of bacteria and selection of recombinants by antibiotic selection and blue-white screening.
5. Transfer of Chloramphenicol Resistance to *E. coli* by Generalized Transduction.
6. Bacterial conjugation through transfer of genes coding for antibiotic resistance
7. Demonstration of DGGE.

BTI 202: Biosafety & Bio analytical Techniques Course: BTIE452A0 25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To provide knowledge of biosafety practices, biosecurity, and risk management in biological research.*
- *To develop an understanding of radioisotope handling, centrifugation, microscopy, chromatography, spectroscopy, and electrophoresis techniques.*
- *To enable students to apply modern analytical tools for studying biomolecules, cells, and molecular processes.*

Course Outcomes (COs):

- *Students will be able to explain biosafety levels, biosecurity codes, and safe laboratory practices for biological and radioactive materials.*
- *Students will gain proficiency in advanced techniques including microscopy, chromatography, spectroscopy, and electrophoresis.*
- *Students will apply analytical tools for biomolecular separation, structural characterization, and functional analysis in biological systems.*

Course Content:

Unit 1 - Biosafety: Biosafety requirements, decontamination and waste management, risk assessment, biosafety rules in India. Biorisk management, laboratory biosecurity, code of conduct, code of ethics, code of practice, International biosecurity issues.

Unit 2 - **Radioactivity:** Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.

Unit 3 - Sedimentation: Principles & applications of centrifugation, rotational speed, overview of types of centrifugation, ultracentrifugation, density gradient centrifugation (rate zonal and isopycnic).

Unit 4 - Microscopy: Compound, Bright field, Dark field, Phase contrast, Confocal, Fluorescence, Scanning, Transmission electron microscopes. Atomic force microscope, nuclear spin microscope, Helium ion microscope,

Unit 5 - Chromatography: Principle and overview of partition & adsorption chromatography. Gel filtration, Affinity, Ion exchange, Paper, Thin layer, HPLC, HPTLC and Gas Chromatography.

Unit 6 -Spectroscopic techniques: Principle and application of UV-Vis, Fluorescence, Infrared, FTIR, Circular dichroism, NMR, X-ray diffraction and concept of LC-MS and GC-MS. Raman spectroscopy,

Unit 7 - Gel-Electrophoresis: Principle, Non-denaturing and denaturing gel, isoelectric focusing, Poly Acrylamide Gel Electrophoresis, Agarose gel electrophoresis. 2D vs.3D gel electrophoresis.

BTI 203: Biostatistics and R Programming Course: BTIE453A1 25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To introduce statistical concepts such as descriptive statistics, hypothesis testing, probability, and sampling for biological data analysis.*
- *To develop analytical skills in correlation, regression, and statistical modelling applied to gene expression and bioinformatics data.*
- *To provide hands-on training in R for statistical computing, visualization, and interpretation of biological datasets.*

Course Outcomes (COs):

- *Students will be able to apply statistical tools for summarizing, testing hypotheses, and modeling biological data.*
- *Students will gain competency in probability theory, sampling distributions, and advanced models.*
- *Students will use R and Bioconductor for statistical bioinformatics, data visualization, and high-throughput biological data interpretation.*

Course Content:

Unit 1 -Descriptive Statistics: Measures of central tendency: Mean, Median, Mode; Measures of dispersion: Range, Variance, Standard Deviation, Coefficient of Variation; Skewness and Kurtosis.

Unit 2 - **Hypothesis Testing:** Fundamentals: null and alternative hypotheses; Parametric tests: Student's t-test, Z-test, ANOVA, F-test; Nonparametric tests: Wilcoxon, Mann–Whitney, Kruskal–Wallis; Chi-square test of independence and goodness-of-fit; Type I and Type II errors; Power of a test.

Unit 3 - **Correlation, Regression and Statistical Models in Bioinformatics**: Principle of least squares; Covariance and correlation coefficient; Properties of correlation; Linear regression for biological data; Statistical models in gene expression data; Filtering with p-values and fold-change; Volcano plots and gene expression data visualization; Heat maps, contingency table analysis.

Unit 4 - Probability Distributions and Sampling Theory: Introduction to Probability Theory: Classical and modern definitions; Sample space and events, mutually exclusive and independent events; Conditional probability and Bayes' theorem; Bernoulli trial, Binomial distribution, Poisson distribution, and their approximations; Normal distribution; Sampling theory: Objectives, sampling error, sampling distributions, central limit theorem; Markov and Hidden Markov models (HMM).

Unit 5 - Introduction to R and R for Statistical Applications: Overview of R: installation, packages, scripts, GUIs; R data structures: vectors, matrices, data frames, lists; Data summarization and representation; Introduction to Bioconductor; Microarray and NGS data analysis using R; Applications of R in statistical bioinformatics. Concept of Principal component analysis for the same of simplified presentation of data and its implementation with R.

Unit 6 -Data Visualization and Statistical Representation: Data types: Qualitative and Quantitative; Tabulation and graphical representation of data; Visualization techniques: line plot, scatter plot, histogram, pie chart, heatmap, 3D plots; Role of descriptive plots in hypothesis testing and decision-making; Visualization of regression, ANOVA, and correlation outcomes using R.

BTI 208: Biostatistics and R Programming **Course: BTIE453A8** **25 Marks (P25)**

Course Objectives (COBs):

- Introduce students to the fundamentals of R programming, data handling, and visualization.
- Develop analytical skills for applying statistical tests, probability models, and correlation analysis using R.

Course Outcomes (COs):

- Students will be able to use R for data management, basic programming, and graphical representation of biological data.
- Apply R-based statistical methods for hypothesis testing, error analysis, and probability distributions.

Course Content:

1. R installation, basics & data handling
2. Data structures: vectors, data frames, lists, matrices
3. Control structures: if-else, loops, functions
4. File I/O and package usage
5. Graphics: basic plots & ggplot2
6. Statistical parameters, correlation & error analysis
7. Probability distributions & Central Limit Theorem
8. Hypothesis testing: p-values, parametric & non-parametric tests
9. Biostrings for sequence analysis

Advanced data operations & special plots (heatmaps, circular, treemaps)

BTI 204: Immunology & Medical Biotechnology **Course: BTIE454A1** **25 Marks (T20 + IA5)**

Course Objectives (COBs):

- *To provide a detailed understanding of immune system organization, immune responses, antigen–antibody interactions, and immunological assays.*
- *To develop knowledge of clinical immunology, stem cell biology, drug discovery, and molecular diagnostic approaches.*
- *To familiarize students with modern therapeutics, clinical trial design, regulatory frameworks, and applications in rare and infectious diseases.*

Course Outcomes (COs):

- *Explain the fundamental and applied aspects of immunology, including immune mechanisms, vaccines, and clinical disorders.*
- *Gain practical insights into stem cell research, drug discovery strategies, molecular diagnostics, and therapeutic protein development.*
- *Competency in analysing clinical trial processes, regulatory requirements, and translational applications of biotechnology in healthcare.*

Course Content:

Unit 1 - Fundamental Concepts of Immune System: Overview of innate and acquired immunity; Phagocytosis; Complement system and inflammatory responses; Pathogen recognition receptors (PRR), pathogen associated molecular patterns (PAMP); Mucosal immunity; Antigens, immunogens and haptens; Cells and tissues of the immune system; lineages of immune cells; primary and secondary lymphoid organs; Major Histocompatibility Complex (MHC) – MHC genes, immune responsiveness, disease susceptibility.

Unit 2 - Immune Responses of B and T Lymphocytes: Immunoglobulin structure, classes and diversity; B-cell receptor, antibody genes and rearrangement; T-cell receptor, maturation and subsets; Cell-mediated immunity, ADCC, cytokines; Antigen processing and presentation; Memory and self–non-self-discrimination.

Unit 3 - Antigen-Antibody Interactions and Techniques: Antigen–antibody reactions (precipitation, agglutination, complement fixation); Immunological assays: RIA, ELISA, Western blot, ELISPOT, FACS, immunofluorescence; Biosensors; Cytotoxicity assays; CMI assays; Apoptosis and knockout/transgenic models.

Unit 4 – Clinical Immunology and Vaccines: Immunity to microbial infections; hypersensitivity (Types I–IV); autoimmunity (mechanisms, examples, therapies); transplantation immunology and graft rejection; tumor immunology and cancer immunotherapy; Methods of inducing resistance; Types of vaccines; Vaccine design and delivery systems; Vaccination schedules and herd immunity; Hazards of immunization. Disease-specific vaccines: Tuberculosis, HIV/AIDS, Ebola, Zika.

Unit 5 – Stem Cell Technology: Embryonic, adult and induced pluripotent stem cells; Stem cell markers, culture and differentiation; Stem cell niches; Therapeutic applications in regenerative medicine, genetic disorders and cancer; Ethical and regulatory issues in stem cell research.

Unit 6 – Drug Discovery and Molecular Diagnostics: Drug discovery- rational drug design, combinatorial chemistry, computer-aided design, antisense technology; Regulatory framework (FDA, IND process); Molecular diagnostics: biosensors, nucleic acid probes, antibody-based assays, nanotechnology in clinical diagnosis and tissue typing.

Unit 7 – Modern Therapeutics, Clinical Trials and Licensing: Gene therapy- approaches, vectors and applications; Therapeutic proteins (interleukins, interferons, tPA, erythropoietin); Nutraceuticals, SCP and bioactive peptides; Chiral technology; Clinical trials: phases I–IV; ICMR guidelines; licensing procedures in India;

Molecular and Cell Biology of human Rare Diseases and management; Biology and management of infectious diseases.

BTI 209: Diagnostic test & Microbial Pathology **Course: BTIE454A8** **25 Marks (P25)**

Course Objectives (COBs):

- *To provide students with hands-on training in immunological techniques, microbial characterization, and biochemical assays.*
- *To develop skills in identification of pathogenic bacteria and fungi through staining, culture, and biochemical tests.*
- *To train students in clinical and diagnostic microbiology methods for analysing patient-derived samples.*

Course Outcomes (COs):

- Students will be able to perform immunological assays and interpret results.
- Students will gain competence in microbial identification, biochemical characterization, and antibiotic sensitivity testing.
- Students will apply clinical microbiology techniques for detection of pathogens in biological samples.

Course Content:

1. Estimation of TC & DC.
2. Separation of macrophage and examination of phagocytosis.
3. Ouchterlony double diffusion technique.
4. Precipitation techniques: immunodiffusion, immuno electrophoretic method.
5. Agglutination reactions: Widal, Haemagglutination, Haemagglutination Inhibition
6. Estimation of blood sugar, urea, SGOT & SGPT.
7. Immunization with a specific antigen and raising of the antibody (demonstration).
8. Characterization of *E. coli* and *P. aeruginosa* by biochemical tests.
9. Identification of pathogenic fungi *Aspergillus niger* and *Candida albicans*.
10. Enumeration and identification of microbes associated with urine.
11. Analysis of antibiotic sensitivity of microbes present in urine.
12. Study of resident and pathogenic microbes of skin and oral cavity.

Study of pathogenicity of *Staphylococcus aureus* by coagulase test.

BTI 205: Advanced Bioinformatics **Course: BTIC455X1** **25 Marks (T20 + IA5)**

Course Objectives (COBs):

- *To impart theoretical and practical knowledge of sequence, genome, proteome, transcriptome, and metabolome analysis using advanced computational tools.*
- *To introduce concepts of systems biology, network modelling, and integration of multi-omics data for biological interpretation.*

- *To provide an understanding of machine learning and AI-based approaches in computational biology, emphasizing classification, prediction, and pattern recognition.*

Course Outcomes (COs):

- *Students will be able to apply algorithms, statistical models, and bioinformatics tools for sequence analysis, genome annotation, and functional predictions.*
- *Gain proficiency in proteomics, transcriptomics, metabolomics, and systems biology approaches to explore complex biological networks.*
- *Establish the ability to use machine learning and advanced computational methods for solving biological problems and interpreting omics datasets.*

Course Content:

Unit 1 - Advanced sequence analysis: Dynamic programming algorithm: Introduction to PAM and BLOSUM matrices; differences; between distance and similarity matrices. Global and local pairwise alignment methods – Smith-Waterman and Needleman-Wunsch algorithms; Definition of sequence patterns - use of Hidden Markov model (HMM) in assigning homology. Concepts behind multiple sequence alignment; ClustalW, TCoffee. BLAST, sequence search, difference versions of BLAST, gapped BLAST and BLAT.

Unit 2 - Genomics: Genome anatomy: prokaryotic vs. eukaryotic genomes; Gene prediction in microbial and eukaryotic genomes; Neural networks and pattern discrimination methods; Promoter prediction and challenges in genome analysis; Comparative genomics: orthologs, paralogs, proteomes; Ancient conserved regions, horizontal gene transfer, gene order conservation; Functional genomics; CpG islands detection; RNA structure prediction methods and approaches.

Unit 3 - Proteomics: Protein and proteome analysis from 2D gels, mass spectrometry, sequence data; Protein property and structure prediction - sequence patterns, transmembrane proteins; 3D structure prediction: threading, template-based modelling; Protein prediction tools and web servers.

Unit 4 - Transcriptomics & Metabolomics: Gene expression profiling; qRT-PCR, RNA-seq experiments, ChIP-seq design; Small non-coding RNA analysis (miRNA, siRNA, Reaper, R tools); Differential expression analysis: DESeq, DEXSeq; Microarrays: DNA and protein microarrays, normalization, differential expression; Metabolomics: informatics and statistics, isoform discovery, alternate expression

Unit 5 - Systems Biology & Network Analysis: Systems biology concepts – biochemical and metabolic networks, regulatory networks; Mathematics of networks: Networks and their representation, adjacency matrix, weighted networks, bipartite networks; Statistical modeling: hierarchical models, Bayesian statistics; Pathway and network analysis of omics data; Synthetic Oligonucleotide/DNA- based, RNA-based, Peptide-based Technologies and Applications.

Unit 6 - Basic concepts of Machine Learning: Basic notions of learning, introduction to learning algorithms, supervised and unsupervised learning, reinforcement learning, instance based learning and analytical learning; Introduction to Support Vector Machines and their applications; Introduction to Neural Networks Classifying Samples from two populations using; Multilayer Perceptron and back propagation; Using genetic algorithm and Perceptron for feature selection and supervised classification; Recurrent and feed forward associative neural networks; Applications of ANN, SVM etc.; Random Forest.

BTI 210: Advanced Bioinformatics Course: BTIC455X8 25 Marks (P25)

Course Objectives (COBs):

- *To train students in sequence analysis through BLAST, alignment algorithms, and multiple sequence alignment tools.*
- *To familiarize students with protein domain, structure, and interaction analysis using open-source bioinformatics platforms.*
- *To introduce computational approaches for evolutionary studies and predictive modelling using machine learning methods.*

Course Outcomes (COs):

- *Students will be able to perform local installations of bioinformatics tools, generate alignments, and interpret structural-functional relationships.*
- *Gain proficiency in phylogenetic analysis, protein domain identification, and protein-protein interaction studies.*
- *Students will apply advanced computational methods, including ANN and SVM, for prediction and biological data analysis.*

Course Content:

1. Install BLAST locally, create a database locally, and use various command-line parameters to improve search criteria and interpretation of results from Blast, manipulating results from Blast to extract regions of sequences with significant hits.
2. Global and pairwise alignment using online and offline tools. Study the effects of different scoring matrices and gap penalty schemes on the alignment.
3. Collate sequences of proteins based on homology, create multiple sequence alignment using local installation of ClustalW and visualise for editing in CLC work bench, BioEdit, etc.
4. Extract profiles from multiple sequence alignment and compare them with conserved structural regions in the PDB structure for a given family of proteins.
5. Locally install HMMAER and InterProScan tools to identify domains of interest.
6. Protein structure analysis using open-source tools, protein-protein interaction analysis.
7. Create phylogenetic tree using offline tools and visualise using iTOL.
   Use of ANN or SVM as a prediction server.

BTI 207: Review Work & Seminar   Course: BTIE456A9   25 Marks (P25)

Course Objectives (COBs):

- *To develop scientific writing skills through preparation of a review article in standard journal format.*
- *To cultivate critical analysis and synthesis of literature relevant to microbiology and biotechnology.*
- *To enhance presentation and defence skills through viva-voce discussion of the review work.*

Course Outcomes (COs):

- *Able to write a comprehensive review article following scientific journal guidelines.*
- *Students will critically evaluate and integrate published research in the context of the course curricula.*
- *Gain confidence in orally defending their scientific interpretations before a panel of experts.*

Course Content:

One review article on any topic relevant to the course-curricula is to be prepared by the student in standard journal format and to be defended during viva-voce before end-term examination.

BTI 211: Industry Visit & Internship **Course: BTIO457X9** **25 Marks (P25)**

Course Objectives (COBs):

- *To provide exposure to industrial/research laboratory practices in microbiology and biotechnology.*
- *To bridge the gap between theoretical classroom learning and real-world applications.*
- *To develop professional skills in documentation, teamwork, and technical communication.*

Course Outcomes (COs):

- *Students will gain first-hand understanding of industrial processes, laboratory protocols, and organizational workflow.*
- *Ability to maintain records, prepare detailed reports, and present observations effectively.*
- *Students will acquire practical experience and professional confidence for future research or industry careers.*

Course Content:

1. **Visit to Industry:** Students will compulsorily participate in educational tour to Microbiology/Biotechnology based Industries conducted by the department and will submit a tour report separately.
2. **Internship:** Students will experience the real world working experience in industries/research laboratories/ hospitals/ food and dairy units/agricultural organizations/environmental monitoring facilities for 10 days. Students have to maintain a logbook, recording their daily activities and observations. At the end of the training, they must submit a comprehensive report and present their findings through a seminar/viva-voce. Evaluation will be based on performance at the host institution, quality of documentation, report writing, and oral presentation.

	Semester III					
Course Code	**Course No.**	**Course Content**	**Credit**	**Marks**	**No. of Hours**	**Credit (L-T-P)**
BTIO501X0	BTI 305	MOOC Course	4	50	40	**4** (4-0-0)
BTIC502X1	BTI 301	Plant and Animal Biotechnology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC503X1	BTI 302	Food and Bioprocess Technology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC504X1	BTI 303	Agro-Enviro-Marine Biotechnology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC505X1	BTI 304	Omics Technology & Big Data Analysis	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC502X8	BTI 306	Plant and Animal Biotechnology	2	**25** (P25)	20	**2** (0-0-2)
BTIC503X8	BTI 307	Food and Bioprocess Technology	2	**25** (P25)	20	**2** (0-0-2)
BTIC504X8	BTI 308	Agro-Enviro-Marine Biotechnology	2	**25** (P25)	20	**2** (0-0-2)
BTIC505X8	BTI 309	Big Data Analysis	2	**25** (P25)	20	**2** (0-0-2)
BTIO506X9	BTI 310	Community Out-reach Program and report preparation	2	**25** (P25)	20	**2** (0-0-2)
TOTAL			**22**	**275**		

BTI 305: MOOC Course **Course: BTIO501X0** **25 Marks (T20 + IA5)**

Course Objectives (COBs):

Course Outcomes (COs):

Course Content: To be notify later

BTI 301: Plant and Animal Biotechnology **Course: BTIC502X1** **25 Marks (T20 + IA5)**

Course Objectives (COBs):

- *To provide students with conceptual and practical understanding of plant and animal biotechnology including tissue culture, genetic transformation, and genome editing.*
- *To impart knowledge of advanced technologies such as omics, nanobiotechnology, synthetic biology, transgenic approaches, and molecular farming.*
- *To develop skills for applying plant and animal biotechnology in healthcare, agriculture, industry, and environmental sustainability.*

Course Outcomes (COs):

- *Students will acquire knowledge of core principles and techniques in plant and animal cell/tissue culture, genetic manipulation, and cryopreservation.*
- *Students will be able to apply modern biotechnological tools such as CRISPR, omics, synthetic biology, and hybridoma technology for solving real-world problems.*
- *Students will gain the ability to critically analyze and integrate biotechnology applications in areas like agriculture, biopharmaceuticals, nutraceuticals, regenerative medicine, and environmental management.*

Course Content:

Unit 1 – Fundamentals of Plant Biotechnology: Phytohormones**,** Plant tissue culture: principles, totipotency, aseptic techniques; Media preparation: MS, B5, hormone regulation; Micropropagation: callus culture, organogenesis, somatic embryogenesis; Protoplast culture, somatic hybridization, cybrids; In vitro conservation and cryopreservation of germplasm. Seed processing and certification.

Unit 2 – Advanced Plant Biotechnology: Omics approaches in plant biotechnology**; Genome editing advances**: base editing, prime editing, CRISPR/Cas variants; **Synthetic biology in plants**: chassis plants, modular pathway engineering; N**anobiotechnology applications**: nanoparticle-mediated delivery, biosensors, nano-fertilizers; Large-scale plant cell, tissue, and hairy root culture for metabolite production. Plantibody, plant molecular farming.

Unit 3 – Applied Plant Biotechnology: Plant genetic transformation: Agrobacterium-mediated and direct gene transfer methods (biolistics, electroporation); Transgenic plants: strategies for resistance (insect, virus, herbicide, stress tolerance, nematode resistance); Metabolic engineering: production of bioactive compounds, edible vaccines; Molecular farming: recombinant proteins, nutraceuticals, phytoremediation.

Unit 4 – Fundamentals of Animal Biotechnology: Animal cell culture: primary culture, continuous cell lines, embryo culture, stem cells; Media composition, growth factors promoting proliferation of animal cells (EGF, FGF, PDGF, IL-1, IL-2, NGF, erythropoietin), serum-free culture; Cryopreservation and cell banking; Cell viability assays and characterization; Cytogenetics: karyotyping, chromosomal aberrations.

Unit 5 – Applied Animal Biotechnology: Genetic manipulation of animal cells: transfection, viral vectors, genome editing (CRISPR/Cas9); Transgenic and knock-out animals: methods (pronuclear injection, ES cell technology, SCNT); Hybridoma technology: monoclonal antibody production and applications; Applications: gene therapy, regenerative medicine, biopharmaceuticals, organoid culture. Nude and SCID mice.

BTI 306: Plant and Animal Biotechnology	Course: BTIC502X8	25 Marks (P25)

Course Objectives (COBs):

- *To provide hands-on training in plant breeding, tissue culture, and molecular techniques.*
- *To develop experimental skills in animal biotechnology including protein profiling, cytotoxicity, and gamete cryopreservation.*
- *To introduce students to bioassays and biopesticide applications for sustainable agriculture and health.*

Course Outcomes (COs):

- *Acquire practical skills in plant tissue culture, breeding techniques, and molecular marker applications.*
- *Students will demonstrate competence in protein profiling, cytotoxicity assays, and reproductive biotechnology.*
- *Analyse microbial/biopesticide interactions and evaluate their applications in plant and animal systems.*

Course Content:

1. General Breeding Techniques: Emasculation, pollination and tagging
2. Tissue culture techniques: Preparation of various tissue culture media.
3. Tissue culture of explants.
4. Isolation and culture of protoplasts and microspores
5. Application of RFLP technique in plant breeding.
6. Protein profile of silk gland and haemolymph of larval forms of silk worm.
7. Biopesticide effect on mosquitoe larvae.
8. Cytotoxicity assay of plant extract against cell line.

Morphology study and cryopreservation of male gametes of bull.

BTI 302: Food and Bioprocess Technology	Course: BTIC503X1	25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To provide students with fundamental and applied knowledge of industrial microorganisms, fermentation technology, and bioprocess engineering.*
- *To impart skills in food biotechnology including fermentation, spoilage control, preservation, and production of microbial foods.*
- *To create awareness of food safety, quality assurance, and regulatory standards in industrial and food biotechnology.*

Course Outcomes (COs):

- *Students will understand microbial strain development, fermentation processes, and downstream operations in industrial biotechnology.*

- *Students will gain knowledge of food spoilage mechanisms, preservation techniques, fermented foods, and microbial foods.*
- *Students will be able to analyze foodborne pathogens, apply quality assurance practices, and connect industrial microbiology with food safety regulations.*

Course Content:

Unit 1 - Industrial Strain: Prerequisites of potentially useful industrial Microorganisms, Isolation, Screening / selection, purification and improvement of industrial microbial strains. Methods of preservations and maintenance of microbial strains and stock culture.

Unit 2 - Fermenter and Fermentation: Basic principle and function, design, types, components and their function. Batch, fed-batch, and continuous operation of bioprocess. Liquid state fermentation (surface and submerged) and solid state fermentation.

Unit 3 - Bioprocess Engineering & Operations: Bioprocess development; stoichiometry of growth and product formation; energy balances: basic energy concept. Fluid flow and mixing: classification of fluids, viscosity, non-Newtonian fluids, Rheological properties of fermentation broth; heat transfer; mass transfer: molecular diffusion, oxygen uptake in cell culture, oxygen transfer in fermentor and measurement of oxygen transfer coefficient.

Unit 4 - Scale up and Downstream Processing: Factors depending on scale up process of fermentation. Different techniques association with downstream processing.

Unit 5 - Immobilization: Cell and enzyme Immobilization. Advantages and disadvantages. Industrial applications of immobilization.

Unit 6 - Industrial products: Production aspects of industrial alcohol, organic acids; amino acids; vitamin.

Unit 7 - Microbial Food Spoilage and Preservation Techniques: Classification of common food items; Normal microbial flora of common foods (milk, meat, fish, cereals, vegetables and fruits); Factors influencing microbial growth in food Contamination of foods; Mechanism and factors governing the spoilage of food; Detection of spoilage and characterization; Food preservation methods: physical, chemical and biological.

Unit 8 - Fermented Food & Drinks: Production, microbes and benefits of Soy Sauce, Sauerkraut, Sausage, Yogurt, Kefir, Cheese, Beer, Wine, Champagne, Whiskey and Vodka. Oriental fermented food (Miso, Natto, Tempeh, Poi, Sufu, Ontjom, Kombucha, Haria, Kanji, Ngari).

Unit 9 – Microorganisms as food: Single cell protein, algae as food, mycoprotein and mushroom.

Unit 10 - Foodborne Diseases & Quality assurance: Food deterioration by mycotoxins; Characteristics of food borne diseases caused by *Clostridium, Listeria, Salmonella, Shigella*; Epidemiology and outbreak investigation; Government regulatory practices and policies; FSSAI, FDA, EPA, HACCP, ISI.

BTI 307: Food and Bioprocess Technology — Course: BTIC503X8 — 25 Marks (P25)

Course Objectives (COBs):

- *To provide practical exposure in isolation and characterization of food-associated microorganisms.*
- *To develop skills in microbial fermentation processes for production of food, beverages, enzymes, and metabolites.*
- *To train students in analytical and bioprocess techniques for monitoring microbial activity, product yield, and process efficiency.*

Course Outcomes (COs):

- *Students will be able to isolate, identify, and characterize microorganisms from fermented foods.*
- *Students will gain practical expertise in fermentation-based production of alcohol, baker's yeast, curd, and microbial enzymes.*
- *Students will demonstrate analytical competence in measuring endotoxins, organic acids, substrate utilization, and process optimization.*

Course Content:

1. Isolation and characterization of microorganisms from fermented foods.
2. Production of alcohol by fermentation from molasses.
3. Preparation of baker's yeast using molasses.
4. Measurement of endotoxin in food products.
5. Production of curd with respect to microbial load and organic acid formation.
6. Immobilization of microbial cells/enzyme by calcium alginate gel entrapment
7. Determination of substrate consumption rate for amylase production in batch culture.
8. Microbial production of amylase through Solid state fermentation

BTI 303: Agro-Enviro-Marine Biotechnology Course: BTIC504X1 25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To provide knowledge of marine, agricultural, and environmental biotechnology with emphasis on microbial and algal applications.*
- *To familiarize students with advanced biotechnological tools for waste management, genetic engineering, and bioremediation.*
- *To develop practical understanding of sustainable approaches for environmental conservation, food security, and industrial applications.*

Course Outcomes (COs):

- *Students will understand marine biodiversity, bioresources, and their applications in food, pharmaceuticals, and industry.*
- *Students will acquire skills in microbial applications for agriculture, waste conversion, and environmental sustainability.*
- *Students will apply bioremediation, phytoremediation, and biotechnological strategies to address real-world ecological challenges.*

Course Content:

Unit 1 - Marine Biotechnology & Bioproducts: Marine floral and faunal diversity. Conservation and management-in situ and ex situ (Marine biosphere reserves; Marine parks).Seaweed culture and applications; Marine microalgae in aquaculture: antioxidants (carotenoids, astaxanthin); Marine hydrocolloids (agar, agarose, carrageenan, alginates, chitosan, chitin); Marine enzymes in fish processing; Marine lipases in modification of fats and oils.

Unit 2 - Marine Genetic Engineering & Environmental Biotechnology: Preservation of marine microbes; Culture Collection Centres (ATCC, IMTECH, NCCSMCC etc.). Microbial nutrition - influence of environment factors on microbial growth, activity and distribution. Production of transgenic fishes (growth hormone, antifreeze proteins, disease resistance); Marine pharmaceuticals and bioactive compounds from sea weed; Marine biofouling and biotechnological control; Marine bioremediation: biosurfactants, oil spill control, extremophiles in marine environments; Microbiome and Environmental DNA (eDNA) analysis.

Unit 3 - Agricultural Biotechnology and Microbial Applications: Concept of photosynthesis, solute transport, seed processing, and storage. Microorganisms as biofactories for production of antibiotics, amino acids, lipids, enzymes, steroids, secondary metabolites, Biopolymers and bioplastics; Biotechnological potentials of microalgae as food, feed, colorants, biofuels, pharmaceuticals; Cyanobacteria and microbial biofertilizers (Rhizobium, Azotobacter, Azospirillum, Phosphobacteria, VAM) and Microbial biopesticides (Bacillus, Trichoderma).

Unit 4 - Biocontrol & Waste Conversion: Biological pest control through microbial antagonists (bacteria, fungi, viruses); Risks of GMOs: ecological and health considerations; Bioconversion of agro-wastes like cellulosic and non-cellulosic residues; Biopulping, biobleaching, and biofuels from agro-byproducts.

Unit 5: Waste Management & Xenobiotics: Aerobic and anaerobic wastewater treatment; Effluents treatment of dairy, distillery, tannery, sugar, antibiotic industries; Bioreactors for waste water treatment, Disinfection and Disposal, medical waste management, composting, methane generation; Microbiology of xenobiotic degradation: hydrocarbons, substituted hydrocarbons, pesticides, dyes, surfactants, oil pollution.

Unit 6 - Bioremediation & Phytoremediation: Fundamentals, strategies, and applications of bioremediation (biostimulation, bioaugmentation); control of air pollution. Bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, pesticides, TNT); Microorganisms in bioremediation: white rot fungi vs specialized bacteria; Phytoremediation methods: phytoaccumulation, phytovolatilization, rhizofiltration, phytostabilization.

BTI 308: Agro-Enviro-Marine Biotechnology Course: BTIC504X8 25 Marks (P25)

Course Objectives (COBs):

- *To provide hands-on training in isolation, cultivation, and utilization of marine and soil microorganisms for biotechnological applications.*
- *To develop analytical skills in assessing environmental parameters, effluent quality, and microbial degradation of pollutants.*
- *To connect theoretical knowledge of agro-marine biotechnology with real-world problem-solving in sustainable agriculture and environmental management.*

Course Outcomes (COs):

- *Students will be able to isolate, culture, and apply beneficial microbes for agriculture and bioremediation.*
- *Students will gain practical skills in analysing pigments, enzymes, biopolymers, compost nutrients, and effluent quality parameters.*
- *Students will demonstrate competence in laboratory-scale biotechnological processes including seaweed culture, composting, and pollutant degradation.*

Course Content:

1. Estimation of chlorophyll and carotenoids from marine algae.
2. Demonstration of seaweed culture techniques in laboratory-scale tanks.

3. Screening of marine microbes for enzyme production (amylase, lipase, protease).
4. Demonstration: PCR-based detection of eDNA from marine samples.
5. Screening of soil microbes for production of biopolymers.
6. Isolation and mass culture of cyanobacteria (Anabaena, Nostoc, Spirulina).
7. Isolation and application of microbial biofertilizers (Rhizobium, Azotobacter, VAM).
8. Production and extraction of pigments (phycocyanin, β-carotene) from microalgae.
9. Laboratory-scale composting of agro-waste and analysis of nutrient content (before and after).
10. BOD, COD, and TSS analysis of industrial effluents.
11. Isolation of dye-degrading bacteria/fungi from polluted sites.

White-rot fungal degradation of lignin/persistent organic pollutants.

BTI 304: Omics Technology & Big Data Analysis **Course: BTIC505X1** **25 Marks (T20 + IA5)**

Course Objectives (COBs):

- *To introduce fundamental concepts of genomics, transcriptomics, proteomics, and other omics.*
- *To familiarize students with sequencing technologies, big data handling, and analysis tools.*
- *To develop skills for applying integrative omics in health, agriculture, and environment.*

Course Outcomes (COs):

- *Students will understand principles of omics, sequencing methods, and data analysis pipelines.*
- *Students will gain proficiency in transcriptomics, proteomics, metagenomics, and functional genomics tools.*
- *Students will apply multi-omics approaches for biomarker discovery, diagnostics, and biotechnology innovations.*

Course Content:

Unit 1 - Introduction to Omics, Genomics, and Big data: Basics of Genomics and Omics; Importance of Omics in biology and medicine; Human Genome Project: goals and outcomes; Structure and organization of genomes; Genome variation and molecular markers; Introduction to sequencing technologies (Sanger vs. NGS); Introduction to Big data: Characteristics, data structures and data repositories; Exploratory analysis of big data in R environment; Handling large-scale biotech data, tools, and technologies.

Unit 2 - Genome Sequencing and Annotation: Whole genome sequencing approaches: shotgun, clone-by-clone; DNA sequencing generations: 1st, 2nd, 3^{rd}; Common sequencing platforms (Illumina, Nanopore, Ion Torrent); Genome data formats (FASTA, GFF, VCF, BED); Genome assembly and read mapping.

Unit 3 - Transcriptomics and Gene Expression: Overview of transcriptomics (mRNA, lncRNA, miRNA); Methods: Microarray, RNA-Seq, qRT-PCR; RNA-Seq pipeline: quality check (FastQC), alignment (HISAT2), quantification (HTSeq), differential expression (DESeq2); Gene expression databases: GEO, ArrayExpress; Functional analysis of transcriptomic data.

Unit 4 - Proteomics and Metagenomics: Basics of proteomics and its importance; Techniques: 2D-PAGE, LC-MS/MS, MALDI-TOF; Protein–protein interaction methods; Databases: UniProt, PRIDE, ExPASy; Introduction to metagenomics and its applications.

Unit 5 - Epigenomics and Functional Genomics: Epigenetic mechanisms: DNA methylation, histone modifications; Techniques: ChIP-seq, ATAC-seq, Bisulfite sequencing; Functional genomics: assigning gene functions; Comparative genomics: whole-genome alignment, synteny.

Unit 6 - Applications of Omics and Multi-Omics: Applications of omics in health, agriculture, environment, and drug discovery; Introduction to integrative omics (multi-omics); Visualization tools: Cytoscape, IGV, Reactome; Overview of metabolomics: NMR, LC-MS, GC-MS; Role of metabolomics in biomarker discovery and diagnostics.

BTI 309: Big Data Analysis	Course: BTIC505X8	25 Marks (P25)

Course Objectives (COBs):

- *To introduce students to modern next-generation sequencing (NGS) data analysis workflows and tools.*
- *To develop skills in genome assembly, annotation, and functional interpretation of biological datasets.*
- *To train students in advanced comparative genomics, metagenomics, and transcriptomics analyses.*

Course Outcomes (COs):

- *Able to perform quality assessment, assembly, alignment, and annotation of genomic and transcriptomic data.*
- *Gain expertise in metagenomics and comparative genomics for microbial diversity and evolutionary studies.*
- *Students will demonstrate competence in identifying genetic variations, antibiotic resistance, CRISPR elements, and functional pathways.*

Course Content:

1. Visualise sequence reads, conduct quality check using FastQC and DNA short reads assembly using Velvet and SPAdes, etc.
2. Read alignment to a reference genome using BWA, SAMtools, Visualise using IGV, Genome browsers (UCSC, Ensembl), etc.
3. Predict SNPs, and compare samples using bedtools.
4. Gene annotation with BAKTA/Augustus, use BLAST, KEGGmapper for function prediction.
5. RNA-seq assembly, analysis, count reads per gene, identify DEGs (with DESeq).
6. Metagenome Assembly - amplicon (QIIME) and MAGs (metaSPAdes), classify microbes by phylum/OUT, compare abundance between samples, functional analysis using PICRUSt.
7. Identification of ICE (Integrative and Conjugative Elements) and CRISPR in microbes, plasmid, and antibiotic resistance genes.
8. Comparative Genomics – analysing genome synteny (genome alignment) between two species using progressive Mauve, MUMmer, etc., Pan and core genome analysis, Visualise using BRIG, Circos.

BTI 310: Community Out-reach Program and report preparation	Course: BTIO506X9	25 Marks (P25)

Course Objectives (COBs):

- *To sensitize students about their social responsibilities as microbiologists/biotechnologists.*
- *To encourage active participation in community-based awareness programs on health, hygiene, and sustainable practices.*
- *To train students in documentation and scientific communication through report preparation.*

Course Outcomes (COs):

- *Able to design and execute outreach activities related to microbial diseases, water hygiene, or fermented foods.*
- *Develop communication skills to effectively convey scientific knowledge to the general public.*

- *Students will prepare and submit a structured report, demonstrating reflection on community engagement and social impact.*

Course Content:

Students will serve the society in any form (by spreading social awareness on microbial diseases / water hygiene/fermented food or any kind of social work) and shall submit a written report to HOD.

Semester IV						
Course Code	**Course No.**	**Course Content**	**Credit**	**Marks**	**No. of Hours**	**Credit (L-T-P)**
BTIC551X1	BTI 401	Structural Bioinformatics and Drug Design	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC552X0	BTI 402	Next-Generation Microbiotechnology	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIO553X0	BTI 403	Intellectual Property Right, Bioethics, & Entrepreneurship	2	**25** (T20 + IA5)	20	**2** (2-0-0)
BTIC551X8	BTI 404	Structural Bioinformatics and Drug Design	2	**25** (P25)	20	**2** (0-0-2)
BTIC554X9	BTI 405	Grand Viva-voce	2	**25** (P25)	20	**2** (0-0-2)
BTIC555X9	BTI 406	Project Work	8	**100** (P100)	80	**8** (0-0-8)
BTIC556X9	BTI 407	Research/ Start-up Proposal Design	4	**50** (P50)	40	**4** (0-0-4)
TOTAL			**22**	**275**		

BTI 401: Structural Bioinformatics and Drug Design   Course: BTIC551X1   25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To provide students with an understanding of protein structure, computational modelling, and molecular dynamics simulations for structural biology applications.*
- *To familiarize students with cheminformatics, docking, and computational drug design, including virtual screening and ADMET prediction.*
- *To develop practical skills in using bioinformatics and computational chemistry tools for protein analysis, ligand design, and structure-based research.*

Course Outcomes (COs):

- *Students will be able to predict, validate, and analyze protein structures using computational and structural bioinformatics tools.*
- *Students will gain the ability to perform molecular mechanics calculations, molecular dynamics simulations, and energy minimizations to study biomolecular interactions.*
- *Students will be able to design, evaluate, and virtually screen drug candidates using docking, pharmacophore modeling, and cheminformatics approaches.*

Course Content:

Unit 1 - Protein Structure Prediction and Validation: Structural motifs: Greek key, Jelly roll, Rossmann fold; Protein structure prediction methods: Chou-Fasman and GOR methods, Homology modeling, *Ab initio* modeling; Validation of computational predictions: Secondary structure elucidation using Peptide bond, phi, psi and chi torsion angles, Ramachandran plot; Hydrogen bond analysis: Coulomb and empirical methods; Structural comparison algorithms and metrics: DALI, CE, RMSD, Z-score; Structure classification databases: SCOP, CATH FSSP; Applications: Interface design, scaffold design, ligand binding site design, protein switches; Tools: PyMOL, Chimera,etc.

Unit 3 - Molecular Mechanics and Computational Chemistry: Molecular mechanics: concepts, force fields, introduction to the Leap Frog, Verlet etc. algorithms to compute movements of atoms, concept of velocity distributions and temperature; explicit water models and periodic boundary conditions. Advantage and limitaions of implicit solvation. Energy minimization: energy barriers and local/global minima, saddle points; geometry optimization. Introduction to the concept of ligand/small molecule parameterization using quantum chemical tools.

Unit 4 - Molecular Dynamics Simulations: Introduction to MD and molecular interactions; Solvation models and simulation constraints; MD configuration files and ensembles; Explicit solvent simulations, time-step dynamics; Trajectory analysis and transport properties; Tools: GROMACS.

Unit 5 - Molecular Representations and File Formats: Molecular representations: SMILES, graphs, images; Coordinate systems: Cartesian, fractional, internal; File formats: PDB, MMCIF, MOL2, SDF; Visualization: cartoon, ribbon, solvent-accessible surfaces; Superposition and alignment: Kabsch algorithm, Euler angles.

Unit 6 - Drug Discovery, Docking and Cheminformatics: Drug discovery pipeline: target identification, Lipinski's rule; Structure-based and ligand-based drug design; AI and deep learning applications in structure-based drug design; Docking: algorithms, scoring functions; Virtual screening: LBSV, pharmacophore-based; Pharmacophore modeling: ligand/receptor-based; QSAR: 2D/3D descriptors; *In silico* ADMET & combinatorial libraries; Tools: AutoDock, Vina, SwissPDBViewer, etc; Types of drug delivery system.

BTI 404: Structural Bioinformatics and Drug Design Course: BTIC551X8 25 Marks (P25)

Course Objectives (COBs):

- *To train students in protein structure prediction, visualization, and validation using computational tools.*
- *To provide hands-on exposure to molecular docking, ligand design, and virtual screening in drug discovery.*
- *To develop computational skills in molecular dynamics simulations and interaction analysis of biomolecules.*

Course Outcomes (COs):

- *Students will be able to model, visualize, and validate protein structures using standard bioinformatics software.*
- *Students will acquire the ability to design ligands, predict binding sites, and perform docking studies.*
- *Students will demonstrate proficiency in running molecular dynamics simulations and analyzing biomolecular behavior.*

Course Content:

1. Homology modelling using MODELLER.
2. Graphical representations of molecules using open-source software and editing PDB files.
3. Structure Validation: Procheck, WHATIF, VERIFY 3D.
4. Protein – ligand and protein-protein interactions, inducing point mutations and analyzing molecular interactions.
5. Ligand building for drug screening, binding site prediction on protein structures.
6. Virtual screening and docking studies using Autodock and Vina.
7. Molecular simulation studies using GROMACS, analysing a molecular dynamics trajectory, and calculation of RMSD.

BTI 402: Next-Generation Micro biotechnology Course: BTIC552X0 25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To introduce students to advanced and sustainable approaches such as waste valorization, circular bioeconomy, and nanobiotechnology for addressing global challenges.*
- *To provide an understanding of the role of Artificial Intelligence, biosensors, and cutting-edge technologies in microbiology, diagnostics, and healthcare.*
- *To explore the integration of biotechnology with neuroscience, materials science, and environmental sustainability for innovation and translational applications.*

Course Outcomes (COs):

- *Students will be able to analyze and apply circular bio-manufacturing concepts for waste-to-value bioproducts, biomaterials, and sustainable bioprocesses.*
- *Students will gain the ability to apply AI, nanotechnology, and biosensor-based tools for advancements in microbiology, diagnostics, and therapeutics.*
- *Students will be able to critically evaluate emerging areas such as the microbiome-brain axis, and neurobiotechnology for human health and disease management.*

Course Content:

Unit 1 - Waste Valorization and Circular Biomanufacturing: Microbial conversion of agro-industrial and municipal waste; E-waste, Biofactories for bioplastics (PHA, PLA), biofuels, and biosurfactants; Mycelium and microbial biomaterials in packaging, textiles, and construction; reuse of waste, Circular economy principles, and life cycle assessment (LCA).

Unit 2 - Artificial Intelligence in Life Sciences and Microbiology: AI and machine learning in genomics, proteomics, and metagenomics; Predictive modeling of microbial growth and fermentation outcomes; AI-based drug discovery and precision diagnostics.

Unit 3 - Nanobiotechnology: Advances and applications of nanotechnology; Microbial synthesis of nanoparticles, uses of nanoparticles in agriculture and Medicine; Carbon dot, Toxicity of nanoparticles.

Unit 4 - Neurobiotechnology and the Microbiome-Brain Axis: Gut-brain axis and role of the microbiome in behavior and cognition; Psychobiotics and microbial metabolites in neurodegeneration; Nanoformulations for crossing the blood-brain barrier. Concept of neurobotics.

Unit 5 - Biosensors: Basic components (bioreceptor, transducer, signal processor); Types (enzyme-based, microbial, DNA, immunosensors); surface plasmon resonance, AI based biosensor, Applications in diagnostics, environmental monitoring, food quality, and pharmacology.

BTI 403: Intellectual Property Right, Bioethics, & Entrepreneurship — Course: BTIO553X0 — 25 Marks (T20 + IA5)

Course Objectives (COBs):

- *To impart knowledge of Intellectual Property Rights (IPR), biosafety, biosecurity, and bioethics as applicable to biotechnology research and industry.*
- *To familiarize students with the principles of bio-business, entrepreneurship, and technology management in the biotech sector.*
- *To develop entrepreneurial skills, professional competence, and personality traits necessary for leadership and innovation in biotechnology.*

Course Outcomes (COs):

- *Students will be able to explain the concepts of IPR, biosafety, biosecurity, and bioethics, along with their relevance to microbial biotechnology and society.*
- *Students will gain the ability to analyse and apply strategies in bio-entrepreneurship, technology management, and regulatory compliance.*
- *Students will demonstrate professional, entrepreneurial, and interpersonal skills for career development, teamwork, and effective participation in biotech enterprises.*

Course Content:

Unit 1 – Intellectual Property Rights (IPR): Definition and types of Intellectual Property (patents, trademarks, copyrights, trade secrets, geographical indications); Importance of IPR in microbial biotechnology; Patentability criteria (novelty, inventive step, industrial applicability); Patenting of microbial strains and products; National patent filing process (India/other relevant countries).

Unit 2 - Biosafety and Biosecurity: Definition, scope, and concerns (Indian & global); laboratory biosafety – hazards, risk assessment, BSL-1 to BSL-4; biosafety in plants, animals, and environment; food & feed safety (incl. heavy metals); risk analysis – goals, information, characterization, planning; national & international regulations and agencies (OECD, EPA, RCGM, GEAC, IBSC, FSSAI, BRAI); safe handling of recombinant DNA products in research and industry.

Unit 3 – Bioethics: Principles of bioethics; ethical issues in biological sciences and biotechnology (nature, risk-benefit distribution). Bioethics in healthcare – confidentiality, consent, euthanasia, ART, prenatal diagnosis, genetic screening, gene therapy, transplantation. Ethical considerations in stem cell research, human/animal experimentation, animal rights and welfare. Legal, social, and economic impacts; role of biotechnology in globalization, international relations, and development.

Unit 4 – Bio-Business: Scope of bio-entrepreneurship; pharma and biotech industry dynamics; strategies and operations of biotech firms. Lab-to-market translation, innovation communication, entrepreneurship challenges, and bio-marketing. Support from public and private agencies (MSME, BIRAC, TTB-DST).

Unit 5 – Bio-Management and Technology Management: Contracts and agreements in joint ventures and product development. Business plan preparation – strategy, legal, feasibility, and financial aspects. Collaborations and partnerships in biotech ventures. Technology assessment, development, upgradation, and transfer. Quality control and regulatory compliance (CDSCO, ISO, NBA, GMP, GLP).

Unit 6 – Entrepreneurship, Skill & Personality Development: Entrepreneurship: motivation, approaches, management concepts, organizational behavior, and skill development; Business opportunity identification, market research, financial planning, operations, marketing, sales, and small business management; Institutional support systems; Personality development and team building: recruitment and interview techniques, teamwork, interpersonal skills, leadership, time and resource management, goal setting, stress management, and diversity in organizations.

BTI 405: Grand Viva-voce	Course: BTIC554X9	25 Marks (P25)

Course Objectives (COBs):

- *To evaluate the comprehensive understanding of concepts, techniques, and applications covered across the two-year programme.*
- *To assess the students' ability to integrate theoretical knowledge with experimental/practical skills in microbiology and biotechnology.*
- *To develop confidence in scientific communication, critical reasoning, and problem-solving through expert interaction.*

Course Outcomes (COs):

- *Students will demonstrate holistic knowledge of core and advanced topics in microbiology, biotechnology, and related interdisciplinary fields.*
- *Students will gain the ability to critically analyse, interpret, and apply concepts to real-world biological and industrial challenges.*
- *Students will enhance their oral presentation, defence, and discussion skills before an expert panel, preparing them for research, industry, or higher studies.*

Course Content:

Students will be evaluated on all the topics discussed in the two years programme by a panel of experts.

BTI 406: Project Work	**Course: BTIC555X9**	**100 Marks (P100)**

Course Objectives (COBs):

- *To provide students with hands-on training in independent research methodology, experimental design, and data analysis.*
- *To encourage critical thinking, creativity, and problem-solving in addressing research questions in microbiology/biotechnology.*
- *To develop scientific writing and presentation skills through dissertation preparation and defence before experts.*

Course Outcomes (COs):

- *Able to conduct independent laboratory research, analyse results, and draw meaningful scientific conclusions.*
- *Produce a dissertation report demonstrating clarity, scientific rigor, and adherence to academic standards.*
- *Communicate their research findings through oral presentations and defend them before an expert panel.*

Course Content:

Three months duration research work to be done at any laboratory. The outcome of the work is to be presented during end-term examination with submitting a project dissertation write up duly certified by the host institute or supervisor. A presentation of the accomplishments will be required before a panel of experts. Evaluation will be based on both the project report and presentation.

BTI 407: Research/ Start-up Proposal Design	**Course: BTIC556X9**	**50 Marks (P50)**

Course Objectives (COBs):

- *To familiarize students with the structure, requirements, and standards of national grant proposal formats.*
- *To develop skills in formulating innovative, feasible, and impactful research/start-up ideas.*
- *To train students in professional scientific communication, budgeting, and proposal defence before experts.*

Course Outcomes (COs):

- *Students will be able to design a structured and well-justified research/start-up proposal with clear objectives and methodology.*
- *Students will demonstrate the ability to prepare project timelines, budget plans, and address feasibility.*
- *Students will effectively defend their proposal through critical discussion, demonstrating confidence, clarity, and depth of subject knowledge.*

Course Content:

A grant proposal on any relevant topic in biology will have to be prepared by students following the format of DST/DBT/ICMR, India. The students will also be required to defend the proposal before a panel of experts. Both the written proposal and its defense will be taken into consideration for evaluation.