Syllabus of M.Sc. in Biotechnology at the Institute of Health Sciences, Presidency University

Course Code	Title	T/P/S	Credit	Marks
	SEMESTER I (Total credit: 20; Total mark: 250)			
BITG0701	Biochemistry, Enzymology & Bioenergetics	T	4	50*
BITG0702	Molecular biology & Recombinant DNA technology	T	4	50*
BITG0703	Cell biology & Genetics	T	4	50*
BITG0791	Biosafety & Practical on Biochemistry, Enzymology, Cell biology	P	4	50
BITG0792	Practical on Molecular biology, Recombinant DNA technology, Genetics	P	4	50
	SEMESTER II (Total credit: 20; Total mark: 250)			
BITG0801	Immunology and disease biology	T	4	50*
BITG0802	Microbiology & Analytical techniques	T	4	50*
BITG0803	Bioinformatics & Genomics and Proteomics	T	4	50*
BITG0891	Practical on Microbiology & Bioinformatics and Genomics	P	4	50
BITG0892	Practical on Immunology, & Analytical techniques	P	4	50
	SEMESTER III (Total credit: 20; Total mark: 250)			
BITG0901	Plant biotechnology & Environmental Biotechnology	T	4	50*
BITG0902	Emerging technologies	T	4	50*
BITG0903	Bioprocess engineering and technology	T	4	50*
BITG0991	Practical on Plant & Environmental Biotechnology	P	4	50
BITG0992	Practical on Bioprocess engineering and technology & Emerging technologies	P	4	50
	SEMESTER IV (Total credit: 20; Total mark: 250)			
BITG1001	Biostatistics & Bioethics and Intellectual Property Right	T	4	50*
BITG1091	Dissertation: Scientific writing and presentation	S	4	50
BITG1092	Dissertation: Journal presentation and group discussion	S	4	50
BITG1093	Dissertation: Thesis writing and defense	S	4	50
BITG1094	Dissertation: Innovation, Design and Entrepreneurship Alliance (IDEA) & Grand Viva	S	4	50
	Total credit and marks:		**80**	**1000**

Theory (T): Credit-4, Contact hour per week-4 h; Practical (P)/Sessional (S): Credit-4, Contact hour per week-8 h

*50 marks of theory paper are distributed as 35 marks for End semester exam and 15 marks for continuous assessment

Aims and Objectives:

The aims of this program are to build upon the basic undergraduate level knowledge of biochemical and biological processes, function of biomolecules, and various organisms from viruses and bacteria to plant and mammalian cells. Emphasis will be given to the molecular details of these processes in normal and diseased conditions. This program will provide better understanding of the pathways of pathogenesis of various organisms, recent technological advances to study these processes and to understand how to utilize the acquired knowledge for biotechnological advancement and to develop novel strategies for biomedical interventions in various diseases and disorders.

Program Outcomes (PO):

PO1: Fundamental knowledge and critical thinking-

Students should gain thorough knowledge on various aspects of biology and biotechnology, and the molecular basis of numerous physiological processes in various organisms.

PO2: Critical thinking and research aptitude-

Students should identify the scientific problem and are able to apply different biotechnological strategies and techniques to examine the problem, and to interpret results.

PO3: Effective Communication-

Students should be able to analyze, and write scientific literature, can communicate clearly in person and through electronic media in English and can connect with people to share their ideas and technology. If required, students should be able to communicate in any other language he/she feels comfortable with others.

PO4: Ethics-

Students can recognize different intellectual properties rights (IPR) and ethical issues related to biotechnological processes and products.

PO5: Social Interaction-

Elicit views of others, mediate disagreements and help reach conclusions in group settings.

PO6: Environment and Sustainability-

Students can be able to understand the issues related to biosafety, environmental biotechnology, and sustainable development.

Program Specific Outcomes (PSO):

PSO-1: Understand the basic concepts of different aspects in Biochemistry, Molecular and Cell Biology, Microbiology, Immunology, Biophysics, Biostatistics and Bioinformatics to appreciate diverse physiological processes in various life forms.

PSO-2: Learn different techniques and strategies pertaining to diverse field of biotechnology at theoretical and practical level, such as Recombinant DNA technology, Plant biotechnology, Environmental biotechnology, Enzyme technology, Nanotechnology, Fermentation, Tissue engineering, Genomics and Proteomics, and Synthetic Chemistry.

PSO-3: Gain experience of understanding and executing short-term research projects in related fields.

PSO-4: Learn various biosafety and other safety measures to conduct experiments in the lab or in fields.

PSO-5: Learn ethical conducts in academics, and in biotechnology research, both in the academic and industry set up, intellectual property rights and other etiquettes related to biotechnology for holistic

development of critical mind and attitude for basic and translational research, and entrepreneurship.

Teaching-learning process

Teachers with expertise in a certain field will teach that module by having a proper idea of the curriculum, assessing learning needs, and establishing specific learning objectives. Teachers will be in continuous interaction with the students so that the various teaching and learning strategies can be implemented, while maintaining the students' motivation and curiosity about the subjects. Special care will be taken for underperforming students to make them feel confident about the subject.

Mode of assessment

Teaching will include lectures (online or offline), hands-on training, laboratory dissertation and industrial visit. Evaluations will be in two parts- internal assessment and final assessment/examination. Both time-bound written and oral examinations will be held. The presentations and interaction during presentations will be evaluated in an objective manner. Quizzes and group discussion will be conducted for continuous assessment. Regular performance for the laboratory courses will also be assessed in an objective manner.

SEMESTER I

BITG0701

A. Biochemistry **32 h**

Unit I: Chemical basis of life

Enthalpy, entropy and free energy; Spontaneity and equilibrium; Colloids, Micelle; Phase diagram of water, buffers and pH, ionic strength, maintenance of blood pH; Ionic and covalent bonds, Van der Waals forces, hydrogen bonds; Polarity and dipole moment; Hydrophobicity; Principles of absorption spectroscopy- Beer-Lambert's law; Chemical kinetics- order, rates and rate constant, Arrhenius equation Molecular conformations; Basic stereochemistry and its importance in biotechnology

Unit II: Biomolecules and their function

Composition, function and metabolism of carbohydrates and lipids; Vitamins and cofactors in metabolism, their deficiencies and associated disorders

Unit III: Structure and function of nucleic acids, and proteins

Structure and function of nucleic acids, difference in RNA and DNA structure; A, B and Z-DNA,
Structure of amino acids and peptides - Ramachandran plot, secondary and tertiary structures

B. Enzymology **16 h**

Enzyme kinetics and enzyme technology

Structure, classification and general properties of enzymes; Active site and specificity of enzyme; Enzyme substrate complex, induced fit theory.

Enzyme kinetics and inhibition, Factors affecting enzyme activity. Abzymes and Isozymes; Overview of protein-ligand interaction

Mechanism of enzyme inhibition- competitive, non-competitive, allosteric and irreversible inhibition; Hill equation. Enzyme regulation- allosteric regulation, covalent modification, zymogen activation.

Enzymes as therapeutic agents.

C. Bioenergetics **16 h**

Transport across membrane, ABC transporter, phosphotransferase system, drug export systems, amino acid transport.

Respiration- glycolysis, fermentation, Krebs cycle, gluconeogenesis, electron transport system; ATP synthesis. Photorespiration in bacteria and plants

Course Outcome (CO):

On completion of this course students should be able to-

- Gain fundamental knowledge in biochemical processes, biomolecules, enzymes and cellular bioenergetics that are essential to understand any biological process, and the molecular basis of various pathological conditions from a biochemical perspective.
- Gain critical thinking abilities in various aspects of chemistry, biochemistry, and bioenergetics.

- Gain analytical skills to determine various chemical parameters (such as pH, reaction rate, entropy, enthalpy, Km, Vmax etc) of different biochemical processes or cellular bioenergetics that are occurring in vivo or in vitro.

BITG0702

A. Molecular Biology **32 h**

Unit I: Chromatin structure and modifications

Chromatin organization- histone and DNA interactome; Structure and assembly of prokaryotic and eukaryotic DNA polymerases; DNA-replication, repair and recombination.

Unit II: RNA and Transcriptional control

Transcriptional initiation, elongation and termination; Structure and assembly of prokaryotic and eukaryotic RNA Polymerases; Post-transcriptional control; miRNAs and siRNAs; Structure and folds in RNA molecules- tRNA and microRNA; riboswitch and ribozymes; RNA transport, localization and function.

Unit III: Translational controls

Genetic code and its properties; Wobble hypothesis; prokaryotic and eukaryotic protein synthesis- initiation, elongation, termination; co- and post-translational modifications (acetylation, glycosylation, ubiquitination); Protein Folding and protein degradation, Protein trafficking and transport.

Unit IV: Control of gene expression at transcription and translation level

Regulation of gene expression in viruses, prokaryotic and eukaryotic genes, chromatin remodeling and gene silencing; Epigenetic regulation.

B. Recombinant DNA technology **32 h**

Unit I: Recombinant DNA technology

Restriction endonucleases, restriction mapping, DNA and RNA modifying enzymes (viz. polymerase, reverse transcriptase, ligase, alkaline phosphatases, terminal transferase, nuclease) Vectors (viz. Plasmid, Cosmid, Fosmid, Phagemid, BAC, YAC, PAC, HAC, and shuttle vectors).

Cloning methods (directional and gateway), introducing engineered plasmids into a bacterial cell - transformation, conjugation, and transduction; Identification and analysis of recombinant DNA clones.

Expression vectors – bacterial, yeast, insect, mammalian and plant expression systems; Yeast two-hybrid systems; Phage display

Construction of cDNA and genomic DNA libraries; use of transposon in genetic analysis; Genetic manipulation of microorganisms and strain improvement – Knock-down and knock-in system.

Unit II: Techniques in genetic engineering

PCR- designing primers; Different types of PCR- Allele Specific, Assembly, Asymmetric, Colony, Helicase dependent, Hot-start, Inverse, Methylation specific, multiplex, nested, Quantitative/Real-Time, RT-PCR, touchdown, touch up, VNTR etc. 5'-/3'-RACE, site-directed mutagenesis

Application of PCR in molecular diagnostics.

Methods of nucleic acid detection, Denaturing gradient gel electrophoresis (DGGE), DNA-protein interaction study - EMSA, DNA foot-printing; S1 nuclease mapping, RNase protection assay
Strategies of gene delivery - chemical, physical or mechanical method), Lentiviral/retroviral vectors and their usage in gene manipulation and delivery. Genome editing tools – CRISPR/Cas9, TALENs, ZFNs
Techniques in gene expression analyses - Reporter gene, Northern blot, Fluorescent in situ hybridization, Reverse transcription PCR, SAGE, DNA microarray, Tiling array, RNA-Sequencing

Course Outcome (CO):

On completion of this course, students should be able to-

- Understand the detailed molecular mechanisms of central dogma of life, details of nucleic acids and nucleosomes, molecular regulation of gene expression at genetic and epigenetic levels at normal physiological conditions and how it differs under stressful or pathological conditions.
- Gain critical thinking ability to understand different strategies of recombinant DNA technology (RDT) starting from restriction mapping of DNA to the most recent genome editing techniques, and genetic engineering in human health
- Develop analytical skills to apply those continuously evolving RDT strategies (such as PCR, real-time PCR, gene sequencing etc) in molecular biology, biotechnology or diagnostic laboratories.

BITG0703

A. Cell Biology **32 h**

Unit I: Cellular organization and cytoskeleton

Cellular organelles, cell wall, extracellular matrix; Prokaryotic cells and components; Structure of cell membrane, Cell-cell and Cell-matrix interaction; Cytoskeleton and motor proteins; Microscopic techniques to visualize cells and organelles

Unit II: Cell Cycle and Cellular activities

Mitosis and meiosis and their regulation; Cell cycle and its regulation, checkpoints, aneuploidy; Apoptosis, Necrosis and Autophagy; Proliferation and differentiation

Unit III: Cell signaling and communication

Signaling molecules; Receptors- G-protein coupled receptor, Receptor Tyrosine Kinase (RTK), cytokine receptors; Pathways of intracellular signal transduction; Regulation of hematopoiesis

B. Genetics **32 h**

Unit I: Microbial genetics

Plasmids - types, replication, partitioning, copy-number control
Methods of gene transfer in bacteria-transformation, conjugation and transduction, mapping genes using these methods; Bacterial recombination- homologous, site-specific and transpositional
Phage genetics- lytic and lysogenic cycles of bacteriophage; Virulent and temperate phage, prophage
Study of plaque morphology, mapping of phage chromosome by phage crosses.

Unit II: Yeast genetics

Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.

Unit III: Human genetics

Human genetics - pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders, DNA polymorphism in mapping; structure and function; polygenic inheritance.

Population genetics- genetic drift, neutral evolution; Fishers theorem, Hardy-Weinberg equilibrium, linkage disequilibrium; in-breeding depression; population bottlenecks, Bayesian statistics; spatial variation & genetic fitness. Quantitative genetics - complex traits, mapping QTLs

Course Outcome (CO):

On completion of this course, students should be able to-

- Gain the fundamental and comparative knowledge of cellular components, and biological processes of a cell of prokaryotic and eukaryotic origin, control of cellular growth and various signaling processes of prokaryotic and eukaryotic cells. Students should also understand the principles of genetics, and phylogenetic and evolutionary conservation/divergence.
- Gain critical thinking ability to analyze various cell biological processes and signaling, the relationship between phenotype and genotype in humans, and genetic traits and mapping
- Develop analytical skills to utilize the principles of cell cycle pathways, or the microbial and higher eukaryotic genetics in various biotechnological interventions.

BITG0791

Biosafety and Practical on Biochemistry, Enzymology, Cell biology **128 h**

Unit-1: Principles and demonstration of Biosafety

Chemical and biohazard safety; Safety measurement for radioactive material; Social responsibility and Whistleblowing

- Demonstration of biosafety and chemical safety, Use of PPE

Unit-2: Practical on Biochemistry, Enzymology, Cell biology

1. Aseptic techniques in biotechnology- a) Preparation of bacterial growth medium and autoclaving and b) Preparation of buffer and sterile filtration
2. Determination of unknown protein concentration by absorption spectroscopy
3. Extraction of cellular protein, and quantitation using Bradford method
4. Quantitative analysis of amino acids, nucleic acids (DNA and RNA), carbohydrates and lipids
5. Separation of circular and linear DNA by agarose gel electrophoresis
6. Determination of pH optima, Km, Vmax and Kcat of an enzyme (viz. alkaline phosphatase)

7. Determination of cell number (mammalian cells) by hemocytometer
8. Microscopic observation of subcellular structures/organelles

Course Outcome (CO):

On completion of this course, students should be able to-

- Familiarize with various lab safety protocols, basic laboratory instruments, their care and usage protocols, and measurement of the necessary parameters.
- Utilize the basic knowledge in carefully and analytically conduct different experiments of biochemistry and cell biology.

BITG0792

Practical on Molecular biology, Recombinant DNA technology, Genetics **128 h**

1. Preparation of competent *E. coli* cells
2. Transformation of competent *E. coli* cells with a plasmid to determine transformation efficiency
3. Plasmid isolation and restriction digestion – mapping
4. Gene cloning and recombinant screening
5. Genomic DNA extraction from mammalian cells
6. Primer designing using web-based tools for gene cloning and real-time PCR detection
7. Nested PCR
8. RNA and cDNA preparation - Reverse Transcriptase PCR and Real-Time PCR (qPCR)
9. Molecular marker detection – RFLP
10. Concept of lac-operon: a) Lactose induction of b-galactosidase, b) Glucose Repression

Course Outcome (CO):

On completion of this course, students should be able to-

- Familiarize with laboratory instruments used to analyze macromolecules such as DNA and RNA
- Carefully and critically conduct different experiments utilizing various RDT techniques and concept of genetics to analyze those macromolecules.

SEMESTER II

BITG0801

Immunology and disease biology **64 h**

Unit I: Introduction to Cellular and molecular immunology

Fundamental concepts of the immune system: Innate immune response, adaptive immune response, B and T cell activation, complement pathway; Major Histocompatibility Complex- MHC genes, MHC and immune responsiveness and disease susceptibility, Vaccine and Vaccine technology

Unit II: Immunodiagnostic techniques

Introduction to antigen-antibody reaction; In vitro diagnostic assays- precipitation, agglutination hemagglutination, RIA, ELISA and its specific applications; Immunophenotyping by Flow cytometry; Development of immunodiagnostic kits. Cytogenetics techniques

Unit III: Host pathogen interaction

Mechanism of microbial pathogenesis (bacteria, virus, yeast, parasites), genetics of pathogenicity and virulence. Alteration of host cell behavior by pathogens, pathogen-induced diseases: bacterial (Tuberculosis, *Helicobactor*, *Salmonella, Vibrio cholerae*), Viral (Hepatitis, HIV, Ebola, Zika, Influenza and coronavirus). Hospital-acquired infections; Pathogenic fungi; Pathogenicity of parasites (*Entamoeba, Naegleria, Leishmania, Trypanosoma, Plasmodium*), mode of action, virulence.

Unit IV: Host-Microbiome Interaction

Microbial communities in the human body, role of Microbiota in human health; Microbial interactions with the host immune system; gut-brain axis; microbial diversity analysis; potential for microbiome-directed therapeutics to impact human disease.

Unit V: Cancer biology and immunotherapies in cancer

Cell transformation and cancer, proto-oncogene, oncogene, virus induced cancer, tumor suppressor genes; Metastasis, therapeutic interventions in human cancers

Unit VI: Hypersensitivity, inflammation and transplantation immunology

Type I (Allergy), Type II (antibody mediated) and Type III (immune complex mediated) and Type IV (delayed type) hypersensitivity reaction, chronic inflammation, autoimmunity, transplantation immunology

Course Outcome (CO):

On completion of this course students should be able to-

- Gain fundamental knowledge of immunology and immune responses during everyday life due to various pathological conditions, and the importance of host-pathogen interactions in diseases.
- Gain critical thinking ability in applying the knowledge in immunology and disease biology
- Develop analytical skills to understand designing of experiments to determine various immune responses, and strategies of immunodiagnostics.

BITG0802

A. Microbiology **48 h**

Unit I: Microbes and their general characteristics

Origin of life: Miller–Urey experiment; Evolution of prokaryotes and eukaryotes, Endosymbiotic theory, Prokaryotic diversity and taxonomy. Culture dependent and independent approach; Polyphasic taxonomy, species concept.

Morphology and ultra-structure of Bacteria, cellular component, flagella, pili, fimbriae, extracellular layers, cell wall, cell membrane, plasmids and episomes, endospore, cysts, bacterial chromosome, inclusion bodies and pigment; Growth kinetics and bacteria cultivation: Aerobic and anaerobic cultures, different phases of growth. Batch, continuous and synchronous culture,

Chemotaxis (signal transduction in microbes), quorum sensing, biofilm formation, Phototaxis, magnetotaxis.

Extremophiles, Archaeal diversity, and characters; Virus- Classification, capsid, envelope and genetic material; General characteristics and importance of protozoa, algae, fungi

Unit II: Control of Microorganisms

Methods of sterilization, disinfection, antimicrobial agent (antiseptics, sanitizer, germicide)

Chemical control- dye solutions, alcohol, acid, alkali, halogen, heavy metal, phenol, phenol derivatives, formaldehyde, ethylene oxide, detergents. Assessment of chemical disinfectant, chemotherapeutic agents- sulphonamides

Antibiotics; Multidrug resistance in microbes, mechanism of action and antimicrobial spectrum

Food preservation: temperature, irradiation, drying, cannying, control of water activity, chemicals (organic acids, food additives - class I and II), combination of methods (Hurdle concept), Biopreservation

Unit III: Food Microbiology

Foodborne Infections (sources, transmission, and control) by bacteria- *Clostridium*, *Escherichia*, *Listeria*.

Foodborne Intoxication (sources, transmission, and control) - Botulism, Staphylococcal, Mycotoxins

Uses of Microbes in Food- Importance of fermented foods; Microbial stress response in food, starter cultures, microbiology of fermented foods; Probiotics, prebiotics and synbiotics, nutraceuticals (Cr/Se yeast), functional foods, Single-cell proteins (SCP)

Microbial Detection and Food Safety - Conventional Methods, sampling for microbial analysis, qualitative methods of microbial detection and its quantitation, biosensors, controlling the microbiological quality of food, quality and criteria, sampling schemes

B. Analytical techniques **16 h**

Principle of centrifugation, different types of centrifuges, Ultracentrifugation; Differential & density gradient centrifugation; Separation and analysis of proteins; Filtration and Dialysis

Principles of protein purification, Various chromatography techniques- Size exclusion chromatography, Ion exchange chromatography, Affinity chromatography

HPLC, FPLC, Gas chromatography

Course Outcome (CO):

On completion of this course students should be able to-

- Gain vivid knowledge of microorganisms to identify and characterize their major categories based on structural, physiological, and genetic similarities and diversity. Students should also identify and analytically demonstrate how to control microbial growth, interactions between microbes, hosts and environment, and food safety.
- Gain critical thinking ability to understand the principles and strategies of various analytical techniques that are used in most biotechnology laboratories and industries
- Develop analytical skills to utilize microbial physiology and growth, and the various analytical techniques in advancing biotechnological processes.

BITG0803

A. Bioinformatics **32 h**

Unit I: Introduction to Bioinformatics

Scope and applications of bioinformatics, global bioinformatics scenario, definition of terms- orthology, paralogy, xenology and analogy; Similarity and identity

Introduction to databases- types of databases, information retrieval system (Entrez and SRS) and database collaboration, file formats, sequence, structure and pathway databases of nucleotides and proteins

Unit II: Application of bioinformatics

Multiple Sequence Alignment, progressive method, iterative method; data searching tools for homologous sequences analysis - BLAST & FASTA; Sequence editors - BioEdit, BoxShade

Prediction tools- profile, motifs, domains and feature identification

Phylogenetic prediction: Phylogenetic tree construction-distance based method and character-based methods; Prediction of genes and proteins (structure & functions), Phylogenetic analysis package – MEGA

Unit III: Protein modeling

Protein structure prediction: protein folding and model generation; secondary structure prediction; Homology modeling: potential applications; Protein function prediction

B. Genomics and Proteomics **32 h**

Unit I: Genomics

Concept of Genomics, Genome mapping – Genetic and physical mapping, Genetic markers; methods and techniques used for gene mapping, molecular/genetic markers in genome analysis – RFLP, AFLP, RAPD, VNTR, Microsatellite polymorphism, SSR, SNP; molecular markers linked to disease resistant genes Application of molecular markers in forensic, disease prognosis, genetic counseling and pedigree analyses; linkage analysis, cytogenetic techniques, Fluorescent In Situ Hybridization in gene mapping, somatic cell hybridization, and radiation hybrid maps

DNA-Sequencing – Maxam Gilbert and Sanger Dideoxy methods, Automated sequencing; Genome sequencing projects for microbes, plants and animals; Human Genome Project (HGP), Next-generation sequencing – Roche/454 pyrosequencing, Illumina (Solexa), SOLiD, Ion Torrent; Application of Next-Gen

Sequencing technologies – Whole genome, Exome, 16S rRNA amplicon, RNA-Seq, ChIP-Seq, Methyl specific sequencing etc.
Functional genomics, Application of genomics, Epigenomics, Proteogenomics, Structural genomics, Metagenomics, Comparative genomics, Personal Genomics, Pharmacogenomics/pharmacogenetics, Pharmacodynamics.

Unit II: Proteomics

Concept of Proteomics; Sample preparation, Gel-based proteomics - isoelectric focusing and two-dimensional gel electrophoresis (2-DGE), two-dimensional fluorescence difference in-gel electrophoresis (DIGE), mass spectrometry – different types of mass spectrometers (MALDI-TOF Q-TOF, LC-MS), protein and peptide sequencing; Multidimensional proteomics: SELDI-TOF. Quantitative proteomics - stable isotope labelling by amino acids in cell culture (SILAC), isotope-coded affinity tag (ICAT), isobaric tagging for relative and absolute quantitation (iTRAQ); Label-free proteomics.

Course Outcome (CO):

On completion of this course students should be able to-

- Comprehend the basic theory of various bioinformatics principles, algorithms, and computational tools to analyze sequences of DNA/RNA/proteins and related databases. Students should also acquire knowledge and understanding of fundamentals of genomics and proteomics, and their applications in various applied areas of biotechnology.
- Develop critical thinking ability in utilizing the diverse bioinformatics tools in predicting protein structure, and molecular markers for various prognostic and diagnostic applications.
- Gain the skills to analyze big data (viz. genome mapping and sequencing) of healthy and pathological conditions, and to develop novel computational strategies for such application.

BITG0891

Practical on Microbiology & Bioinformatics and Genomics **128 h**

1. Isolation of bacteria from environmental samples (sample collection, serial dilution, media preparation, enrichment culture, spread plate and pour plate, CFU count, pure culture preparation, staining and biochemical tests)
2. Microbiological assay of antibiotics (MIC and Paper disc)
3. Bacterial culture preservation (-80°C glycerol stock) & revival
4. Detection and enumeration of indicator and index microorganisms for food borne pathogens (total enterobacteria, total coliform & aerobic spore former)
5. Identification of spoilage causing bacteria and fungi of food samples – fruits, vegetables, bread
6. Isolation of lactic acid producing bacteria and production of fermented milk products/Sauerkraut
7. Isolation and purification of amylase enzyme
8. Preparation of spawn for mushroom cultivation
9. BLAST based logical searches, Sequence alignment and deductions (computational)
1. Phylogenetic tree construction (computational)

2. DNA sequencing analyses (computational)
3. 16S rRNA amplicon based Next Generation Sequencing analyses (Computational)

Course Outcome (CO):

On completion of this course, students should be able to-

- Conduct simple microbiological experiments and analyze data obtained from complex processes
- Design and conduct computational assays using learnt tools
- Critically analyze genomics and proteomics dataset

BITG0892

Practical on Immunology & Analytical techniques **128 h**

4. Isolation and purification of IgG from serum
5. Precipitation reaction by double immunodiffusion (Ouchterlony method) and radial immunodiffusion (Mancini's method)
6. Detection of antigens or antibodies by ELISA – Indirect and Sandwitch ELISA
7. Blood typing – A, B, AB and O
8. Immunoblotting assay for protein detection
9. Immunoprecipitation assay
10. Separation of cellular proteins on SDS-PAGE
11. Ammonium sulphate precipitation of a protein and dialysis
12. Purification of a recombinant protein by affinity chromatography

Course Outcome (CO):

On completion of this course, students should be able to-

- Familiarize with laboratory instruments and techniques used to perform various immunological and immunodiagnostic studies
- Students should be able to conduct analytical experiments using various instruments

SEMESTER III

BITG0901

A. Plant biotechnology **32 h**

Unit I: Micropropagation, organogenesis and cell culture systems

Media for in vitro culture, selection of suitable media, plant growth regulators. Concept of totipotency; Callus culture; initiation and maintenance of callus, micropropagation, direct and indirect morphogenesis, somatic embryogenesis and synthetic seed production; haploid, doubled haploid and triploid culture; Culture systems, Isolation of single and aggregate of cells and regeneration of plants; Protoplast culture-Isolation of protoplast, culture of protoplast, and their regeneration into plants.

Unit II: Plant genetic transformation

Prerequisites for transgenic plant production; Vectors: types of vectors used in higher plants; Tumor-inducing (Ti) plasmids, binary and cointegrate vectors; Plant selection markers, reporter genes (GFP, luciferase, GUS); Agrobacterium-mediated transformation, pollen-mediated gene transfer.

Physical delivery methods: particle bombardment and microinjection. Chemical mediated DNA delivery; electroporation, liposome, and ultrasonication mediated methods, analysis of transgenics.

Unit III: Genetic engineering for biotic and abiotic stress tolerance

Resistance to biotic stresses (insect, viral, fungal and bacterial resistance etc.); Herbicide resistance in transgenic plants. Resistance against abiotic stresses (drought, salinity, heavy metal etc.), enhancement of phytoremediation properties in transgenic plants and wasteland utilization. Genetic engineering for enhancing photosynthetic efficiency; Nutrient uptake efficiency improvement; Improvement of seed and fruit quality

Unit IV: Molecular farming

Transgenic plants with recombinant protein in plant root exudates; value-added special crops. Edible vaccines, plantibodies, production of glucocerebrosidase and hirudin

B. Environmental Biotechnology **32 h**

Unit I: Introduction to environment and Environmental Problems

Concept of ecology and ecosystem, environmental problems - ozone depletion, pesticides, greenhouse effect, water, air and soil pollution, radioactive pollution

Response of microbes, plant and animals to environmental stresses.

Unit-II: Environmental Toxicology

Sources of environmental toxicity and its impact on human health: Heavy metals toxicity, pesticides in water, endocrine disruptors; Biochemical aspects of arsenic; Environmental carcinogenicity

Bioaccumulation and biomagnification, mode of entry of toxic substances, xenobiotic detoxification and biotransformation

Concept of LADME, LD50, IC50. Bioassays for determination of environmental toxicants

Unit III: Biotechnology for remediation of polluted habitats

Bioremediation- process and organisms involved; Constraints and priorities of bioremediation. Bioaugmentation; ex-situ and in-situ processes; intrinsic and engineered bioremediation.

Major pollutants and associated risks; organic pollutant degradation- microbial aspects and metabolic aspects- factors affecting the process and recent developments; Phytoremediation.

Genetically engineered microorganisms in biotreatment of wastes-hydrocarbons and oil spills; Microbiologically enhanced oil recovery (MEOR)

Unit-IV: Biotechnology in Waste Management and Recent Advances

Indicator organisms in water pollution; Biotechnological methods for pollution detection, biosensors.

Sewage and wastewater treatment: Primary, secondary and tertiary treatment, sludge treatment and disposal.

Composting of solid wastes, aerobic & anaerobic digestion: methane production, pros and cons of anaerobic process, Energy generation from waste.

Course Outcome (CO):

On completion of this course students should be able to-

- Gain fundamental knowledge and strategies of plant and environmental biotechnology that includes various plant cell and tissue culture techniques, micropropagation, genetic engineering for crop improvement, and transgenic plant based molecular farming
- Critically analyze various environmental problems such as air, water and soil pollution, ozone depletion, and numerous toxicological impacts on environment and human health
- Gain analytical skills to examine various biotechnological remedial interventions against different types of pollutants, and strategies of waste management

BITG0902

Emerging technologies **64 h**

Unit I: Optical microscopy methods

Basic Microscopy: Light microscopy- lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast (DIC)

Fluorescence microscopy: Optical arrangement, light source; filter sets: excitation filter, dichroic mirror, and barrier, optical layout for image capture

Advanced Microscopy: Confocal microscope-principle, resolution and point spread function, light source: gas lasers & solid-state, detectors; Deconvolution

Unit II: Biophysical techniques

Protein folding- pathways of protein folding, diseases associated with protein folding

Analyzing protein structure and function- Fluorescence spectroscopy, FRET, Fluorescence anisotropy; Isothermal calorimetry; Circular Dichroism (CD) and Optical Rotatory Dispersion (ORD)

Principles of NMR, X-ray crystallography and Cryo-Electron Microscopy in structure determination

Unit III: Nanobiotechnology

Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and its applications; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.

Bio-inspired nanomaterials for a new generation of medicine. Nanomaterial for drug delivery, Concepts of smart stimuli responsive nanoparticles.

Unit IV: Basic Principles of Drug Discovery, Development, and Nanotheranostics

Identification of druggable target; Lead optimization and bioanalytical assay development in support of *in vitro* and *in vivo* studies; Absorption, Distribution, Metabolism, and Excretion (ADME) principle, Pharmacodynamics and Pharmacokinetics (PD/PK); Regulatory approval of drugs; Design considerations in the development of Nanodrugs: Optimization of nanoparticle properties for suitability of administration through various routes of delivery; Targeting strategies for nanoparticles: Principles of Passive and Active Targeting. Nanotoxicity; Importance of imaging in drug discovery; Theranostic nanoparticles and their implication in cancer management.

Unit V: Tissue engineering

Tissue engineering, biomaterials, evolution of biomaterials; type of biomaterials; medical textiles, hydrogels, decellularization of tissues and their use as scaffolds; additive manufacturing techniques - fused deposition modeling, selective layer sintering, bioprinting, application of 3D printing in tissue engineering; characterization of scaffolds; protein adsorption on scaffolds, stem cell behavior on scaffolds - adhesion, proliferation and differentiation; In vivo response to biomaterials, Tissue engineered products in market.

Course Outcome (CO):

On completion of this course students should be able to-

- Understand the principles of various emerging techniques on advanced microscopy, biophysics, nanotechnology, drug development, and the use of biomaterials in tissue engineering
- Gain critical thinking abilities about the application of nanotechnology in health, agriculture, and environmental conservation, and developing in vivo tissue engineering strategies
- Gain the skills to analyze complex processes involving advanced spectrometric methods such as fluorescence, circular dichroism, FT-IR, NMR, Cryo-EM

BITG0903

Bioprocess engineering and technology **64 h**

Unit I: Preparation and optimization of medium

Selection of medium composition, concept and methods of sterilization, microbial growth parameters and environmental factors, kinetics of batch and fed batch fermentation, environmental conditions. Synchronous culture, chemostat and turbidostat

Unit II: General concepts and application of fermentation

Fermentation- general concepts, applications, and structure of a fermenter; Range of fermentation process- microbial biomass, enzymes, metabolites, recombinant products, transformation process; Components of fermentation process. Types of fermentations- aerobic and anaerobic fermentation, submerged and solid-state fermentation, factors affecting submerged and solid-state fermentation, substrates used in solid-state fermentation and its advantages; Culture media- types, components, and formulations.

Sterilization: Batch and continuous sterilization. Bioreactors, membrane Bioreactors. Isolation, preservation, and maintenance of industrial microorganisms, kinetics of microbial growth and death, Monod model, sterilization of media for fermentation, air quality management and air sterilization. Measurement and control of fermentation parameters - pH, temperature, O_2

Unit III: Process development and optimization

Process development, Optimization- classical and statistical methods of optimization; Immobilization- different matrices, whole cell, and enzyme immobilization; Scale up of bioprocess, Analysis of batch, stability of microbial reactors, analysis of mixed microbial populations, specialized bioreactors (pulsed fluidized, photobioreactors).

Unit IV: Production of Microbial Biomass

Production of ethanol, citric acid; amino acids, wine, beer, vitamins; microbial enzymes Baker's yeast, mushroom. Production of biopesticides and biofertilizers: Microbial inoculants- Selection and establishment of nitrogen-fixing bacteria. Production of *Rhizobium, Azotobacter*, *Azospirilla*, *Azolla*, cyanobacteria and other nitrogen-fixing bacterial cultures. Quality control of bio inoculants; Phosphate solubilizing bacteria; mycorrhiza; plant growth promoting rhizobacteria (PGPR); Composting and bio-composting, biocontrol microbial inoculants.

Unit V: Necessity of Downstream Processing

Overview of a bioprocess including upstream and downstream processing; Importance of downstream. Processing in biotechnology, characteristics of biological molecules and their separation characteristics based on stability; other biological properties, problems and requirements of bioproduct purification; Characteristics of biological mixtures; Downstream process economics.

Unit VI: Biomass Removal and Cell Disruption

Physico-chemical basis of bio-separation processes. Removal of particulate matter; biomass insoluble; flocculation and sedimentation, Cell disruption- mechanical, enzymatic, and chemical methods.

Course Outcome (CO):

On completion of this course students should be able to-

- Learn and appreciate the relevance of microorganisms from industrial context, and the fundamental principles for basic methods in production technique for bio-based products.
- Critically analyze a biological production process, calculate yield and production rates of the same and interpret data obtained from various similar processes.

- Develop analytical skills to design and operate fermenters for important microbial/enzymatic industrial processes in food and fuel industry, and analyze any bioprocess from market point of view to develop improved strategies

BITG0991

Practical on Plant & Environmental biotechnology **128 h**

1. Regeneration of tobacco plants via tissue culture method.
2. Preparation of competent cells of Agrobacterium spp. and transformation with suitable vector
3. Transformation of tobacco plants by following leaf disc method
4. Confirmation of transgene integration in the transgenic tobacco plant genome by PCR and gus staining assay
5. Cytotoxicity assay of H2O2 treated mammalian cell line through MTT
6. Single gel electrophoresis to determine DNA damage in mammalian cell line exposed to arsenic toxicity using a Comet Assay kit
7. Characterization of cellulose/ pectin decomposition, starch hydrolyzing microorganisms from environmental samples
8. Enrichment of N_2-fixing bacteria and assessment of its secreted ammonia with Nessler's reagent.

Course Outcome (CO):

On completion of this course students should be able to-

- Gather hands on knowledge on various methods of Plant tissue culture based micropropagation, cell-based assays to determine environmental stress and toxicity.
- Use microbiological methods for enrichment of symbiotic microbes and analysis of product generation.

BITG0992

Practical on Bioprocess engineering & Emerging technologies **128 h**

1. Laboratory fermenter sterilization, operations and scale up of selected strain.
2. Green synthesis of nanoparticles
3. Synthesis of superparamagnetic iron oxide nanoparticles (SPION)
4. Fluorescence spectroscopy experiment (microtitre plate based)
5. Cell culture on scaffolds - cell seeding and analysis
6. Imaging bacteria and parasite cells
7. Acquisition and analysis of fluorescent-labeled mammalian cell images

Course Outcome (CO):

On completion of this course students should be able to-

- Perform and analyze bioprocess development using principles of fermentation
- Design, conduct and analyze various biophysical, and nanotechnology-based studies
- Familiarize various sophisticated instruments and its running protocols
- Analyze data from complex experiments related to tissue engineering and drug design

SEMESTER IV

BITG1001

A. Biostatistics **32 h**

Unit I: Basics of Biostatistics

Principles and practice of statistical methods in biology; samples and populations; Data collection and graphical representation

Measures of central tendency- mean, median, mode; Measures of dispersion- range, mean deviation, coefficient of variation; standard deviation, standard error.

Unit II: Application of Biostatistics

Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, calculation of Karl-Pearson's coefficient of correlation; analysis of variance, factorial experiment design; Use of biostatistics software.

B. Bioethics and Intellectual Property Rights **32 h**

Unit I: Bioethics

Overview of research misconduct, rules and regulations in India; data management; privacy policies, institutional and professional code of ethics and standards of practice

Ethical use of bioresources- agricultural ethics and transgenic crops, animal subjects; Protection of human subjects; stem cell ethics; eco sourcing-code of practice

Mentor-mentee responsibilities; Collaboration, Bias, Conflicts of Interest; Publication- plagiarism

Cyber Security Awareness; understanding phishing attacks, malware, antivirus software.

Unit II: Intellectual Property Right (IPR)

Concept and provisions of IPR; Patents, Trademarks, Copyright, Conditional information, Breeder's right. Patent-types, scope, criteria, applying for a patent. Protection of Biotechnological inventions.

Unit III: Quality, Ethical and Legal Implications

International standards, Quality accreditation and certification – NABH standards

Quality checks - quality assurance samples, master sample, internal controls, techniques and concepts of statistical quality control and statistical process control; Operational aspects – calibration, accuracy checks of quality control; FDA and EPA regulations for clinical use of DNA tests and commercial release of chemical products.

Course Outcome (CO):

On completion of this course, students should be able to-

- Understand various ethical rules related to research activities in industry or academia, different types of intellectual property rights in protecting products derived from biotechnology research
- Critically apply the essentials of product development in various industries and obtaining patents
- Gain analytical skills for application of statistics in biological and biotechnological processes

BITG1091

Dissertation: Scientific writing and presentation

Preparation of a hypothesis-driven research proposal on biomedical/biotechnical science, which should include a brief literature review, origin of proposal, significance and potential impact of the proposed research on ongoing scientific advancement, experimental design, pitfalls and alternative strategies (following the SERB format for three years of research funding); Both the written proposal, and an oral presentation with logical framework of the proposed research will be assessed

BITG1092

Dissertation: Journal presentation and group discussion

Will learn to read, understand, discuss and present recent research articles in biomedical sciences or biotechnology during the weekly departmental seminar

BITG1093

Dissertation: Thesis writing and defense

As part of an individual laboratory, students will be engaged in understanding the major research question of that lab, and will perform a project, which will train them in executing standard laboratory protocols, related techniques and technologies, data collection, data analysis, and ethical aspects of research. A written dissertation, and an oral presentation on the project will be assessed

BITG1094

Dissertation: Innovation, Design and Entrepreneurship Alliance (IDEA)

In this module, the students will be generating ideas towards technological applications and bioentrepreneurship. For this, the students will need to submit a write-up on their ideas for innovative solutions in biotechnology followed by a presentation in front of an expert panel.

Dissertation: Grand Viva

This module will cover all the topics that were discussed in the two years of the course and the students' performance will be evaluated both on their thinking and analytical abilities in front of an expert panel.

Course Outcome (CO) of Dissertation (BITG1091-1094):

On completion of this course students should be able to-

- Apply all the acquired knowledge throughout the courses in understanding and executing one small topic of research of their own interest in their choice of lab
- Critically read, analyze and present a recently published literature of related topic
- Build a novel hypothesis-driven research proposal with proper plan of experimental methods
- Generate a novel biotechnological entrepreneurship idea that may be readily implemented
- Acquire presentation skills and etiquette of gathered knowledge, journals, own research idea and data, and novel plans of research and entrepreneurship idea

Recommended Textbooks and Reference books:

1. Voet, D., & Voet, J. G. Biochemistry (4th ed) Hoboken, NJ: J. Wiley & Sons.
2. Stryer, L. Biochemistry. New York: Freeman.
3. Lehninger, A. L. Principles of Biochemistry; New York, NY: Worth.
4. Ebbing, D. D., & Wrighton, M. S. (1990). General Chemistry. Boston: Houghton Mifflin.
5. Watson J.D. et al. Molecular Biology of Gene, (7th edition). Pearson
6. Alberts, B. et al. Molecular Biology of the Cell (6th Ed.). New York: Garland Science.
7. Lodish, H. F. et al. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
8. Cooper, G.M., Hausman, R.E. The Cell: a Molecular Approach (5th edition). Sinauer Associates
9. Russel. iGenetics: A molecular Approach, (3rd edition). Pearson
10. Snyder L. et al. Molecular genetics of bacteria (4th Ed.); ASM Press, Washington DC
11. Primrose & Twyman. Principle of gene manipulation and genomics (7th Ed.); Wiley Blackwell
12. Brown T.A. Gene cloning and DNA analysis: An introduction (6th Ed.); Wiley Blackwell
13. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's Microbiology. (10th edition) New York: McGraw-Hill.
14. Black, J.G., Black, L.J. Microbiology Principles and Explorations (9th Ed.). Wiley
15. Gerard J. Tortora, Berdell R. Funke, Christine L. Case. Microbiology by Tortora. Pearson Education
16. M.T. Madigan and J.M. Martinko. Biology of Microorganisms (11th Ed.) Pearson Prentice Hall, USA
17. Jay, J.M., Loessner, M.J., Golden, D.A. Modern Food Microbiology (7th Ed.)
18. Frazier W.C. Food Microbiology, Tata McGraw Hills Publishing Company Limited
19. Adams, M.R. and Moss, M.O. Food Microbiology (4th Ed.). New Age Int. (P) Ltd. Pub. New Delhi
20. Punt J, Stranford S, Owen J, Jones P, Kuby Immunology (8th Ed). Macmillan Learning
21. Delves PJ, Martin SJ, Burton DR, Roitt IM, Roitt's essential Immunology (13th Ed.). Wiley Learning
22. Abbas AK, Lichtman AH, Pillai S, Cellular and Molecular Immunology (10th Ed.). Elsevier Health Sc.
23. Salle AJ, Fundamental Principles of Bacteriology, (7th edition). Mc-Graw Hill Book Company Inc.
24. Adams, M.R., Moss, M.O. Issues in Environmental Science, (2008), RSC Publishing
25. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
26. Lesk, A.M. 2005, 2nd edition, Introduction to Bioinformatics. Oxford University Press.
27. Andreas D. Baxevanis, B. F. Francis Ouellette 2001 Bioinformatics: A Practical Guide to the Analysis of Genes, Wiley-Interscience
28. Durbin R., Eddy S., Krogh A. and Mithchison G. 2007 Biological Sequence Analysis, Cambridge University Press.
29. Haller, D. The Gut Microbiome in Health and Disease, 2018, Springer
30. Slater, A., Scott, N., & Fowler, M. (2008). Plant biotechnology: the genetic manipulation of plants (2nd ED). OUP Oxford.
31. Singh, B. D. (2011). Plant Biotechnology. India: Kalyani Publishers.
32. Razdan, M. K. (2002). Introduction To Plant Tissue Culture, (2nd Ed.) Oxford and IBH publishing
33. Sujata Bhat. Biomaterials (2nd edition). Narosa
34. Buddy D. Ratner. Biomaterials Science: An introduction to materials in medicine. (3rd edition). Academic Press
35. Chattopadhyay K.K. Introduction to nanoscience and nanotechnology. (2009) Prentice hall India learning private limited.
36. Jegan S.R. Nanobiotechnology- a technological revolution, Labmart academic publishing

37. Krogsgaard-Larsen et al. Textbook of Drug Design and Discovery (4th Edition). CRC Press.
38. Neelina H. Malsch (2005). Biomedical Nanotechnology. CRC Press
39. Das, S., Dash, H.R. Microbial Biotechnology- A Laboratory Manual for Bacterial Systems (2015).
40. Arceivala, S. J. & Asolekar, S. R. Wastewater Treatment for Pollution Control and reuse (2015). McGraw Hill Education India Pvt. Ltd.,
41. Glazer, A.N., Nikaido, H. Microbial Biotechnology: Fundamentals of Applied Microbiology (2nd Edition), Cambridge University Press
42. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, (Vol. I, 8th Edn.). The World Press, Kolkata.
43. Chap T. Le and Lynn E. E. (2016): Introductory Biostatistics, Wiley
44. Goel. IPR Biosafety and Bioethics, (2013). Pearson
45. Rajmohon Joshi. Biosafety and Bioethics. Isha Books.