Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 301	Cell Biology and Genetics	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	CO1: To understand the basic organization of cells and organisms and the tools needed to study them CO2: To understand the basic processes of the cell machinery, cell-cell interaction and the eukaryotic cell cycle. CO3: To apply the knowledge of cell process regulation and cell cycle in understanding the use of a cell as a biological tool for manufacturing biomolecules. CO4: To learn the fundamentals of Genetics and its applications. CO5: To solve problems associated with genetic diseases and their transmission from one generation to the next
Topics Covered	**Classical Genetics:** Mendelian inheritance; Euploidy and aneuploidy (4) Genetic interactions (2) **Molecular Genetics**-Split and Overlapping genes; Transposons & Retrotransposons; Mutation (6) DNA Repair and human diseases (4) Recombination (2) **Internal Organization of the cell**: Cells as experimental models, Cells and cellular organelles, Tools of cell biology- Microscopy and cell Architecture, Purification of cells, Membrane structure, Membrane Transport of small molecules and electrical properties of membranes (8) **Cytoskeleton and cell movement:** Structure and organization of actin filaments, Actin myosin and cell movement, intermediate filaments, microtubules, microtubule motors and movements, cell-cell interactions (6) **Cell signalling** Signaling molecules and their receptors, function of cell surface receptors, pathways of intracellular signal transduction, signal transduction and the cytoskeleton, signalling in development and differentiation (6)

	Cell cycle and cancer Eukaryotic cell cycle, meiosis and fertilization, stem cells, Development and causes of cancer, oncogenes, tumor suppressor genes (4)
Text Books, and/or reference material	• Molecular Biology of Cell by Albert et.al. John Wiley & Sons • The Cell by Cooper. ASM Press • Cell and Molecular Biology by Karp. John Wiley & Sons • M.W.Strickberger: Genetics, Pearson. • In Introduction to genetic analysis, Griffiths, Miller, Suzuki, Lewontin and Gelbart, Freeman and Company. • Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 • Stratchan & Read: Human Molecular Genetics • David Freifelder: Microbial Genetics, Jones and Bartlett Publisher Inc. 1987

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 302	MICROBIOLOGY AND BIOPROCESS TECHNOLOGY	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC01 (LIFE SCIENCE)		CT+EA					
Course Outcomes	CO1: To develop knowledge on different types of microorganisms including viruses and microscopy for the visualization of microorganisms, their characteristic features as well as internal and external structures and their functions. CO2: To impart an understanding on microbial classification and taxonomy, microbial community and interactions,microbial nutrition, nutritional types, growth media, growthin different systems, and control of microorganisms using various physical and chemical treatments including antimicrobial drugs. CO3: To develop knowledge on microbial metabolism, energy transduction mechanisms, and microbial genetics CO4: To acquire experimental knowhow of microbial production of various industrial products such as alcohol, antibiotics, amino acids, vitamins exopolysaccharides, enzymes, etc. from industrial strains.						

	CO5: To illustrate the upstream and downstream processing for product recovery and purification.
Topics Covered	**PART A: Microbiology** **Introduction to microbiology:**History and scope of microbiology, major contribution and events in microbiology, different types of microorganisms – characteristic features, microbes and diseases, microbes in human welfare [**2]** **Microbial structures:**Different types of microscopy, preparation and staining of specimens, microbial shape, size, arrangements, overview of procaryotic and eucaryotic cell – internal and external structures, cytoplasmic matrix, nucleoid, plasmids, ribosomes, flagella, pilli, fimbrie, spores, bacterial and archaebacterial cell walls and cell membranes, Viruses – types, structures, multiplications [**5]** **Microbial classification and taxonomy:**Domains of life, classification, taxonomic ranks, techniques for determining microbial taxonomy and phylogeny, prokaryotic phylogeny and diversity [**2]** **Microbial nutrition, growth and control:**Common nutrient requirements, nutritional types, uptake of nutrients by cell, culture media, pure culture, microbial growth – batch culture and continuous culture, growth curve, measurement of growth, influence of environmental factors on growth, control of microorganisms by physical and chemical agents[**5]** **Microbial metabolism:**Energy release and conservation, chemoorganotrophic fueling processes, aerobic respiration, glycolysis, TCA cycle, electron transport and oxidative phosphorylation, anaerobic respiration - nitrate and sulphate reduction, fermentations,chemolithotrophy, phototrophy[**5]** **Microbial genetics:**Conjugation, Transduction, Transformation [**3]** **PART B: Fermentation Technology** A) Introduction to Bioprocess Technology: Microbial Culture systems; Media formulation sterilization and optimisation; Development of Inoculum; Basic concepts of bioprocess development in industry; Downstream Processing and fermentation economics. B) Commercial Strain Development & Microbial Processes: Sources of industrial cultures and maintenance. Alcohol production: Production of Industrial Alcohol –Recent developments (Lingo cellulose and human insulin); Cellular control and regulation for production of microbial metabolites – Primary and Secondary metabolite; Mutants and genetically engineered strain development. Bioprocess types: submerged, stationary, solid and semi-solid – with their merits and demerits. C) Microbial production of Vitamins: 1) Vitamin B12 - Organisms used, production method-process, recovery and assay. 2) Vitamin C - Organisms used, production method, process, recovery and assay. D) Lectures Microbial Production of Antibiotics : Organism used, production process and recovery of- (Bacitracin, Chloramphenicol , Pencillin, Streptomycin and Tetracyclines) E) Lectures Microbial Production of acids, viz., citric, lactic,Acetic acid, vinegar and gluconic acid. Mechanism of each fermentation, their uses.its spoilage and prevention F) Production of Amino acids (Lysine and glutamic acid) and Enzymes its new Developments

	G) Production of Recombinant proteins: Human insulin, growth factors, human erythropoietin(EPO), Monoclonal antibody
Text Books, and/or reference material	**Text Books:** Prescott, Harley and Klein's Microbiology – McGraw Hill Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill L.E. Casida.Jr, Industrial Microbiology, New Age International Publisher W. Crueger, AnneliseCrueger, Biotechnology: A Textbook of Industrial Microbiology, Pnima Publishing Corporation Fermentation microbiology and biotechnology. Ed. E.M.T. El-Mansi , C.F.A. Bryce, B. Dahhou, S. Sanchez, A.L. Demain, A.R. Allman. 3rd ed. Taylor and Francis. **Reference books:** Microbiology by Tortora, Funke and Case Brock Biology of Microorganisms General Microbiology by Hans G Schlegel, Cambridge Atkinson.B andMarituna.F, Biochemical Engineering and Biotechnology Handbok,The Nature Press, Macmillan Publ.Ltd.4 James E Bailey, David F., Ollis, Biochemical engineering fundamentals, second edition. McGraw Hill

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC303	BIOCHEMISTRY AND ENZYME TECHNOLOGY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	CO1: To understand the principles of bioenergetics and to correlate them with the metabolic pathway. CO2: To impart an understanding on the fates of macromolecules during metabolism. CO3: To provide an understanding on the importance and synthesis of energy currency molecule, ATP. CO4:To interpret the regulation in the metabolic pathway and to study the role of hormones in the metabolic pathway. CO 5- To understand mechanism and kinetics of enzyme action and their regulation for application of enzymes in living system and for industrial purpose.
Topics Covered	**Module 1** **(3+2)5** Biomolecules, Vitamins Principles of Bioenergetics **Module 2** **Carbohydrate and its metabolism** **5** **Carbohydrate Biosynthesis** - Gluconeogenesis, Biosynthesis of glycogen, starch, Sucrose , Photosynthetic Carbohydrate Synthesis, **Glycolysis and catabolism of hexoses -** Glycolysis, pentose phosphate pathway of glucose oxidation, Citric acid cycle, regulation of citric acid cycle, glyoxylate cycle . Role of hormones in metabolism **Oxidative Phosphorylation and Photo Phosphorylation** - Oxidative Phosphorylation, Regulation of Oxidative Phosphorylation, Photosynthesis **Module 3** **3** **Lipid and its metabolism** O**xidation of Fatty acids** - Transport of fatty acid, beta-oxidation, Ketone bodies **Lipid Biosynthesis** - Biosynthesis of fatty acids **Module 4** **3** **Protein and its metabolism** **Amino acid oxidation and production of Urea** - Metabolic fates of amino groups, Nitrogen excretion and the urea cycle, Pathways of amino acid degradation

	Nitrogen metabolism, Biosynthesis of amino acids, **Module 5** **2** **Nucleic acid and its metabolism** Biosynthesis and degradation of Nucleotides **Module 6** **12** **Enzyme Technology and Vitamins** **Enzymes:** Nomenclature of enzymes, Enzyme kinetics, Mechanism of enzymatic, Catalysis, Active site, Activators and inhibitors, Coenzymes, Isoenzymes, Michaelis-Menten equation, Km and Vmax value, Regulation of enzyme activity (single-substrate and multi-substrate reactions). Vitamin's as coenzyme **Production of enzymes and immobilisation** : Production of industrial enzymes such as proteases, amylases, lipases, cellulases, whole cell biocatalysis. Enzyme immobilization: Methods of immobilization of enzymes-physical & chemical techniques, Kinetics of immobilized enzyme, Effect of external mass transfer & intra-particle diffusion, limitation & applications of immobilized enzymes, Bioreactors using immobilized enzyme. Engineering of Enzymes **Application of enzyme** in leather industry, detergent industry, dairy industry; Lignocellulose degrading enzymes.
Text Books, and/or reference material	**Text** 1. Biochemistry by LubertStryer. W. H. Freeman & Company, NY 2. Biochemistry by Lehninger. McMillan publishers **Reference:** 1. Biochemistry, Voet&Voet 2. Fundamental of Enzymology by Price and Stevens (2002): Oxford University Press 3. Enzyme technology by Chaplin and Bucke. Cambridge Univerity Press

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS352	BIOCHEMISTRY LABOARTORY	PCR		0	3	3	1.5
Pre-requisites		BTC303					

Course Outcomes	CO1: To design , analyze and solve problems and learn to plot graph and interpret data CO2: To develop skills to perform experiments and have hands on training. CO3: To apply the results and data to solve problems in daily activities and industry.
Topics Covered	1. To prepare Tris-HCl Buffer with a specific pH (eg. pH 8.8) 2. Qualitative and quantitative estimation of carbohydrates 3. Qualitative and quantitative estimation of aminoacids and determination of the unknown concentration of protein concentration by plotting a standard curve of BSA using Bradford reagent 4. Ammonium sulphate precipitation and dialysis for a protein 5. Separation and Identification of Amino acids by Paper Chromatography and Thin Layer Chromatography 6. Analysis of Protein purity and determination of molecular weight of pure protein by SDS PAGE and Coomassie Brilliant blue staining of proteins on SDS gel 7. Extraction of Enzyme Tyrosinase from commercially available mushrooms and Assay of Enzyme Tyrosinase with determination of specific activity of Enzyme Tyrosinase 8. Effect of substrate concentration on the activity of Enzyme Tyrosinase and determination of MichelesMenton parameters of Enzyme Tyrosinase 9. Effect of inhibitor concentration on the activity of Enzyme Tyrosinase
Text Books, and/or reference material	**Text Books:** Practical Biochemistry by David T Plummer **Reference Books:** Biochemistry by Voet and Voet

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS351	Microbiology Lab	PEL	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
	CT+EA

Course Outcomes	CO1: To learn and become familiar with types of culture media, preparations of culture media, sterilization procedures, types of equipments. CO2: To understand the concept of sterility, working principles and applications of instruments: autoclaving, laminar air flow hood etc. CO3:To learn about the isolation and maintenance process of bacterial cultures. CO4: To apply the understanding of the cultural and morphological characteristics of microorganisms grown in pure culture.Applications in Antimicrobial effect and CO5: To interpret microbial growth phases its kinetics specific growth rate.to determine the effects of chemicals on bacteria and to understand the quality of water.
Topics Covered	**Microbial culture media preperation:** Basic concepts of nutrition materials in media, classes of culture media, how to prepare growth media. **The control of microbial growth :** To study the methods of sterilization: autoclaving, laminar air flow hood, irradiation, filtrations, chemical and gas. **Isolation of microorganisms from an environment of choice :** To demonstrate the ubiquity and diversity of microbes in the environment, samples from immediate areas of the environment will be obtained and cultured and dilution methods. **Isolation and Maintenance of pure cultures :** To study the different techniques of isolation and maintenance of pure cultures: subculturing, streak plate method, pour plate method, spread plate method. **Bacterial morphology and staining :** To study the physical properties and differentiation of microorganisms with the help of different staining procedures: differential and structural staining. Techniques of Gram staining, endospores staining, microscopic study. **Estimation of coliform bacteria:** To study the estimation of coliform bacteria in water by MPN (most probable number)

	test. **Study of bacterial growth:** To study the growth pattern of bacteria, specific growth rate calculation, different growth phases of bacteria. **Antimicrobial activity study:** To determine the antibiotic susceptibility via sensitivity disk methods, calculation of zone of inhibition.
Text Books, and/or reference material	Textbook : 1. Benson HJ. 2002. Microbiological applications: a laboratory manual in general microbiology: McGraw-Hill New York, NY. 2. Harley JP. 2004. Laboratory exercises in microbiology: McGraw-Hill Science/Engineering/Math Reference books: 1. Brown AE. 2009. Benson's Microbiological Applications: Laboratory Manual in General Microbiology, Short Version: McGraw Hill 2. Madigan MT, Martinko JM, Dunlap PV, Clark DP. 2012. Brock biology of microorganisms: Pearson/Benjamin Cummings. 3. Pollack RA. 2004. Laboratory exercises in microbiology, 3e. Recherche 67: 02

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC401	MOLECULAR BIOLOGY AND rDNA TECHNOLOGY	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC01 Life Science BTC301 Cell Biology and Genetics BTC303 Biochemistry and Enzyme Technology		CT+EA					
Course Outcomes		**CO1:** Students will acquire basic understanding of molecular biology topics: nucleic acid structure and chemistry; organization of genome in chromosomes; regulation of replication, transcription, translation and DNA repair. **CO2:** Students will acquire knowledge of recombinant DNA techniques on: nucleic acid amplification and gene cloning; manipulation of DNA sequences; preparation and screening of nucleic acid libraries; gene silencing; analysis of variations in genome sequence. **CO3:** Students will be proficient in applying basic understanding of molecular biology topics in analyzing and solving problems related to recombinant DNA technology.					

	CO4: Students will be able to design strategies to solve problems related to recombinant DNA technology.
Topics Covered	1. Nucleic acid structure: Nucleotides and nucleic acids, DNA structure, different forms of DNA, unusual DNA structure, different types of RNA, RNA structure. [3] 2. Nucleic acid chemistry: Denaturation and renaturation, hybridization, nonenzymatic transformation (Mutation) – spontaneous and induced, point mutation - transition, transversion, mutation involving more than one base pairs, insertion, deletion, frame shift mutation, forward and back mutation, null mutation, Loss-of-function and gain-of-function mutation, silent mutation, DNA sequencing. [4] 3. Chromosome organization: Chromosomal elements – genes and intergenic regions, regulatory sequences; DNA supercoiling, linking number, Chromosome structure: Histones, Non-histones, Nucleosome, Chromatin. Chromosome structure in prokaryotes & eukaryotes. [4] 4. DNA replication and repair: Central dogma, DNA replication in prokaryots and eukaryots – set of fundamental rules, DNA polymerases, proteins and enzymes involved in replication, process, accuracy. [4] 5. Transcription and post-transcriptional processing: DNA-dependent RNA synthesis in prokaryotes and eukaryotes, RNA polymerases, transcription process, termination, selective inhibition, RNA processing – capping, splicing of introns, differential RNA processing; RNA-dependent synthesis of RNA and DNA. [4] 6. Protein synthesis – translation: Genetic code, ribosome, transfer RNA, protein biosynthesis stages – attachment of amino acid to specific tRNA, initiation, elongation, termination, folding and processing; inhibition of protein synthesis. [4] 7. DNA repair: DNA repair – multiple repair systems. [3] 8. Regulation of gene expression: Regulation of gene expression in bacteria - operon concept; Regulation of gene expression in eukaryotes, hormonal control of gene expression in eukaryotes. [3] 9. Introduction to recombinant DNA and Gene Cloning Tools of recombinant DNA: Vectors; plasmid, bacteriophage viral vectors, cosmids, yeast artificial chromosome. Expression vectors, and selection of suitable Host. [5] 10. Restriction endonucleases and other enzymes use and mechanism of action and analysis, Genomic DNA and cDNA library preparation. Strategies for engineered vectors use and regulation for enhanced gene expression and purification. [5] 11. Screening and selection of clone with desired gene and protein of interest: Colony and plaque hybridization. antibody based assay, Protein activity. Application of gene cloning and DNA Analysis. [3] 12. Molecular probes: Preparation of molecular probes DNA probes, RNA probes, radioactive labeling, Non-radioactive labeling, use of molecular probes in DNA fingerprinting. Southern blotting, Northern blotting, Western blotting, In-situ hybridization. [4] 13. MOLECULAR TECHNIQES: Polymerase chain reaction, different types and their use. Antisense RNA technology, Site directed mutagenesis, Use of RFLP, SNP and Microarray. [4]
Text Books, and/or reference material	Text Books: 1. Gene IX by B. Lewin, Pearson 2. Molecular biology of the cell by Alberts et. al., Garland science Reference Books 1. Molecular Biology of the Gene, 7th edition 2013. Watson et. al. Published by Pearson. 2. Cell and molecular Biology, Concepts and experiments Gerald Karp, John Wiley and Sons. 3. The Cell - A molecular approach, GM Cooper ASM Press 4. Genomes, T. A. Brown, John Wiley and Sons PTE Ltd

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC 402	Immunology	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	CO1: To understand the role of the components of the immune system and its classification CO2: To understand the role of the immune cells and their immunological response in the context of human diseases including infectious diseases, autoimmunity, and cancer. CO3: To learn the fundamentals and principles of immunological techniques and their application. CO4: To understand methods of generations of Polyclonal and Monoclonal Antibody and the use of custom made genetically engineered antibodies. CO5: To solve problems associated with drugs and their toxic response based on the knowledge of immunological response.
Topics Covered	**Immunology-** fundamental concepts and anatomy of the immune system Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Haematopoesis; Organs and cells of the immune system-primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing (6) **Immune responses generated by B and T lymphocytes** Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; (2) Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily (3) Kinetics of Active and Passive Immunity, Basis of self –non-self discrimination; (4) B cell maturation, activation and differentiation; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses (6) Hypersensitivity, Antibody Dependent Cell Cytotoxicity; Cytokines-properties, receptors and therapeutic uses; Antigen processing and presentation Hapten-carrier system. Complement system. (4) **Antigen – Antibody Interaction dependent Techniques**

	Precipitation, Agglutination; Advanced immunological techniques- RIA, ELISA, Western blotting, ELISPOT assay, Immuno-electron microscopy and Immunoflourescence techniques (6) **Clinical Immunology** Preparation and clinical uses of Monoclonal and Polyclonal antibody. (3) Transplantation; Autoimmunity; (5) Vaccination: Principles and development of vaccines against different diseases. (3)
Text Books, and/or reference material	Textbook: 1. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 2. Janeway et al., Immunobiology, 4th Edition, Current Biology publications. 1999 Reference Books: 1. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002. 2. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven, 1999. 3. Goding, Monoclonal antibodies, Academic Press. 1985.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO 441	FOOD BIOTECHNOLOGY	PER/OER	3	0	0	3	3
Pre-requisites		Life science- BTC-01					
		BTC-01					
Course Outcomes	CO1: To Quantitate and identify the spoilage microorganisms present in food. CO2: To learn the concepts of food fermentation and increase the shelf life of food. CO3: To learn the concepts in genetically modified food and increase the agricultural yield by using genetic engineering approach. CO4: To apply the concepts of antioxidant and nutraceutical for health and wellness. CO5: To follow the regulations and ethical issues of food safety by using good manufacturing practices in industry and genetically modified food.						

Topics Covered	**Food Microbiology:** **[8]** Microorganism in food, Intrinsic and extrinsic parameters of food**,** rapid methods for identification of microorganism in food, Food borne illness, Biosensors –use and application **Food preservation** **[8]** Pasteurization, sterilization, Canning, thermal process of food with numericals, Irradiation, Dehydration, low temperature , use of preservatives **Food fermentation** **[10]** **Role of lactic acid bacteria in fermentation and strain improvement**, Fermentation of meat, fish, vegetables, beverages , dairy product, non-beverage product , use of genetic engineering techniques for improved quality product**.** **Genetically modified food** **[8]** Fruit ripening, amino acid, vitamin content, Golden rice. Safety aspects of genetically modified food, Ethical and regulatory issues **Biotechnology in relation to food product** **[4]** Antioxidant, nutraceutical, **Food safety** **[6]** Legal status of irradiated food and preservatives, Concept of HACCP, Hazop, codex alimentarius, ISO series, detection of toxin, heavy metal , pesticide and herbicides
Text Books, and/or reference material	**Text Book** Food microbiology by James . M. Jay Food Microbiology by Frazier and Westhoff Plant Biotechnology by Slater **Reference Book** Fundamentals of Food Biotechnology by Lee

Department of Biotechnology

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS451	Cell Biology and Genetics Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		BTC301					
Cell Biology and Genetics (BTC301)							

Course Outcomes	CO1: To design, analyze and solve problems related to cell biology and Molecular genetics and interpretation of data obtained by the lab experiments. CO2: To develop skills to perform experiments related to cell biology and Molecular genetics and have hands on training on the related area. CO3: To learn to interpret data, draw conclusion and develop trouble shooting skills.
Topics Covered	1. Isolation of chromosomal DNA from mammalian cells. 2. Genotyping PCR of a genetically modified cell. 3. Isolation of mRNA and RT-PCR to determine the level of transcription of the gene. 4. Studying to detect variations like single nucleotide polymorphism. 5. Studying bacterial conjugation. 6. To examine the morphology of cells 7. Identification of cellular organelles by staining method 8. Cell proliferation assay 9. Cell adhesion assay 10. Cell migration assay
Text Books, and/or reference material	**Text Books:** **Reference Books:** • Molecular Biology of Cell by Albert et.al. John Wiley & Sons • The Cell by Cooper. ASM Press • M.W.Strickberger: Genetics, Pearson.

Department of Biotechnology

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

BTC 501	**Biochemical Reaction Engineering and Bioreactor Design**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	CO1 – To gain knowledge about Chemical and Biochemical processes, order of reactions, different theories and effect of various parameters on rate constant of a reaction C02- To study about different reactions in batch reactors, kinetics of enzyme catalyzed reactions with respect to Michaelis-Menten and Briggs-Haldane relationship, immobilized enzyme systems and immobilized cell bioreactors, principles of enzyme inhibition CO3- To acquire knowledge about different ideal and non-ideal reactors, ATP Balances and energetics, reaction kinetics and various structured and unstructured models for Biochemical systems, microbial growth kinetics CO4- To learn about various types of Novel Bioreactors, their design considerations and applications in the field of Biochemical Engineering CO5- To study about Bioreactor design, mass transfer in bioprocess systems, scale up, instrumentation and control, fermentation utilities applied o bioprocess and bioreactor considerations in plant and animal cell culture
Topics Covered	Rate of chemical reaction; Effect of Temperature on Rate Constant, Arrehnius equation, Collision Theory, Transition State Theory, Order and Molecularity of a Chemical reaction, Elementary Reactions, First, Second and Third order reactions, Pseudo-first order reaction, Determination of rate constant and order of reaction. [5] Interpretation of batch reactor data for simple and complex reactions. Kinetics of Enzyme catalyzed reactions for free and immobilized enzymes.–derivation of Michaelis-Menten equation, Briggs-Haldane relationship, the determination and significance of kinetic constants, Lineweaver-burk and Eadie-Hofstee plot, principles of enzyme inhibition – Competitive, noncompetitive and uncompetitive. [5] Stoichiometry of cellular reactions, degree of reduction balances. ATP balances and energetics, Model analysis of metabolic networks; Reaction kinetics – unstructured and structure population balances and morphologically structured models. Multicomponent Bioreactors in steady state and in transient operation. [5] Fundamentals of homogeneous reactions for batch, plug flow and mixed flow reactors. [5] Concept of ideal and non ideal reactors, Residence time distribution, Models for non ideal reactors (Dispersion model, tanks-in-series model). [5]

	Microbial growth kinetics. (Batch, continuous, fed batch). Growth kinetics with plasmid instability. [4] Bioreactor design: Fluidized bed bioreactor, Bubble column bioreactor, Air lift bioreactor, Tower bioreactor. Hollow fiber reactor, Membrane reactor. [4] Design of fermenter. Fermenter utilities – boiler and refrigeration system. [5] Immobilized cell bioreactor system. Mass transfer in bioprocess system. Two film theory, K_{la} determination. Scale up concepts. Bioreactor considerations for plant and animal cell culture [5] Bioprocess instrumentation and control. Computer controlled bioreactors. [2]
Text Books, and/or reference material	Text 1. Bioprocess Engineering: Basic Concepts (2nd Edition), Shuler and Kargi, Prentice Hall International. 2. Bioprocess Engineering Principles – Pauline M Doran. Academic press 3. Chemical Reaction Engineering ,O Levenspiel, Wiley 4. Principles of Fermentation Technology, Stanbury and Whitaker, Pergamon press Reference 1. Biochemical Engineering. Fundamentals, Bailey & Olis, McGraw-Hill Biochemical Engineering, Humphrey and Aiba. Academic Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC502	CELL & TISSUE CULTURE	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC01 Life Science BTC301 Cell Biology and Genetics		CT+EA					
Course Outcomes	**CO1:** Students will acquire knowledge on plant and animal cell and tissue growth conditions. **CO2:** Students will be acquainted with plant and animal cell and tissue culture techniques in laboratory and industry setups. **CO3:** Students will be proficient in applying basic understanding of plant and animal cell and tissue growth requirements in plant and animal tissue culture techniques.						
Topics Covered	1. Introductory history, plant & animal cell culture facilities laboratory organization, media & aseptic conditions. [2]						

	2. Plant growth hormones, Cell culture, cellular totipotency, somatic embryogenesis, anther, pollen and ovary cultures, protoplast culture. [6] 3. Haploid production, triploid production, in vitro pollination and fertilization, zygotic embryo culture, somatic hybridization and cybridization, genetic transformation, somaclonal and gametoclonal variant selection. [7] 4. Production of disease-free plants, clonal propagation. [3] 5. Industrial applications: secondary metabolite production, germplasm conservation. [3] 6. Animal Cell Culture: Historical Background. [1] 7. Importance of and progress in Animal Cell Culture Technology. [1] 8. Biology of Animal Cell; Cellular Interactions. [5] 9. Importance of Serum and Serum Free Media. [2] 10. Culturing and Sub-Culturing of Animal Cells. [3] 11. In Vitro Transformation of Animal Cells. [1] 12. Cell Differentiation & Cell Movement. [2] 13. Cloning of Animal Cells. [2] 14. Cell Line Preservation. [1] 15. Cell Line Characterization. [2] 16. Chromosome Spreading and Karyotype Analysis. [2] 17. Mycoplasma: Detection and Control. [1] 18. Monoclonal Antibody Production. [2] 19. Insect Cell Culture: An Overview. [2]
Text Books, and/or reference material	Text Book: 1. Razdan – Introduction to Plant Tissue Culture, 2nd edition, 2007, Oxford and IBH Publishing. 2. "Culture of AnimalCells: A manual of basic technique", 4 th Edition Author(s)/Editor(s): Freshney RI. Publisher: WIELY-LISS ISBN:0-471-34889-9. Reference Book: 1. Bhojwani and Razdan –Plant Tissue Culture: Theory and Practice, a revised edition, 2009, Elsevier. 2. Jha and Ghosh – Plant Tissue Culture: Basic and Applied, revised 2nd edition, 2016, Platinum Publishers.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC503	Bioseparation and Biochemical Analysis	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end-term examination (ET))					
Basic Physics, Mathematics including basics of Differential & Integral Calculus, Basic concepts of Chemistry & Biochemistry		CA+ET					
Course Outcomes	CO1: To learn the concepts of separation including purification sequence and its monitoring and the properties of proteins underlying bioseparations. CO2: To learn techniques of biochemical analysis of biomolecules.						

	CO3: To learn and analyze, mathematically wherever applicable, the various unit operations in bioseparation. CO4: To understand the design aspects of unit operations in bioseparation. CO5: To solve problems of bioseparations including industrial bioseparations.
Topics Covered	**Basic Concepts** **[3]** Basic concepts of Bio-separation Technology **Basic Analytical Tehniques:** **[10]** Introduction to Biomolecules, Buffers Estimation of carbohydrate, protein, and lipid, and enzyme assay Quantitation of DNA and RNA Methods of cell disintegration **Removal of Insolubles** **[9]** Flocculation and conditioning of broth. Filtration at constant pressure and at constant rate; equations for batch and continuous filtration, centrifugal and cross-flow filtration. Centrifugation: basic principles, design characteristics; ultracentrifuges: principles and applications. **Techniques Involved in Separation Processes for Solutes** **[9]** Foam-fractionation; Solvent extraction, aqueous two-phase extraction, adsorption & desorption processes; Salt precipitation Membrane based separation processes: Micro-filtration, Dialysis, Reverse osmosis, Ultrafiltration and affinity ultrafiltration, concentration polarization, rejection, flux expression, membrane modules, dead-end and cross-flow modes. **Advanced Techniques for Bioseparation:** **[9]** Chromatography: paper chromatography, TLC, gel filtration, ion exchange, hydrophobic interaction chromatography, affinity chromatography, HPLC. Electrophoresis: Theory and application of Polyacrylamide and Agarose gel electrophoresis; 2D-Gel electrophoresis **Industrial Application with an example** **[2]**
Text Books, and/or reference material	Textbooks : 1. Practical Biochemistry Principles and techniques (5th ed)/ Principles and Techniques of Biochemistry and Molecular Biology (7th ed): Editor Wilson and Walker, Cambridge University Press 2. Geankoplis, Transport Processes & Unit operations, PHI. Reference books: 1. D. Holme & H. Peck, Analytical Biochemistry, 3rd ed, Longman, 1998 2. Shuler & Kargi, Bio-process Engg. PHI 3. Bailey & Olis, Biochemical Engg. Fundamentals, McGraw-Hill

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO540	Mineral Biotechnology	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
	CT+EA

Course Outcomes	
Topics Covered	**Module-I :** Introduction to Biotechnology applied to Raw Material processing, Biogeochemical reactions – chemical mechanisms and controlling factors, Microbial interventions, Nature and characteristics of Biogeochemically important micro-organisms. 10 **Module-II:** Kinetics of bioleaching; Applications of biogeochemical process in mining and metallurgy, dump, heap and in-situ leaching. 8 **Module-III:** Reactor modeling for leaching, Beneficiation of ored and process residues: recovery of gold, silver, copper, beneficiation of sulfidic tailings from tin processing; purification of ferroginous sand. 8 **Module-IV :** Beneficiation of bauxite, applications of sulphate reducing bacteria; applications of sulphate reducing bacteria, Environmental pollution control: accumulation of metals by microbial cells. 8
Text Books, and/or reference material	Books: 1. H.D. Kumar and S.Kumar , Modern Concepts of Microbiology , Vikas Publishing House , 2nd Edition , 2001 2. M.E. Curtin , Microbial mining and metal recovery biotechnology (1) , pp 229-235 , 1983 Woods D, Rawling D.E., Bacterial bleaching and biomining J.L.(ed), Revolution in biotechnology , Cambridge University Press.

Department of Biotechnology

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 551	Immunology Laboratory	PCR	0	0	3	3	1.5

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
	CT+EA

Course Outcomes	CO1: To learn the fundamentals of immunological techniques CO2: To be able to perform techniques routinely used in immunology, particularly the use of specific antibody in biomolecular applications. CO2: To be able to isolate, count and identify different types of blood cells. CO4: To develop an idea for proper documentation of the work including laboratory procedures, experimental conditions, materials used, equipment used and the results. CO5: To understand the basic hazards of working with human samples and antigens and safety measures to be taken
Topics Covered	1. Cell count with Haemocytometer 2. Determination of viability of the cells 3. Serology: Preparation of the blood smear 4. Blood cell identification 5. Blood grouping by Agglutination assay 6. Quantitative WIDAL test (By tube test and slide test) 7. Precipitation test: Immunodiffusion 8. Enzyme linked Immunosorbent Assay (ELISA) 9. Protein detection by Western blot technique. 10. Lymphocytes isolation using Ficoll Hypaque technique
Text Books, and/or reference material	1. Immunology Laboratory manual. 2. Arti Nigam,Archana Ayyagari,"Lab Manual in Biochemistry, Immunology and Biotechnology", Mc Graw Hill Education, India, 2007

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
BTS-552	**Bioprocess Technology Laboratory**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
		CE+EA					

Course Outcomes	
Topics Covered	1. Production of neomycin by fermentation 2. Production of citric acid by fermentation 3. Production of xanthan/dextran gum by fermentation 4. Production of Bakers yeast by fermentation 5. Cell Immobilization by entrapment method

Text Books, and/or reference material	

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC601	Bioinformatics	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology and Genetics (BTC301), Biochemistry and Enzyme Technology (BTC303), Programming and Data Structure (CSC431)		CT+EA					
Course Outcomes	• CO1: To learn how to integrate both biological and computer skills for addressing important biological questions. • CO2: To acquire knowledge of existing biological databases and understand the methods for storing, organizing, retrieving and analyzing biological data in an efficient way. • CO3: To learn and implement computational algorithms and tools (webservers and standalone programs) for processing biological data						
Topics Covered	1. Introduction to Bioinformatics and its applications (2) 2. Linux and Bash programmingfor bioinformatics (3) 3. Major Information Resources & biological databases (6) 4. Sequence Alignment: Sequence similarity, Sequence identity, Sequence homology, Gap Penalty, local and global alignment, pairwise and multiple alignments, sequence alignment algorithm, Dynamic programming, BLAST and PSI-BLAST, Application of BLAST tool, Concept of Scoring matrix (7) 5. Molecular phylogeny and evolution: Phylogenetics basics and methods for phylogenetic tree constructions (5) 6. Structural Bioinformatics: A. Protein Structure and its visualization, structural alignment (5), B. Protein secondary Structure Prediction (4), C. Protein tertiary Structure Prediction (4), D. RNA Structure Prediction (3) 7. Molecular Docking and Drug design (Basic concepts) (3)						
Text Books, and/or reference material	Text Books: 1. Bioinformatics: Sequence and Genome Analysis by David W Mount, Cold Spring Harbor Laboratory Press 2. Introduction to Bioinformatics by Arthur M Lesk Reference Books: 1. Introduction to Bioinformatics computer Skills by Cynthia Gibas and Per Jambeck						

	2. Protein bioinformatics: an algorithmic approach to sequence and structure analysis by Ingvar Eidhammer, IngeJonassen and William R. Taylor. 3. Essentials of Bioinformatics by Jin Xiong

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE610	Animal Biotechnology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To elucidate the scope of Animal Biotechnology. CO2: To learn the different areas of Animal Biotechnology applications. CO3: To learn the basic technology in each area of Animal Biotechnology. CO4: To learn the future prospect of the Animal Biotechnology.						
Topics Covered	**Animl Cell culture:** History of animal cell culture and development, Development of primary culture, Development of cell line by enzymatic disaggregation, Culture media and growth conditions. Cell type and characterization, origin of animal cell line, maintenance and characterization of different cell lines, Marker gene characterization (8) **Technology – Present and future :** Hybridoma technology/Monoclonal antibody technology, Vaccine production, Organ culture, Transfection of animal cells, Future tissue engineering (4). **In Vitro Fertilization and Embryo Transfer:** Basic knowledge on Fertilization and embryology, Steps involved in IVF, Fertilization by means of micro insemination, PZD, ICSI, SUZI, MESA (4) **Stem cells:** Classification and types, Sources, Markers, Differentiation signals, application, IPSC, Cncer stem cells (4). **Gene Therapy:** Ex-vivo gene therapy, In vivo gene therapy, Viral gene delivery system, Retrovirus vector system, Adenovirus vector system, Adeno-Associated virus vector system, Herpex simplex virus vector system, Non-viral gene delivery system, Prodrug activation therapy, Nucleic acid therapeutic agents (4)						

	Transgenic and Konck out Animals: Methodology, Embryonic Stem Cell method, Microinjection method, Retroviral vector method, Applications of transgenic animals **Recombinanat protein expression and purification:** Expression vectors for mammalian proteins, Cell (S cerevicea, P pasturis etc.) for large scale mammalian protein production, Post translational modification and purification.
Text Books, and/or reference material	1. Animal Cell Culture by John R.W. Masters; Oxford University Press 2. Introduction to Cell and Tissue Culture by Jennie P. Mather and Penelope E. Roberts; Plenum Press, New York and London 3. Molecular Biotechnology: Primrose. 4. Animal Cell Biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press. 5. Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (Eds.), Concepts in Biotechnology, University Press, 1996 6. Hood L.E., Weissman I., Wood W.B. and Wilson J.H. Immunology, Benjamin Cummings, 1989 7. Biotol Series – Butterworth and Heineman, Oxford, 1992

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE611	Industrial Microbiology	PEL	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To interpretbasic concepts for the production of microbial products.fermentation and separation technology CO2: To learn about the different types of Bioreators and their use. CO3: To analyse the principles, and techniques for improving the yield and desired properties in via strain improvement strategies. CO4: They will be able to apply the knowledge related to processes, equipment for industrial purpose and solve the problems.						

Topics Covered	**Industrial Microbiology– BTE611** **Introduction to Fermentation Technology: 12** Basic idea on fermentation process, submerged, stationary, solid and semi-solid – with their merits and demerits. Types of Media for Industrial fermentations; Media Optimization; Sterilization of Industrial Media; Media sterilization,.Preparation of microbial inoculum for Industrial fermentations. **Commercial strain development: 12** Induced mutations, Over producing decontrolled mutants, Catabolic derepressed mutants; Genetically engineered strain; Protoplast fusion technique. Improvement of strain by Site directed mutagenesis and Protein engineering : Definition, methods and application. Improving microbial strain forproduction of Amino acids Lysine and nucleosides and nucleotides foraroma.Methods for production of 5' IMP and 5'GMP iii) Production of 5'IMP and 5'GMP by fermentation. **Microbial processes for production of valuables 10** Introduction, on Microbial growth and its kinetics.Primary and secondary metabolites and their regulation. Microbial production of organic acids, antibiotics,alcohol, bakers yeast, Single cell protein (SCP); Vitamins.Organisms used,(wild and mutated). production method- process, recovery of products separation parameters , purification steps..Application . **Microbial Enzyme Technology: 10** Microbial process for production of enzymes.Commercial production of enzymes; amylases, proteases,cellulase.Enzyme Modification - site directedmutagenesis;Importance of Stability of enzymes;Enzyme stabilization by selection and protein engineering for T4 Lysozyme; Principles & techniques of immobilization of Enzymes, Application of immobilized enzyme in Industrial processes
Text Books, and/or reference material	Books 1. Industrial Microbiology, Casida L E 2. Biotechnology: A textbook of industrial microbiology: CruegerW ,Crueger A 3. Industrial Microbiology, Prescott & Dunn **References:** 1. Prescott's and Dunn's, A. Industrial Microbiology, 4th edition. CBS Publishers, New Dehli , India , 1987. 2. L.E. Cassida.Jr, Industrial Microbiology, New Age International Publisher 3. Atkinson.B and Marituna.F, Biochemical Engineering and Biotechnology Handbok, The Nature Press, Macmillan Publ. Ltd. 4. Bailey &Olis, Biochemical Engineering Fundamentals, MGH. 5. Review papers from reputed international journals to convey the current progress .in this area.

Department of Biotechnology				
	Title of the course		Total Number of contact hours	Credit

Course Code		Program Core (PCR) / Electives (PEL)	Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE612	NUTRACEUTICAL AND NUTRIGENOMICS	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	CO1: To establish the correlation between nutraceuticals with cell signaling pathway. CO2: To target nutraceuticals from different sources for prevention of disease. CO3: To understand the interaction between gut microbiota with functional food components and nutraceuticals and improvement of health. CO4: To formulate the concept of nutrient gene interaction for prevention of lifestyle related disorders.
Topics Covered	Nutraceuticals : General concepts of cell apoptosis/proliferation and molecular targets of nutraceuticals. **[8]** Nutraceutical role in host immune response, in cancer, infection and chronic/acute inflammations. Mechanism of action of Nutraceutical-signaling events, proteomics and transcription factors. **[8]** Nutraceuticals from food and herbs I: Polyphenols, flavonoids and other phenolic compounds**.** **[5]** Nutraceuticals from food and herb -II: Saponins, terpenoids and sulphur compounds, Probiotic food with therapeutic applications, Prebiotics, Genomics of Lactic Acid Bacteria **[7]** Nutragenomics: An introduction, Nutrient gene interaction- Structure of nuclear receptors with reference to carbohydrate, fat and vitamin A, Type 2 Diabetes Mellitus and nutrigenomics, PPAR-γ and Diabetes Mellitus, Bioactive Peptides and its role in Nutrigenomics **[12]**
Text Books, and/or reference material	**Books** 1. Nutritional Genomics: Discovering the Path to Personalized Nutrition by James Kaput, Raymond L. Rodriguez, Wiley Functional Food Ingredients and Nutraceuticals by John Shi , CRC Press 2. Nutraceuticals by Lisa Rapport, Brian Lockwood , Pharmaceutical press **References:**

	1. Nutragenomics and Proteomics In Health Promotion and Disease Prevention by Mohamed M. Rafi, FereidoonShahidi, CRC Press 2. Nutraceuticals: The Complete Encyclopedia of Supplements, Herbs, Vitamins, and Healing Foods by Arthur J. Roberts, GenelleSubak-Sharpe, Mary E. O'Brien (Designer) , Perigee Trade 3. Regulation of Functional Foods and Nutraceuticals: A Global Perspective by Clare Hasler, Blackwell Publishing Professional

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE613	Human Genomics	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Cell Biology and Genetics (BTC301), Biochemistry and Enzyme Technology (BTC303), Molecular Biology and rDNA Technology (BTC401)	CT+EA

Course Outcomes	• CO1: To understand the general organization of human nuclear and mitochondrial genome and know about the salient features and characteristics. • CO2: To acquire knowledge the human genome project and its implication on clinical biology in the post genomic era. • CO3: To familiarize with different scientific techniques used for studying different features of genome. • CO4: To get an overview about different applications of the genomic based knowledge .
Topics Covered	7. Patterns of genome organization (10) 8. Structural genomics (2) 9. Functional genomics (2) 10. Reverse genetics (2) 11. Gene patenting (2) 12. Electronic PCR (2) 13. Genome mapping and genome sequencing (2) 14. Specialized database in molecular biology (2) 15. Human genome project progress (2) 16. Genes in health and disease(2) 17. Genomic disorders and molecular medicine (2) 18. Minimal cell Genome (2) 19. Prospects of Gene therapy in Human (2) 20. Pharmacogenomics (2) 21. Genebank (2) 22. Legal status of gene bank (2)
Text Books, and/or reference material	**Textbook:** 1. T. A. Brown, Genomes, John Wiley & Sons **Reference Books** ● Singer.M, and Berg.P, Genes and genomes, Blackwell Scientific Publication, Oxford ,1991

	• Beebe.T, and Burke.T, Gene Structure and Transcription, 2nd edition,1992, Oxford Univ Press • Glick and Pasteurneck, Molecular Biotechnology, Principles and Applications of Recombinant DNA technology, ASM Press • Strachan & Reed, Human Molecular Genetics, Garland Science. • Cantor & Smith, Genomics, John Wiley & Son

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE614	MOLECULAR VIROLOGY	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology (BTC 301/BT 403), Molecular Biology (BTC 401/ BT 404), and Immunology (BTC 402/ BT 501)		CT+EA					
Course Outcomes		• CO1: Acquire an understanding of virus life cycle and host-virus interactions. • CO2: Acquire an idea about detection, prevention and treatment of virus infections. • CO3: To learn about use of virus in biotechnology.					
Topics Covered		Brief history and principles of virology. (1) Principles of virus classification. (2) General structure of viruses; Viroids, Virusoids, Satellite viruses, and Prions. (2) Genome of plant and animal viruses. Mobile genetic elements. (4) Replications of RNA viruses. (5) Replication of DNA viruses. (5) Virus-cell interactions: cytopathology; virus entry and egress; host cell shut off and IRES; viral persistence and latency. (6) Methods to diagnose virus infections. (3) Antiviral vaccines. (3) Antivirals: interferons and its mechanisms of action. (2) Gene silencing. (2) Culture and purification of viruses. (2) Viral vectors and gene therapy. (2) New and emerging viruses (3)					
Text Books, and/or reference material		Text Books: 3. Principles of Virology: 4th Edition. By S. Jane Flint, Vincent R. Racaniello, Glenn F. Rall, Anna Marie Skalka, and Lynn W. Enquist. Reference Books: 4. Fields Virology by Lippincott Williams and Wilkins.					

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 615	**Biometallurgy**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Microbiology, Chemical Kinetics		CT+EA					

Course Outcomes	**CO 1:** To recapitulate the basics of bioenergetics and to understand the relevant biogeochemistry & microbiology. **CO 2:** To learn about the concepts of bioleaching and biobeneficiation along with the microbiological aspects **CO 3:** To learn about bioleaching processes with typical examples. **CO 4:** To analyze the kinetics of bioleaching **CO 5:** To understand the enzymatic mechanism of bioleaching.
Topics Covered	Recapitulation of basics of bioenergetics (ATP as an energy-rich molecule, oxidation-reduction reactions), Biogeochemical cycles – sulphur, iron, and manganese cycles. Nature and characteristics of biogeochemically important micro-organisms. (9) Bioleaching: definition, scope, advantages & disadvantages; Types: direct, indirect, & indirect contact. Types of bioleaching with respect to reaction intermediates (thiosulphate & polysulphide mechanisms). Autotrophs & heterotrophs as candidate microorganisms for bioleaching. Bioleaching by aerobic and anaerobic microorganisms. (9) Bioleaching processes: in situ, heap & dump, & reactor bioleaching. Bioleaching of copper by *Acidithiobacillus* from chalcopyrites, chalcocite, & covellite. Dump & heap and reactor bioleaching of copper. Uranium bioleaching & biobeneficiation of gold. Environmental pollution control in gold recovery processes. (9) Kinetics of pyrite bioleaching – two-subprocess mechanism- ferric leach kinetics & kinetics of bacterial oxidation of ferrous iron. Modelling of continuous tank bioleaching of pyrite – unsegregated and segregated models. (9) Oxidation of iron by Acidithiobacillus – enzymatic mechanism; role of cytochromes & rusticyanin, elements of electron transport pathways in iron & sulphur oxidation. (6)
Text Books, and/or reference material	**Text Books:** **1.** Pillai Abhilash, B. D. Pandey, K. A. Natarajan. Microbiology for Minerals, Metals, Materials and the Environment, CRC Press, 2018 **2.** Ross W. Smith & Manoranjan Misra, ed. Mineral Bioprocessing, The Minerals, Metals & Materials Society, 1991 **Reference Books:** 1. L. M. Prescott, J.P.Harley, D.A.Klein. Microbiology 5th edn. Mc-Graw Hill, 2002. 2. M.E. Curtin, Microbial mining and metal recovery biotechnology (1), pp 229-235, 1983 3. Woods D, Rawling D.E., Bacterial bleaching and biomining in marx J.L. (ed), Revolution in biotechnology, Cambridge University Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 616	Nanobiotechnology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC01 (Life Science), PHC01 (Physics), CYC01(Chemistry)		CT+EA					
Course Outcomes	• CO1: Acquire an idea about nanoscale phenomenon • CO2: To learn about the basic investigation tools for the nanobiotechnology • CO3: To learn about bottom up and top down synthesis of nanosystems • CO4: to get comprehensive understanding of applications of nanotechnology in biology						
Topics Covered	• Nanotechnology; introduction to miniaturization. (4) • Iinvestigation tools: experimental methods and probes; basic principles of scanning force microscopy; scanning electron microscopy; transmission electron microscopy. Investigation tools: lithography (8) • Nanomaterials: organic and inorganic nanoparticles. Synthesis, assembly, and processing of nanostructures: phenomenon of self-assembly. (6) • Molecular self-assembly and bottom up synthesis of nanomaterials. (6) • Nanoparticles and cancer therapeutics; nanoparticle-based drug delivery. (6)						

	• Nanofiber-based scaffolds and tissue engineering; nanodiagnostics and biosensing. (6) • Nanotoxicology. (4) • Future Concepts in Nanobiotechnology. (2)
Text Books, and/or reference material	Text Book: 1. Understanding Nanomedicine - An Introductory Textbook by Rob Burgess. Refrences Books 1. Springer Handbook of Nanotechnology, by Bharat Bhushan Springer 2. Nanobiotechnology: Concepts, Applications and Perspectives, by Christof M. Niemeyer, Chad A. Mirkin, John wiley 3. Introduction to Nanotechnology, by Charles P. Poole, Frank J. Owens, Wiley-Interscience 4. Nanofabrication and Biosystems : Integrating Materials Science, Engineering, and Biology, by Harvey C. Hoch, Lynn W. Jelinski, Harold G. Craighead, Cambridge University Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 617	**Marine Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes			
Topics Covered	**Marine biology**	Marine Microbiology	2
	Bioprocess engineering of marine products	Genetics for selection of marine species	1
		Dynamics of fish population, Outline of Fisheries biology / production	3
		Planktology	2
		Benthology and Fish Ecology	2
		Aquaculture- Physiology and Reproductive biology of Aquatic plants and animals	3
		Fish Physiology & Aquatic Biology	2
		Marine products- bioprocess engineering for Marine products	2
	Marine products	photobioreactors – light regime	1
		mass transfer and scale up, downstream processing of marine products	3
		Management of Marine production, Storage and transport.	3
		Marine natural products, valuable chemicals, bioactive compounds from micro-algae	3
	Specialized aspects	Cultivation of marine microorganism	1
		marine biomedical and bioactive compounds from marine organisms	2
		commercial bio-products from marine organisms	2
		biohydrogen production in photobioreactor, marine enzymes	3
		Marine bio-film and bio-remediation	2
		marine bio-sensor and transgenic marine organisms	2

		Marine Pharmacology: Potentialities in the Treatment of Infectious Diseases, Osteoporosis and Alzheimer´s Disease	3
		Molecular biodiversity	2
		marine products as biomarkers	2
		Economic and Regulatory Aspects of Marine Biotechnology	2
Text Books, and/or reference material			

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 619	Protein folding, misfolding and diseases	PEL	3	0	0	3	3
BTC401- Molecular biology & rDNA Technology; BTC 303 Biochemistry & Enzyme Technology; BTC 301 Cell biology and genetics		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1: To acquire an understanding of the protein structure • CO2: To learn about the principles of protein folding and misfolding • CO3: To obtain a comprehensive idea of different diseases related to protein misfolding • CO4: Development of cumulative understanding of protein folding, misfolding and diseases to find much-needed cure for the relevant conditions.						
Topics Covered	Basic of protein misfolding related diseases. The hierarchical structure of the protein. Principles of protein stability and folding. (16) Protein misfolding and aggregation. Protein quality control: molecular chaperones, protein degradation, autophagy and aging. (12) Prion Diseases. Alzheimer's Disease. Parkinson's Disease. Huntington's Disease and other unstable repeat disorders. Amyotrophic lateral sclerosis and frontotemporal lobar degeneration. (14)						
Text Books, and/or reference material	Text Books: 1. Fundamentals of Neurodegeneration and Protein Misfolding Disorders by Martin Beckerman, Springer 2. Introduction to Protein Structure by Carl IV Branden, Routledge 3. Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding by Alan Fersht, W. H. Freeman.						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

BTS 651	Molecular Biology and rDNA Technology Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To understand the principle of isolation of nucleic acids through different techniques. CO2: To understand the techniques used in manipulation of nucleic acids. CO3: To develop expertise to apply the toolsof gene cloning and solve the problems associated with production of recombinant protein from genetically modified microorganisms. CO4: To develop an idea for proper documentation of the work including laboratory procedures, experimental conditions, materials used, equipment used and the results CO5: To understand the basic hazards of working with nucleic acids and safety measures.						
Topics Covered	1. Isolation of genomic DNA 2. Quantification of DNA 3. Agarose Gel Electrophoresis of DNA 4. Isolation of RNA 5. Agarose Gel Electrophoresis of RNA 6. Isolation of plasmid – agarose gel electrophoresis (quantitation and purity test) 7. Restriction digestion of plasmid – agarose gel electrophoresis 8. Bacterial transformation using plasmid having antibiotic resistant marker and some other genetic markers. 9. Southern Blotting 10. PCR technique						
Text Books, and/or reference material	Sambrook et al., “Molecular Cloning” A Laboratory Manual						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS652	Bioinformatics Lab	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Programming and Data Structure (CSC431)		CT+EA					
Course Outcomes	• CO1: To acquire programming knowledgeto analyze biological data • CO2: To learn about different biological databases and retrieval of biological data in different file formats. • CO3: To learn different bioinformatics softwares related to sequence, structure and phylogeny						
Topics Covered	23. Bash programming(Linux commands) for data mining (3) 24. Handling Biological databases and sequence and structure retrieval (2) 25. Pairwise Sequence Alignment: BLAST tool and interpreting the results (1) 26. Multiple Sequence Alignment: Clustal, Muscle etc. (1) 27. Phylogenetics methods for phylogenetic tree constructions: Mega, Phylip (1) 28. C and Python scripts to analyse and interpret biological data (3) 29. Protein Structure and its visualization, structural alignmentsoftwares: PyMOL, Rasmol, VMD (1) 30. Protein Structure prediction softwares: Modeller, I-Tasser, Psipred (1) 31. RNA related softwares: Vienna Package (1)						
Text Books, and/or reference material	Text Books: 4. The Linux Command Line: A Complete Introduction 1st Edition by William E. Shotts Jr. 5. Python Crash Course by Eric Matthews Reference Books: 5. A Byte of Python by C.H. Swaroop 6. A Practical Guide to Linux Commands, Editors and Shell Programming 3rd Edition by Mark G. Sobell						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
BTE710	Molecular Plant Pathology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
BTC01		CE+EA					
Course Outcomes	CO1: To understand molecular mechanisms of plant defense systems. CO2: To understand molecular mechanisms of pathogenesis. CO3: To have the idea to design strategies for protection of plants.						
Topics Covered	Introduction to molecular plant pathology [1] Plant diseases [2] Plant disease development and environment [2] Effects of pathogen on plant physiology [2] Biochemistry of plant defense reactions [5]						

	Plant-pathogen interactions [5] Genetic regulation of resistance in host plants [5] Genetic regulation of virulence in pathogen [5] Mechanisms of host defense [5] Mechanisms of pathogenesis [5] Biotechnological approach for plant protection; genetically modified plants to protect against pathogens [5]
Text Books, and/or reference material	Text Book: 1. Plant Pathology; Fifth Edition, Elsevier; By Geroge N. Agrios. 2. Biochemistry and Molecular Biology of Plants; American Society of Plant Biologists; By Bob Buchanon, Wilhelm Gruissem and Russel Jones. 3. Plant Immunity; Methods in Molecular Biology, 2011, 712, Springer. 4. Plant-Pathogen Interactions; Methods in Molecular Biology; By Pamela Ronald, 2007, 354, Springer. 5. Plant-Pathogen Interactions; Annual Plant Reviews; By Nick Talbot, 2004, 11, Blackwell Publishing.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 711	Cancer Biology and Cell Signaling	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC301-Cell Biology and Genetics/BT-817- Cancer Biology		CT+EA					
Course Outcomes	• CO1: To understand the basic concepts of cancer biology and related cellular signaling • CO2: To understand the development and causes of cancer. • CO3: To understand the therapeutic aspects of cancer prevention • CO4: To identify the target molecules that are associated with cancer so that the cancer preventive small molecule inhibitors/phytochemicals can be screened.						
Topics Covered	**<u>Cancer Biology</u>** Introduction to Cancer and Molecular basis of cancer [2] Mutation and DNA damage repair mechanism [2] Cell cycle [3] Oncogenes (tumor viruses) , Tumor suppressors [3] Epigenetics, non-coding RNAs and genome fluidity in cancer [4] Cancer and Stem Cells, Angiogenesis, Apoptosis [4] Cancer therapy, Future of Cancer research [3] **<u>Cell Signaling related to cancer</u>** Introduction to cellular signaling [3] Signaling molecules – (e.g. Hormones, Interferons and others) [3] Receptor-mediated signaling in cells [3]						

	Role of different transcription factors and kinases (e.g. MAP kinases and other ser/thr kinases) [4] Involvement of different signal transduction pathways during cancer initiation, progression and metastasis [5] Small molecule inhibitors of cancer [3]
Text Books, and/or reference material	**Text Books:** 1. Weinberg RA. The Biology of Cancer, 2nd Edition. Garland Science, 2013. 2. Cellular signal processing , 2nd Edition by Friedrich Marks, Ursula Klingmuller and Karin Muller-Decker, Garland Science **Reference:** Selected reviews and primary scientific literature

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE712	FOOD BIOTECHNOLOGY	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To Quantitate and identify the spoilage microorganisms present in food. CO2: To learn the concepts of food fermentation and increase the shelf life of food. CO3: To learn the concepts in genetically modified food and increase the agricultural yield by using genetic engineering approach. CO4: To apply the concepts of antioxidant and nutraceutical for health and wellness. CO5: To follow the regulations and ethical issues of food safety by using good manufacturing practices in industry and genetically modified food.						
Topics Covered	**Food for health and wellness [2]** **Food Microbiology: [6]** Detection of microorganism in food – role of PCR, DNA CHIP, rapid methods for identification of microorganism in food, immunological methods, Bioassay, Biosensors-detection of toxin, heavy metal , pesticide and herbicides **Food preservation [10]**						

	Pasteurization, sterilization, Canning, Irradiation, Dehydration, low temperature Food preservation, use of preservatives, **Food fermentation** **[8]** Role of lactic acid bacteria in fermentation and strain improvement, Fermentation of meat, fish, vegetables, beverages , dairy product, non beverage product , use of genetic engineering techniques for improved quality product. **Genetically modified food** **[6]** Fruit ripening, improvement of sweetness, flavor, starch, amino acid, vitamin content, Golden rice. Safety aspects of genetically modified food, Single cell protein, single cell oil, Spirulina, **Biotechnology in relation to food product and Food Safety** **(5+5)** Antioxidant, nutraceutical, Nutrigenomics Legal status of irradiated food and preservatives, Concept of HACCP, Hazop, codex alimentarius, ISO series
Text Books, and/or reference material	**Text Book** Food microbiology by James . M. Jay Food Microbiology by Frazier and Westhoff Plant Biotechnology by Slater **Reference Book** Fundamentals of Food Biotechnology by Lee

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE713	Biopharmaceutical Process Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes							
Topics Covered	Manufacturing process - Drug substance manufacturing, drug product manufacturing, key factors for process evaluation. Manufacturing and storage of cell bank. Comparison of batch and continuous process for fermentation. Difference						

	between suspension fermenters for cell culture and microbial fermentation. [5] Design and construction of manufacturing facilities for mammalian cell derived pharmaceuticals. Detailed design of a GMP compliant plant with process flow diagram along with utilities, water treatment, waste management and location selection [5] Downstream processing - Harvest of therapeutic proteins from high cell density fermentation broths – centrifugation and filtration. Expanded bed adsorption for separating the biopharmaceutical product from crude solution. Ultrafiltration process design and implementation for biopharmaceutical product recovery. Virus filtration process design for biopharmaceutical product recovery. Product recovery of biopharmaceutical products from transgenic sources – aqueous two phase extraction [12] Role of process development group and manufacturing group in biopharmaceutical process start up. [3] Making changes to a biopharmaceutical manufacturing process during development and commercial manufacturing – a case study [2] Biosimilars and non-innovator biotherapeutics in India – an overview of current situation [2] Fundamental of Quality assurance, Structure of Quality Management Systems, Responsibility of Management and Training of Personnel, Quality Assurance in Development. [3] Quality assurance in manufacturing, GMP, Process validation for cell culture derived pharmaceutical proteins. Regulation [3]
Text Books, and/or reference material	**Books** Text 1. Process Scale Bioseparations for the Biopharmaceutical Industry, Abhinav A. Shukla, Mark R. Etzel, Shishir Gadam, CRC Press 2. Manufacturing of Pharmaceutical Proteins, Stefan Behme, Wiley-VCH References 1. Pharmaceutical Production Facilities: Design and Applications, Graham Cole, Informa Healthcare 2. Large-scale Mammalian Cell Culture Technology, Lubiniecki, CRC Press

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) /	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	

		Electives (PEL)					
BTE714	Bioenergy	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	1. Learn about energy crisis, problems of fossil fuel use, global warming 2. Learn about production of biological solid fuel. 3. Learn about gaseous biofuel production like methane and hydrogen in detail. 4. Learn about liquid biofuels as petrol alternative. 5. Learn about liquid biofuels as diesel alternative 6. Learn about benefits and deficiencies of biofuels, life cycle analysis 7. Learn about Indian initiatives on biofuel like jatropha cultivation and biohydrogen production.
Topics Covered	Energy and fossil fuel use – fossil fuel use, fossil fuel reserves, sustainable fuel sources[3] Consequences of burning fossil fuel – effects of industrial (anthropogenic) activity on greenhouse gases, sources of greenhouse gases [2] Mitigation of global warming – Kyoto protocol, reduction in global greenhouse gases, fuel cells, sequestration of carbon dioxide, alternative energy sources, energy storage. [3] Biological solid fuels – 1st, 2nd and 3rd generation biofuels, types of biomass available, energy and fuel generation using biomass. [4] Gaseous biofuels – methane production using anaerobic digestion process, sewage sludge and from landfill sites, use of methane as transport fuel. Hydrogen production from biological material, biological production of hydrogen, photosynthetic hydrogen production, hydrogen storage, use as transport fuel. Diethyl ether production [6] Liquid biofuels to replace petrol – methanol production. Large scale ethanol production from biomass, use of lignocellulosics for ethanol production, ethanol extraction after production, use of ethanol as fuel. Butanol production and use. [6] Liquid biofuel to replace diesel – synthetic diesel (FT synthesis), bio-oil (pyrolysis), microalgal biodiesel, biodiesel from plant oils and animal fats, properties of biodiesel, glycerol utilization. [4] The benefits and deficiencies of biofuels – reduction in fossil fuel use, fuel economy, reduction in carbon dioxide emission from biofuels, improvement in biodiesel quantity and quality, life cycle analysis of biofuels. [5] Jatropha cultivation, National hydrogen energy road map. [2

Text Books, and/or reference material	Books. 1. Biofuels production, application and development. Alan Scragg, CABI.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE715	Project Engineering for Biotechnology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes							
Topics Covered		Introduction Basic considerations in plant design, project identification, preliminary techno-economic feasibility. Process flow Diagrams and symbols: Symbols of Process Equipments & their concepts, types of flow diagrams, Importance of Laboratory development, pilot plant, scale up methods Piping and valves for biotechnology: design, piping materials, polishing, passivation, sizing of pipes and tubes, connections and cleanability, piping applications, supporting and insulating sanitary tubing, in-line instruments, hoses, valves. Cleaning of process equipment: design and practice, sterilization of process equipment, pharmaceutical water systems: design and validation, utilities for biotechnology production plant, biowaste decontamination systems, Heating, ventilating & air conditioning (HVAC) Programming & facility design, project planning, containment regulations affecting the design and operation of biopharmaceutical facilities. Planning, construction and commissioning of a biopharmaceutical manufacturing plant: planning, construction, commissioning, qualification, validation, project schedules, cost estimates, organization of an engineering project, role & selection of contractors, legal aspects of facility engineering, health, safety and environmental law, building law. Product sales and manufacturing costs: basic principles of cost calculation, fixed cost, variable cost, depreciation, interest, typical costs of biotechnological manufacturing processes, profit and loss calculation. Investments: investment targets, types of investments, investment appraisal, cost comparison, profit comparison, internal rate of return, dynamic payback time. Production concepts: capacity planning, dilemma of in-house manufacturing, aspects of manufacturing out-sourcing, contractual agreements, technology transfer, process optimization after market launch, supply chain management.					
Text Books, and/or reference material		Text Books: 1. Bioprocess engineering: system, equipment and facilities, B K Lydersen, N A D'Elia, K M Nelson. Wiley					

	2. Manufacturing of pharmaceutical proteins, Stefan Behme, Wiley Reference Books: 1. Plant design and Economics for chemical engineers, peter M. S. Timmerhaus, K. D. McGraw Hill. 2. Project Engineering with CPM and PERT, Modes J. Philips, Rheinhold publishers.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE 716	Structural Biology	PEL	3	0	0	3	3
BTC401- Molecular biology & rDNA Technology and BT C303 Biochemistry & Enzyme Technology		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1: To acquire understanding of the basic building blocks of life • CO2: To learn about the most common structural motifs found in protein and DNA • CO3: To understand the atomic level interaction between the protein and DNA • CO4: To learn how to determine protein structure						
Topics Covered	Basic structural principles - The building blocks, motifs of protein structure, alpha-domain structures, alpha/beta structures, beta structures, folding and flexibility, DNA structures. (8) Structure, function and engineering - DNA recognition in prokaryotes by helix-turn-helix motifs. (4) DNA recognition by eukaryotic transcription factors, specific transcription factors (5) Enzyme catalysis with example of serine proteinases, membrane proteins, signal transduction, fibrous proteins (8) Recognition of foreign molecules by immune system, structure of spherical viruses (8) Prediction, engineering and design of protein structures, determination of protein structures (10)						
Text Books, and/or reference material	Text Book: 1. Introduction to Protein Structure: Second Edition by Carl IV Branden, Routledge Reference book: 1. Structure and Mechanism in Protein Science A Guide to Enzyme Catalysis and Protein Folding: Alan Fersht						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE717	Environmental Biotechnology	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
	CT+EA

Course Outcomes	
Topics Covered	Air pollution control methods and equipment - Primary and secondary air pollutants, Effect of air pollutants on health, Control of gaseous and particulate pollutants, air pollution control equipments. 5 Water pollution: sampling and analysis - Sampling, BOD and COD analysis, Bacteriological measurements, Numerical problems 5 Water and waste water treatment processes - Overview of treatment principles. Primary treatment – screening, sedimentation, flotation, neutralization etc. 3 Secondary treatment - Activated sludge process, extended aeration, Trickling filter, Aerated lagoons, Waste stabilization ponds, Aquatic plant systems, UASB reactors. Design of a complete mix activated sludge process. 5 Biomethanation. Nitrification and denitrification operations. Phosphorus removal. Sludge treatment and disposal. Tertiary treatment. Membrane based treatment processes. 8 Solid waste management, Vermiculture, hazardous waste management 4 Specialized aspects - Bioremediation for recovery of metals, Xenobiotics, Degradation of chlorinated hydrocarbons, polyaromatic hydrocarbons, Phytoremediation. Reactors in bioremediation. 5
Text Books, and/or reference material	**Books** Text 1. Introduction to waste water treatment processes, Ramalho, Elsevier. 2. Environmental Engineering: A design Approach, Sincero, Arcadio. P, Sr. & Greogia; PHI 3. Waste water treatment and disposal, Arceivala, Wiley 4. Environmental Biotechnology, Alan Scragg, OxfordUniversity press Reference 1. Waste water Engineering: Treatment, disposal, reuse, by Metcalf & Eddy, Tata Mc Graw Hill Industrial Water Pollution Control, Eckenfelder, McGraw Hill.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE718	Proteomics and Protein Engineering	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
	CT+EA
Course Outcomes	
Topics Covered	
Text Books, and/or reference material	

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE719	Molecular Modelling & Drug Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Biochemistry and Enzyme Technology, Bioinformatics		CT+EA					
Course Outcomes	• CO1: To understand the physical basis of the structure, the dynamic evolution of the system, and the function of biological macromolecules. • CO2: To learn the fundamental concepts of structure-activity relationships • CO3: To learn design of novel, biologically active compounds and To elucidate the mechanism of action of drugs						
Topics Covered	1. Introduction to molecular Simulation Techniques (5) 2. Quantum chemistry for Modeling of small molecules (5) 3. Molecular Dynamics Methods- Molecular Dynamics of rigid non linear poly atomic molecules in ensembles, Structural information from M.D. (5) 4. Force fields for molecular modeling: Choice of functional form. Parametrization of a force field, Distributed multipole and polarizable forcefields, Hydrophobic effect and solvation energy. Potentials of mean force. (10) 5. Conformational analysis: Geometry optimization using steepest descent and conjugate gradients. Restrained and constrained molecular dynamics. Distance geometry. Case studies: Prediction of protein-protein interactions. DNA conformation. (10) Principles of ligand based drug design: SAR, QSAR and 3D-QSAR. Receptor based drug design: Principles of receptor based de novo ligand design. Rigid body molecular Docking. (7)						
Text Books, and/or reference material	Text Books: **1.** A R Leach-Molecular Modelling,. Principles and application 2nd edition–Prentice Hall. **2.** Krogsgaard, L-Text Book of Drug Design and Discovery-2002, Taylor and Francis, London						

	Reference Books: 1. G.Walsh-Biopharmaceuticals-Biochemistry and Biotechnology-2003, Wiley 2. Scolnick.J.(2001) Drug Discovery and Design .Academic Press, London N. R. Cohen, Editor. *Guidebook on Molecular Modeling in Drug Design*. Academic Press, San Diego, 1996.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE720	Nanotherapeutics	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes							
Topics Covered		**UNIT -I NANOPHARMACEUTICALS** **Nano-biotechnology for Drug Discovery** -Gold Nanoparticles for Drug Discovery -Use of Quantum Dots for Drug Discovery -Nanolasers for Drug Discovery -Cells Targeting by Nanoparticles with Attached Small Molecules . 5 Dendrimers , Nanobodies, Nanospheres-Nanotubes –Nano-cochleates.- Nano-molecular Valves for Controlled Drug Release –Nano-motors for Drug Delivery. 6 **UNIT - II ROLE OF NANOTECHNOLOGY IN BIOLOGICAL THERAPIES** **Development of nano medicines** – Nano Shells – Nano pores – Tectodendrimers – Nanoparticle drug system. Biomedical nanoparticles –Liposome's Different types of drug loading – Drug release – Biodegradable polymers. 5 Applications Nano biotechnologies for Single-Molecule Detection -Protease-Activated Quantum Dot Probes. 3 Nanotechnology for Point-of-Care Diagnostics –Nano diagnostics for the Battle Field – Nano diagnostics for Integrating Diagnostics with Therapeutics. 4 **UNIT – III APPLICATION IN CANCER THERAPY & NANOMEDICINE** **Introduction and Rationale for Nanotechnology in Cancer Therapy** -- Diagnostic approach by nano-sensing. 3 Passive Targeting of Solid Tumors: Pathophysiological Principles and Physicochemical Aspects of Delivery Systems -Active Targeting Strategies in Cancer with a Focus on\Potential Nanotechnology Applications. 5 Pharmacokinetics of Nano-carrier-Mediated Drug and Gene Delivery. 4						

Text Books, and/or reference material	**References:** 1. Kewal K. Jain , The Handbook of Nano-medicine Humana Press, (2008). 2. Zhang, Nanomedicine: A Systems Engineering Approach" 1st Ed., Pan Stanford Publishing, (2005). 3. Robert A. Freitas Jr., ―Nano-medicine Volume IIA: Biocompatibility, Landes Bioscience Publishers, (2003).

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE721	**BIOMATERIALS**	PEL	3	0	0	3	3
BT C303 Biochemistry & Enzyme Technology, CYC01 Chemistry		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1: Classify the biomaterials and recognize their production and properties. • CO2: Explain the application areas of biomaterials • CO3: To realize the important basic properties and requirements for biomaterials • CO4: Recognize the importance of relationships between living tissues and biomaterials						
Topics Covered	• Definition of biomaterials – biologically derived materials or materials compatible with biology. **(2)** • Common biomaterials: some proteins, many carbohydrates and some specialized polymers. **(4)** • Collagen (protein in bone and connective tissues): Structure production and its use. **(3)** • Fibroin (protein in silk): Production and its use. **(2)** • Production of these proteins by conventional cloning methods. **(3)** • Carbohydrates: Modified carbohydrates acting as lubricants for biomedical applications; Polydextrose; Carbohydrates modified by enzymes; **(8)** • Biopolymers: Synthesis from a simple biological monomer (eg hyaluronate polymers); Dextrans (used in chromatography columns); Rubberllike materials produced by bacteria and fungi (Polyhydroxybutyrate PHB), Polycaprolactone(PCL); Production of a copolymer of PHB and PHV(polyhydrovaleric acid), sold as Biopol by fermentation by Alcaligenes eutrophus; Biodegradable polymers **(8)** • Industrial biopolymers: Production of polyphenol resins by the enzyme soybean peroxidase; Evaluation of the properties of biopolymers to make good biomaterials; Tensile strength (both elasticity and breaking strength); Hydration, visco – elastic properties; viscosity. **(8)** • Biomaterials for Organ Replacement; Tissue Engineering; tissue replacements, cardiovascular; biodegradable and bioactive materials, drug delivery systems. **(4)**						
Text Books, and/or reference material	Text Book: 1. Biomaterials: Principles and Applications by J.B. Park and J.D. Bronzino. 2. Biomaterials: SUJATA V. BHATT, Second Edition, Narosa Publishing House,2005. 3. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoet and Lemons, Second Edition: Elsevier Academic Press, 2004. Reference book: 1. Biomaterials Science and Biocompatability, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE722	Vaccine Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC402/BT501 Immunology		CT+EA					
Course Outcomes	• CO1: To understand the factors that influence vaccine design and development • CO2: To understand how research based discovery has driven vaccine development • CO3: To know about the different types of vaccines • CO4: To learn about the quality control and regulation in the vaccine production • CO5: To understand the importance of vaccination as a public health strategy						
Topics Covered	History of vaccine development- Importance of vaccines (2) Immunological response to vaccines (2) Vaccine design and development: Epitope identification; Vaccine efficacy, Adjuvants (6) Different types of vaccines: Inactivated toxins, Inactivated whole bacteria or viruses, Live attenuated bacteria or viruses; Subunit vaccines, Polysaccharide vaccines, Conjugated vaccines ; Recombinant DNA vaccines, Edible vaccines, Virus like particles(8) Next-generation vaccines: Human Immunome project; Human antibodies as vaccines (4) Production techniques used for vaccines (4) Storage and preservation of vaccines (4) Delivery methods: microspheres, nanoparticles; ISCOMS and immunomodulators (6) Regulatory issues in vaccine production: OIE guidelines for production and seed lot management; Manufacturing recommendation; Final product release tests (5) Vaccine safety-the debate (1)						
Text Books, and/or reference material	Text Books: 1. New Vaccine Technologies: Ronald W. Ellis (Landes Bioscience), 2001. 2. Vaccines: Stanley A. Plotkin, Walter A. Orenstein, Paul A. Offit(Elsevier), 6th Edition Reference Books: 1. Medical Microbiology : Samuel Baron , 4th Edition (University of Texas) 2. Advances in Vaccine Technology and Delivery: Cheryl Barton, Espicom Business Intelligence. 3. "Vaccine manual: The production and quality control of veterinary vaccines for use in developing countries": Noel Mowat ,Daya books.						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE723	Stem Cell Biology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Cell Biology, Biochemistry, Genetics, Molecular Biology		CT+EA					
Course Outcomes	• CO1: To understand the basic mechanisms of how cells differentiate into specific tissues in response to a variety of biologic signaling molecules and the use of such factors for tissue production in-vitro.						

	• CO2: To acquire knowledge on the molecular basis of cellular and functional changes of different organs that occur in disease and treatments that cause tissue remodeling to correct these changes • CO3: To gather insights on how studies of the developmental, cellular and molecular biology of regeneration have led to the discovery of new drugs/therapy for regenerative therapy. • CO4: To understand the recent advances on application the regenerative therapy from well characterzied case studies.
Topics Covered	32. An Introduction to Stem Cells (2) 33. Adult Stem Cells (1) 34. Embryonic Stem Cells (1) 35. Induced Pluripotent Stem Cells (1) 36. Hematopoietic Stem Cells (1) 37. Messenchymal stem cells , cord blood cells, Lessons from Medipost company products like Neurostem, Cardiostem, Cartistem, Pneumostem (4) 38. Molecular and Cellular Bases of Organ Development (6) 39. Cloning of Somatic Cells by Nuclear Transfer, iPSC based cloning, Production of chimera animals (4) 40. Molecular Bases of degenerative disease (1) 41. Therapeutic Uses of Stem Cells with examples (2) 42. In vivo Regeneration of Tissues by Cell Transplantation (2) 43. IPS Cells as Experimental Models of Neurodegenrative Disorders: use of them as disease modelling platform, novel drug testing and tissue renerarative therapy and implantation studies(2) 44. Studies of Patients Treated with Stem Cells, The modalities of treatment, Preperation of cells/tissues/scaffolds and Trnasplantation procedure (3) 45. Tissue Regeneration Driven by Growth Hormones (2) 46. Organ of dish, Orgnoid culture, Tissue Bioprinting to develop transplantation quality organs, Bioartificial Organs (8) 47. Biobanking of stem cells and the ethical considerations in regenerative medicine. (2)
Text Books, and/or reference material	Text Books: 7. Stem Cells, Tissue Engineering And Regenerative Medicine By: David Warburton 1st Edition. 8. Principles of Regenerative Medicine by Anthony Atala Robert Lanza Tony Mikos Robert Nerem , 3rd Edition. 9. Translational Regenerative Medicine by Anthony Atala and Julie G. Allickson Reference Books: 1. The Developping Human by Keith L. Moore/T.V.N. Persaud/ Mark G. Tenth edition. 2. Encyclopedia of Tissue Engineering and Regenerative Medicine by Rui Reis, Ist Edtion.

Department of Biotechnology				
			Total Number of contact hours	Credit

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO740	Genetic Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	
Topics Covered	Introduction to Molecular Biology and Genetic Engineering: [3] Structures of macromolecules such as Carbohydrates, Proteins, Enzymes, Lipids and Nucleic Acids: [8] Basics of cell biology, prokaryotes vs. eukaryotes, sub-cellular structures, their organization and functions: [8] Central Dogma of molecular biology, DNA Replication, Transcription, Reverse Transcription, Translation: [8] Methods of genetic engineering; Genetic engineering of microbes, plants and animals: [8]
Text Books, and/or reference material	*Text Book:* Molecular Cell Biology by Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, Paul Matsudaira. Molecular Biology of the Cell by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts , Peter Walter. Molecular Biology of the Gene by James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick. *Reference Book:* 1. Biochemistry by Lubert Stryer. W. H. Freeman & Company, NY 2. Biochemistry by Lehninger. McMillan publishers

Department of Biotechnology				
	Title of the course		Total Number of contact hours	Credit

Course Code		Program Core (PCR) / Electives (PEL)	Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 751	Bioseparation and Biochemical Analysis Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end-term examination (ET))					
Bioseparation & Biochemical Analysis (BTC 503)		CA+ET					
Course Outcomes	**CO1:** To determine the specific cake resistance & filter medium resistance by constant pressure filtration/pressure-time variation in constant rate filtration **CO2:** To prepare a cell-free extract by sonication/homogenization and identify a specific protein therein by Western Analysis **CO3:** To learn the technique of salt precipitation of a protein and subsequent dialysis for removal of the salt and to get an idea of other equipment for concentrating a protein **CO4:** To construct a binodial diagram and study the extraction of a protein in an aqueous two-phase system **CO5:** To separate out a protein from a mixture by gel filtration/ion exchange chromatography and to concentrate a protein by ultrafiltration **CO6:** To extract and estimate biomolecules such as lipids, DNA, & RNA						
Topics Covered	1. Filtration (constant pressure filtration) 2. Preparation of cell-free extracts from cultured cells 3. Salt precipitation of protein and Dialysis 4. Extraction and estimation of total lipid content 5. Separation/concentration of proteins by Ultrafiltration. 6. Aqueous two phase extraction (binodial diagram) 7. Separation of proteins by gel permeation/ion-exchange chromatography 8. Identification of a specific protein present in the cell-free extract by Western Analysis 9. Determination of DNA and RNA concentration by UV absorption 10. Demonstration of lyophilization & Rotary vacuum evaporation						
Text Books, and/or reference material	Textbooks : 3. Practical Biochemistry Principles and techniques (5th ed)/ Principles and Techniques of Biochemistry and Molecular Biology (7th ed): Editor Wilson and Walker, Cambridge University Press 4. Geankoplis, Transport Processes & Unit operations, PHI. Reference books: 4. D. Holme & H. Peck, Analytical Biochemistry, 3rd ed, Longman, 1998 5. Shuler & Kargi, Bio-process Engg. PHI 6. Bailey & Olis, Biochemical Engg. Fundamentals, McGraw-Hill						

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS752	CELL & TISSUE CULTURE LAB	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC01 Life Science BTC301 Cell Biology and Genetics BTC 502 Cell and Tissue Culture		CT+EA					

Course Outcomes	CO1: Students will be acquainted with basic plant tissue culture techniques. CO2: Students will be acquainted in basic animal cell culture techniques. CO3: Students will attain knowledge of application of cell and tissue culture techniques in academic and industrial laboratories. CO4: Students will have knowledge of biosafety and ethical issues related to cell and tissue culture.
Topics Covered	**Plant Tissue Culture** 1. Preparation and sterilization of plant tissue culture media. 2. Preparation of explants. 3. Callus induction in rice. 4. Regeneration of rice callus tissue. 5. Rooting of regnerants in rice. **Animal Cell Culture** 6. Sterilization Techniques, Preparation of Media & Preparation of Sera 7. Primary Cell Culture 8. Preparation of established Cell lines 9. Cell Counting and Viability 10. Staining of Animal Cells & Preservation of Cells
Text Books, and/or reference material	1. Laboratory manual.

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 753	BIOCHEMICAL REACTION ENGINEERING LABORATORY		0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	
Topics Covered	1. Microbial cell growth kinetics 2. Microbial cell inhibition kinetics 3. Substrate degradation, cell growth and product formation study using immobilized cells in a continuous packed bed reactor. 4. Substrate degradation, cell growth and product formation study using immobilized cells in a continuous fluidized bed reactor. 5. Function of bioreactor- a) calibration of DO electrode. b) Calibration of pH electrode. 6. RTD studies in a packed bed reactor
Text Books, and/or reference material	

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 754	Vocational Training / Summer Internship and Seminar		0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes							
Topics Covered							
Text Books, and/or reference material							

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS755	Project-I	PCR	0	0	3	3	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
All the Program Core subjects		CT and EA					
Course Outcomes	CO1: To design, analyze and solve biological, clinical and biotechnology related research problem problems through participating in scientific project works. CO2: Familiarization with recent researches in the field of biotechnology. CO3: To develop skills to perform experiments, get familiar with different cutting edge technologies used to answer research questions and have hands on training on the related area. CO4: To learn to interpret data, draw conclusion and develop trouble shooting skills. CO5: To learn to present data, and defend a hypothesis forming the basis of a scientific study.						
Topics	11. Each student has to choose a Principle Investigator depending on his/her research interest and inclination and has to get involved in any ongoing research project. 12. Students are required to familiarize themselves with the literature review and scientific techniques and skills.						

Text Books, and/or reference material	**Reference** • Related research papers.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE810	Plant Developmental Biology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					

Course Outcomes	
Topics Covered	Embryogenesis and Organogenesis (4) Soot and root apical meristem (2) Growth of seedlings (5) Environmental Factor (2) Totipotency (4) Phototropism and gravitropism (3) Plant morphology (2) Photomorphogenesis (6) Phytohormones (4)
Text Books, and/or reference material	**Text/reference book:** 1.Lewin B: Genes 2. Albert, B. Molecular biology of the cell

Department of Biotechnology				
	Title of the course		Total Number of contact hours	Credit

Course Code		Program Core (PCR) / Electives (PEL)	Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE811	Bioprocess Plant & Equipment Design	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes							
Topics Covered							

Plant Location and Site Selection:

(5)

- Site and Plant Layout
- Utilites
- Storage Methods and Material Handling
- Plant operation and Control systems
- Environmental considerations

Conventional and unconventional bioreactors and their Design:

(12)

- Batch, Continuous stirred tank bioreactors (CSTBR)
- Plug flow bioreactors
- Enzyme and immobilized bioreactors
- Fluidized bed bioreactors,
- Bubble column bioreactors and Air- lift bioreactors
- Hollow- fiber bioreactors
- Membrane bioreactors
- Bioreactors for plant and animal cell culture systems
- Ideal and non ideal reactors

Sterilization of Bioreactors:

(4)

- Design of Batch and Continuous Media Sterilizers
- Design of Air Sterilizers.

Instrumentation and Control of Bioprocesses:

(4)

- Physical and chemical environmental sensors
- Computer control of bioreactors

Modelling and Simulation of Bioprocesses:

(2)

- Study of structured and unstructured models for analysis of various processes

Design of Bioreactor systems:

(6)

- Design of Filtration and Centrifugation equipments
- Design of Driers.

	• Refrigeration systems • Steam Generation systems • Pumps **Cost Analysis in Bioprocess Engineering:** **(2)** • Estimation of capital investment and operating cost
Text Books, and/or reference material	**Text Books:** 1.Bioprocess Engineering Principles, by Pauline M.Doran Academic Press 2. Bioprocess Engineering ,Kinetics, Biosystems, Sustainability and Reactor Design by Shijie Liu Elsevier 3. Coulson & Richardson's Chemical Engineering Vol.6 Butterworth-Heinemann **Reference Books:** 1. Plant design and Economics for chemical engineers by Peter M. S. Timmerhaus, K. D. McGraw Hill. 2. Coulson & Richardson's Chemical Engineering Vol.3 Butterworth-Heinemann

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE812	Medical & Pharmaceutical Biotechnology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes							
Topics Covered		**Introduction -** Biopharmaceuticals and their development, historical aspects, general steps in development of a drug, sources and strategies (including random, non-random, and rational) of discovering lead compounds 2 **Drug designing** Macromolecules as Targets of drugs: (lipids, carbohydrates, proteins, nucleic acids) 2					

	Drug targets: carrier proteins, structural proteins, enzymes, receptors (including mechanisms – ion channels and membrane-bound enzymes) 4 Concepts and design criteria of agonists, antagonists, partial agonists, and inverse agonists. 3 Rational drug designing, Structure –activity relationships and identification of pharmacophore and auxophore in a lead compound; drug design on the basis of drug-target interactions. 5 **Disease diagnosis** PCR, LCR immunological assay, Detection of genetic, Neurogenetic disorders involving Metabolic and Movement disorders. Treatment-products from recombinant and non-recombinant organisms, Interferons, Antisense therapy, cell penetrating peptides. Gene therapy, Types of gene therapy, somatic virus germline gene therapy, mechanism of gene therapy, Immunotherapy. Detection of mutations in neoplastic diseases MCC, SSCP, DGGE, PTTC. Use of enzymes in clinical diagnosis. Use of biosensors for rapid clinicalanalysis. Diagnostic kit development for microanalysis, Diagnosis of disease by proteomics. 25 **Production of pharmaceuticals** Production of pharmaceuticals by genetically engineered cells (hormones, interferons). Microbial transformation for production of important pharmaceuticals (steroids and semi-synthetic antibiotics). Techniques for development of new generation antibiotics. 15 Drug delivery
Text Books, and/or reference material	Textbooks: 1. An Introduction to Medicinal Chemistry; Graham L.Patrick, Oxford Reference Books: 1. The Organic Chemistry of Drug Design and Drug Action; Richard B. Silverman, Elsevier

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE813	GM Crops	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
BTC402 (Cell & Tissue Culture of Animals & Plants)		CT+EA					
Course Outcomes	CO1: Development of knowledge of natural resistance / tolerance to various biotic and abiotic stress to plants. CO2: Development of ability to design strategy to genetically modify crop plants for quality improvement. CO3: Learning about the strategies toward generating environment friendly GM crops.						

Topics Covered	Introduction	[2]
	Methods of genetic transformation	[4]
	Genetic engineering of resistance to biotic stress	[6]
	Genetic engineering of tolerance to abiotic stress	[6]
	Genetic engineering for removal of environmental pollutants	[4]
	Genetic engineering for quality nutrition and health	[4]
	Genetic engineering for molecular farming	[4]
	Biosafety concerns	[4]
	Removal of selectable markers from GM crops	[4]
	Modern tools of genetic manipulation of plants	[4]
Text Books, and/or reference material	Text Books: 1. H.S.Chawla, Introduction to Plant Biotechnology, Oxford & IBH Publishing co. Pvt..Ltd 2. Slater.A.,Nigel W.S,Flower.R.Mark , Plant Biotechnology: The Genetic Manipulation of Plants, 2003, Oxford Univesity Press. Reference Book: 3. Buchaman, Gursam, Jones, Biochemistry and Molecular Biology of Plants, 1ed, 2000, L.K.International. 4. Bhojwani and Razdan –Plant Tissue Culture: Theory and Practice 1996 Elsevier	

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE815	Bioethics and IPR	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	CO1: To understand the nature of hazards related to biotechnology and the importance of biosafety in research. CO2: To learn and debate on different ethical issues of applications of Biotechnology research including recombinant DNA technology and Human trials. CO3:To realize the importance and basics of intellectual property Rights and laws implemented in this regard. CO4: To learn the basic way to file claim of a patent. CO5: To understand the idea about Entrepreneurship and its economic implication in the area of biotechnology research						
Topics Covered	**Biotechnology and Society:** Introduction to science, technology and society, biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit						

	sharing, environmental sustainability, public vs. private funding, biotechnology in international relations, globalization and development divide. (8) **Bioethics:** Legality, morality and ethics, the principles of bioethics: autonomy, human rights, beneficence, privacy, justice, equity etc. (6) **Biotechnology and Bioethics:** The expanding scope of ethics from biomedical practice to biotechnology, ethical conflicts in biotechnology - interference with nature, fear of unknown, unequal distribution of risks and benefits of biotechnology, bioethics vs. business ethics. (7) Ethical dimensions of IPR, technology transfer and other global biotech issues. Jurisprudential definition and concept of property rights, duties and their correlations, history and evaluation of IPR – like patent design and copyright. Distinction among the various forms of IPR, requirements of a patent able invention like novelty, inventive step and prior art and state of art. (8) **Regulations on ethical principles in biomedical/ biotechnological practice:** The Nuremberg code, declaration of Helsinki; the Belmont report, co operational guidelines – WHO, guidelines of DBT (India), Guidelines of an informed consent Rights/ protection, infringement or violation, remedies against infringement, civil and criminal, Indian patent act 1970 and TRIPS major changes in Indian patent system, post-TRIPS effects. (7) Contents of patent specification and procedure for obtaining a) patents b) Geographical indication, c) WTO Detailed information on patenting biological products, Biodiversity (6)
Text Books, and/or reference material	Textbook: 1. F. H. Erbisch and K. M. Maredis, Intellectual Property Rights in Agricultural Biotechnology, Bios Publishers Text / Reference Books:

	1. Thomas, J.A., Fuch, R.L. (2002). Biotechnology and Safety Assessment (3rd Ed). Academic Press. 2. Fleming, D.A., Hunt, D.L., (2000). Biological safety Principles and practices (3rd Ed). ASM Press, Washington. 3. Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. 4. Encyclopaedia of Bioethics

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTE815	Environmental Microbiome	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Microbiology and Bioprocess Technology (BTC302); Molecular Biology and recombinant DNA Technology (BTC401) ; Bioinformatics (BTC601)		CT+EA					
Course Outcomes	CO1: Develop understanding of Microbial Diversity and Ecology. Understand the Physicochemical and biological factors that define the microbiome in different environments as well as the significance of microbial interaction with environment CO2: Learn about the important tools and techniques used to study microbial ecology or microbiome structure. Learn to apply "Omics" approaches to assess the microbial community structure and function. CO3: Understand the System biology approach to assess the interaction and function of microbiome members in global scale. CO4: Learn to exploit microbial community members for Resource recovery, Environmental clean-up, CH_4 production and consumption, CO_2 sequestration, etc.						
Topics Covered	**Introduction**- Significance, developments and challenges of environmental microbiome study. (4) **Microbial Diversity and ecology**- Environments and microenvironments, ecosystem services, biogeochemistry and nutrient cycles, carbon-nitrogen-sulfur-and other nutrient cycles. (5) **Survey of microbiome in different habitats-** Microbiomes of Terrestial, Marine, Freshwater, Deep sea, Hydrothermal vents, Subsurfaces, Permafrost region etc. Earth microbiome and Human microbiome Project. (5)						

	Microbiome of the built environment- Microbial interactions with environment, microbial influenced corrosion, microbial enhanced oil recovery, mineral recovery, bioremediation of heavy metals and organic pollutants, methane production and consumption (5) **Microbiome characterization**- Metagenomics, metaproteomics and metatranscriptomics, culture dependent and culture independent techniques, conventional and molecular analyses, assessment of microbial metabolic diversity and activities. (6) **System Biology and Microbial interaction**- Approach of system biology in bioremediation, bioremediation with genomics, interaction between community members within microbiome, commensalism, syntrophism, interspecies hydrogen transfer etc. Strategies of bioremediation, Microbial performance assessment. (7)
Text Books, and/or reference material	**Text Book** Brock Biology of Microorganisms- Madigan, Martinko, Bender, Buckley and Stahl- Pearson publisher. Bioremediation and Natural Attenuation: Process Fundamentals and Mathematical models- P J J Alvarez and W A Illman- Wiley Interscience. **Reference Books** Environmental Microbiology: from genomes to biogeochemistry- Eugene L.Madsen- Blackwell Publishing. Environmental Microbiology for Engineers- V.Ivanov- CRC Press. Environmental Microbiology- Maier, Pepper and Gerba- Elsevier (Academic Press).

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO 710	**Industrial Biotechnology**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Life science		CT+EA					
Course Outcomes	CO1- To understand the methods of cell 's bio processing under various conditions, strain improvement methods for better results CO-2 Demonstrate the experimental techniques associated with aseptic processes, media preparation and related upstream processes CO-3 .Design and develop medium for cell cultivation for fermentation process Apply the knowledge of sterilization techniques CO-4 Understand needs of various parts of fermenter and their operation and Design bioreactor based on thumb rules for fermentation operation CO-5 Apply the knowledge of Purification Separation and kinetics theory of Enzyme production for industrial fermentation						
Topics Covered	**UNIT 1 CELL CULTIVATION ,GROWTH KINETICS** -- 10 Hrs Media development for Cell growth and culture for microbes , plant, animal -derived cells and its application. Microbial growth kinetics, logistic growth model, growth of filamentous organism Strain improvement of industrial micro organism. Measurement of cell mass. Cell immobilization. Numericals.. **UNIT 2-MEDIA PREPARATION and STERILIZATION** 10 Hrs Sterilization: basic concepts in sterilization insitu and ex-situ sterilization, Sterilization of medium, air, filters, fermenter. Types of media, Strain preservation , inoculum preparation, Development of inocula for industrial fermentation/ seed fermenter **UNIT 3- BIOREACTOR DESIGN AND ITS OPERATION- 12 Hrs** Purpose and importance of bioreactor, Parts of fermenter and types ; Oxygen requirement, Oxygen transfer in fermenter, , KLa measurement, Measurement of dissolved oxygen concentrations, Estimating Oxygen Solubility'Operational modes of bioreactor: batch, semi-batch/fedbatch, continuous. Major components of bioreactor and its purpose, classification of Bioreactor – SLF, SSF, animal and plant cell culture. Classification of bioreactors for environmental control and management. Fixed bed bioreactor, airlift reactor, hollow fibre reactor, seed reactor.						

	UNIT 4 INDUSTRIAL ENZYMES ,PURIFICATION and A PPLICATIONS -10Hour Enzyme engineered for new reactions-novel catalyst for organic synthesis. Case studies: thermozymes cold adopted enzymes. Ribozymes, therapeutic enzymes of industrial importance (amylase, glucose isomerase, cellulose, lipase, protease, xylanase, invertase, peroxidases). Separation of insolubles: filtration, centrifugation. Extraction and purification of solubles: Ultra filtration, high performance tangential flow filtration, Recovery and purification of intracellular products: cell disruption, chromatographic techniques. Analytical assays of purity level of enzymes.
Text Books, and/or reference material	TEXT BOOKS: 1. Pauline M. Doran, "Bioprocess Engineering Principles", Academic Press, 2 nd Ed., 2012. 2. El-Mansi (Ed.), "Fermentation Microbiology and Biotechnology", CRC Press, 3rd Ed., 2011. REFERENCE BOOKS: 1. Ashok Pandey et al., "Enzyme Technology", Springer Publisher, 2006. 2. Nielsen et al., "Bioreaction Engineering Principles", Plenum Publishers, 2nd Ed., 2002. 3. Mohammed A. Desai (Ed.), "Downstream Processing of Proteins: Methods and Protocols", Humana Press, 2000. 4. Satinder Ahuja, "Handbook of Bioseparations", Vol 2, Academic Press, 1st Ed., 2000.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTO850	Medical Biotechnology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes							
Topics Covered		**Microbial pathogenesis:** Definitions - Infection, Invasion, Pathogen,Pathogenicity, Virulence, Carriers and their types, Opportunistic infections, NosocomialInfections, epidemics. **Diagnosis of Infectious diseases**–Biology of Nitric oxide implications in diagnosis and therapeutics, Ethical problems around prenatal diagnosis, *in vitro* fertilization, cloning, gene therapy. **DrugDesign and Drug delivery system :** Synthesis of compounds in accordance with the molecular structure and biological activity concept. Various principles/ mode of drug action/ screening of drugs/ drug analysis using various techniques . New generation viral vectors for Gene Therapy and advancement in Drug Delivery system, antibody mediated drug delivery of vaccines, Antibiotics **Molecular Medicine:** Antibodies and vaccines-Therapeutic production of antibodies different kind of vaccines and applications of recombinant vaccines.Ribozymes for therapeutic use in viral infection .					

	Cell and tissue therapy – Gene therapy, tissue engineering, stem cell and cloning. In vivo targeted gene delivery **Clinical Toxicology**,**Clinical Research Governance and Ethics:** Basic concept in toxicology. Types and mechanism of toxin action- Epoxidation& drug toxicity, Overview on regulatory affairs for pharmaceuticals, neutraceuticals and medical devices. . International quality standard and related guidelines (ICH-E6). Risk assessment and trial monitoring. Legal and ethical issues on biotechnology, medical research and related clinical practice.
Text Books, and/or reference material	Textbooks 1. Recombinant DNA: Genes and Genomes - A Short Course, Third Edition (Watson, Recombinant DNA) by James D. Watson; Cold Spring Harbor Laboratory Press 2. Biopharmaceuticals- Biochemistry and Biotechnology: Gary Walsh; John Wiley & Sons 3. S. P. Vyas, V. Dixit, Pharmaceutical Biotechnology, CBS Publishers 4. Cedric A and Mim S. et al.: Medical Microbiology, Mosby USA Reference Books 1. Pharmaceutical Biotechnology ; Sambhamurthy & Kar , NewAge Publishers 2. Epenetos A.A.(ed), Monoclonal antibodies: applications in clinical oncology, Chapman and Hall Medical, London 3. V.Venkatesharalu -Biopharmaceutics and Pharmacokinetics-Pharma Books Syndicate 4. Diagnosis: A Symptom-Based Approach in Internal Medicine; C.S.Madgaonkar, Publisher: JPB

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS851	Project-II	PCR	0	0	15	15	5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
All the Program Core subjects		CT and EA					
Course Outcomes	CO1: To design, analyze and solve biological, clinical and biotechnology related research problem problems through participating in scientific project works. CO2: Familiarization with recent researches in the field of biotechnology.						

	CO3: To develop skills to perform experiments, get familiar with different cutting edge technologies used to answer research questions and have hands on training on the related area. CO4: To learn to interpret data, draw conclusion and develop trouble shooting skills. CO5: To learn to present data, and defend a hypothesis forming the basis of a scientific study.
Topics	13. Each student has to choose a Principle Investigator depending on his/her research interest and inclination and has to get involved in any ongoing research project. 14. Students are required to familiarize themselves with the literature review and scientific techniques and skills.
Text Books, and/or reference material	**Reference** • Related research papers.

Department of Biotechnology							
Course Code	Title of the course	Program Core (PCR) / Electives (PCR)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTS 852	Project Seminar	PCR	0	0	0	0	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
All the Program Core subjects		EA					
Course Outcomes	CO1: To familiarize developing skills of oration and ability to present an analysis/interpretation or conclusion pertaining to biological, clinical and biotechnology related research problems. CO2: To develop presentation skills including making PowerPoint presentation with proper animation and schema to convince the audience about a hypothesis/ conclusion. CO3: To develop skills to address scientific questions pertaining to hypothesis, data interpretation and conclusions.						
Topics	15. Each student after completing the project training under a Principle Investigator has to present the progress/conclusion/interpretation explaining their research project.						
Text Books, and/or reference material	**Reference** • Related research papers.						
