MSc BIOTECHNOLOGY
CHOICE BASED CREDIT SYSTEM(CBCS)
DEPARTMENT OF GENETICS & BIOTECHNOLOGY, OSMANIA UNIVERSITY
Course structure for Instruction and Examination (Proposed Scheme for Academic year **2020** onwards)

SEMESTER- I

S No	Syllabus Ref No	Subject		Teaching Hours	Marks		
					Internal Assessment	Semester Exam	Total
	THEORY						
1.	BT 101 T	Cell Biology and Genetics	4	4	20	80	100
2.	BT 102 T	Biological chemistry	4	4	20	80	100
3.	BT 103 T	Microbiology	4	4	20	80	100
4.	BT 104 T	Biostatistics, laboratory management & safety, entrepreneurship	4	4	20	80	100
	PRACTICALS						
1.	BT 151 P	Cell Biology and Genetics	2	4		50	50
2.	BT 152 P	Biological chemistry	2	4		50	50
3.	BT 153 P	Microbiology	2	4		50	50
4.	BT 154 P	Biostatistics	2	4		50	50
		Total	**24**	**32**			**600**

SEMESTER- II

S No	Syllabus Ref No	Subject		Teaching Hours	Marks		
					Internal Assessment	Semester Exam	Total
	THEORY						
1.	BT 201 T	Molecular Biology-The Genome	4	4	20	80	100
2.	BT 202 T	Molecular Biology-Genes to Proteins	4	4	20	80	100
3.	BT 203 T	Immunology	4	4	20	80	100
4.	BT 204 T	Microbial Technology	4	4	20	80	100
	PRACTICALS						
1.	BT 251 P	Molecular Biology-The Genome	2	4		50	50
2.	BT 252 P	Molecular Biology- Genes to Proteins	2	4		50	50
3.	BT 253 P	Immunology	2	4		50	50
4.	BT 254 P	Microbial Technology	2	4		50	50
		Total	**24**	**32**			**600**

M. Sc BIOTECHNOLOGY COURSE STRUCTURE
CBCS syllabus

SEMESTER- III							
S No	**Syllabus Ref No**	**Subject**		**Teaching Hours**	**Marks**		
					Internal Assessment	**Semester Exam**	**Total**
	THEORY						
1.	BT 301 T	Recombinant DNA technology	4	4	20	80	100
2.	BT 302 T	Bioinformatics and its Applications	4	4	20	80	100
3.	BT 303 T	**Elective:** A. Advances in Plant Biotechnology (or) B. Food Biotechnology	4	4	20	80	100
4.	BT 304 T	**Elective:** A. Animal Biotechnology (or) B. Protein Engineering	4	4	20	80	100
		PRACTICALS					
1.	BT 351 P	Recombinant DNA technology	2	4		50	50
2.	BT 352 P	Bioinformatics and its Applications	2	4		50	50
3.	BT 353 P	A. Advances in Plant Biotechnology (or) B. Food Biotechnology	2	4		50	50
4.	BT 354 P	A. Animal Biotechnology (or) B. Protein Engineering	2	4		50	50
		Total	**24**	**32**			**600**

SEMESTER- IV							
S No	**Syllabus Ref No**	**Subject**		**Teaching Hours**	**Marks**		
					Internal Assessment	**Semester Exam**	**Total**
		THEORY					
1.	BT 401 T	Bioprocess Engineering	4	4	20	80	100
2.	BT 402 T	Medical Biotechnology	4	4	20	80	100
3.	BT 403 T	**Elective:** A. Environmental Biotechnology (or) B. Biopharmacology	4	4	20	80	100
4.	BT 404 T	Project Work	4	4	20	80	100
		PRACTICALS					
1.	BT 451 P	Bioprocess Engineering	2	4		50	50
2.	BT 452 P	Medical Biotechnology	2	4		50	50
3.	BT 453 P	A. Environmental Biotechnology (or) B. Biopharmacology	2	4	-	50	50
4.	BT 454 P	Project thesis presentation	2	4		50	50
		Total	**24**	**32**			**600**
		GRAND TOTAL					**2400**

***T-Theory, P-Practical**

SEMESTER-I
THEORY PAPER-I
BT 101 T- CELL BIOLOGY AND GENETICS

1. **Course Objectives (C. Obj.):**
   a. Understand basic aspects of intracellular organization of a eukaryotic cell
   b. To comprehend the Mendelian Genetic principles in humans, plants and animals
   c. Obtain basic knowledge of hierarchical structure and organization of chromosomes, insight into chromosomal anomalies and learn the science behind gene mapping in eukaryotes
   d. To comprehend the biochemical and molecular processes of cell division and cell death

2. **Course Outcomes (C.O):**
   a. Comprehend the cellular architecture and processes
   b. Ability to apply Mendelian inheritance principles to humans, plants and animals
   c. Appreciate the importance of fidelity of chromosome organization and gain an ability to localize genes by appropriate techniques.
   d. Knowledge regarding the basic mechanisms underlying cell division and cell death

Course Plan / Schedule

Unit No.	Topics to be covered	No. of lectures
Unit-1	**Internal Organization of Cell**	
1.1	Membrane structure– lipid bilayer, properties of lipid bilayer, lipid rafts, membrane proteins– peripheral and integral proteins, electric properties of membrane	2
1.2	Structure and function of Endoplasmic reticulum, Structure and function of Golgi Complex, Structure and function of Lysosomes	3
1.3	Structure, biogenesis and functions of mitochondria	2
1.4	Structure, biogenesis and functions of chloroplast	2
1.5	Structure & function of cytoskeleton- introduction to microfilaments, intermediate filaments, microtubules, myosin structure and role in motility	3
1.6	Intracellular protein transport- secretory pathway; protein transport into nucleus, chloroplast and mitochondria; endocytosis and exocytosis	4
Unit-2	**Principles of Inheritance**	
2.1	Chromosome theory of inheritance; Mendel's Laws - Law of segregation & Law of independent assortment- test cross and back cross	2
2.2	Extension to Mendel's Laws- Incomplete dominance (e.g. Flower Color), Codominance (e.g. MN Blood groups); Non allelic interactions- Types of Epistasis, modification of dihybrid ratios; Multiple Allelism (e.g. Coat color in Rabbits, eye color in Drosophila, ABO Blood groups, Rh blood groups, S locus in Nicotiana)- incompatibility and pseudoallelism, Complex loci- R-locus in maize	3
2.3	Penetrance and Expressivity (e.g. Polydactyly, Waardenburg Syndrome), Pleiotropism (e.g. Bardet Biedel Syndrome, Marfan syndrome), Phenocopy (e.g. Microcephaly)	2
2.4	Sex determination in Drosophila, Birds, Man and Bonellia; X-linked inheritanceHemophilia, Color blindness, Lyonization; Y-linked	3

	inheritance- Holandric genes; Sex limited and sex influenced characters; Inheritance patterns in Man-Pedigree analysis	
2.5	Polygenic inheritance, Additive effect- Skin color in man, Kernel color in maize	2
2.6	Non- Mendelian inheritance-Maternal inheritance-Variegation in leaves of higher plants- Mirabilis Jalapa, Poky in Neurospora, Maternal effect - Shell coiling in snails, Uniparental inheritance-mutations in extra nuclear genes in Chlamydomonas, Male sterility in Maize	4
Unit-3	**Chromosomes– Organization and Aberrations, Linkage mapping**	
3.1	Chromosome- morphology, classification, Karyotyping; Features of centromere and telomere; Specialized chromosomes- Polytene & lamp brush chromosomes; Variation in chromosome number- Euploidy, Aneuploidy; Variation in chromosome structure -deletions, duplications, translocations and inversions	4
3.2	Chromatin organization- Nucleosome, loops and scaffolds; Nucleosome phasing ; Chromatin under transcription- euchromatin and heterochromatin	3
3.3	Cytological proof of crossing over- Creighton and McClintock's experiment, correlation between chiasmata and crossing over	2
3.4	Phases of linkage, test cross, recombination frequency, gene mapping, determination of map distances based on two and three point test crosses, coincidence, interference (e.g. Drosophila, Maize)	2
3.5	Tetrad analysis- Neurospora; Mitotic crossing over- Aspergillus, Drosophila	2
3.6	Gene mapping and applications	3
Unit-4	**Cell Division and Cell Death**	
4.1	Cell cycle: Phases (interphase and M phase) and Check points in cell cycle, overview of mitosis and meiosis	3
4.2	Biochemistry of cell division cycle: cyclins and CDKs, APC and SCF complexes, spindle machinery and molecular motors	4
4.3	Mitosis: Stages and molecular mechanisms	2
4.4	Meiosis: Stages and molecular mechanisms	3
4.5	Cellular processes: cell growth, cell differentiation, senescence, autophagy	2
4.6	Cell death: Necrosis, apoptosis (intrinsic and extrinsic pathways)	2

PRACTICALS

BT 151 P: CELL BIOLOGY AND GENETICS

S. No.	Topics to be covered	No. of Hours
1.	Preparation of mitotic chromosomes	4
2.	Preparation of meiotic chromosomes	4
3.	Study of polyploidy in onion root tips	4
4.	Karyotyping of normal & abnormal chromosome sets	4
5.	Preparation of polytene chromosomes	4
6.	Monohybrid and dihybrid ratios ,Multiple alleles, Epistasis-Problems	4
7.	Inheritance patterns in man– pedigree analysis	4
8.	Localization of genes– two & three point test crosses, Tetrad analysis– Problems	4

REFERENCE BOOKS

1. An introduction to Genetic Analysis by Anthony, J.F. J.A. Miller, D.T. Suzuki, R.C. Richard Lewontin, W.M-Gilbert, W.H. Freeman publication.
2. Principles of Genetics by E.J.Gardner and D.P. Snusted. John Wiley & Sons, New York.
3. The Science of Genetics, by A.G. Atherly J.R. Girton, J.F. Mcdonald, Saundern College publication
4. Principles of Genetics by R.H. Tamarin, International edtn McGrawhill
5. Theory & problems in Genetics by Stansfield, Schaum out line series McGrahill
6. Cell & Molecular Biology. E.D.D De Robertis & E.M.F De Robertis, Waverly publication.
7. Molecular Biology of the cell. Alberts, B; Bray, D, Lews, J., Raff, M., Roberts, K and Watson, J.D. Garland publishers, Oxford
8. Molecular Cell Biology Lodish, H., Baltimore, D; Fesk, A., Zipursky S.L., Matsudaride, P. and Darnel American Scientific Books. W.H. Freeman, NewYork
9. Cell and molecular biology by Gerald Karp, Wiley
10. The cell: a molecular approach by Goeffrey Cooper and Robert Hausmann

THEORY PAPER-II
BT 102 T- BIOLOGICAL CHEMISTRY

1. **Course Objectives (C. Obj.):**
   a. To learn the basics of chemistry related to biomolecules
   b. To understand the carbohydrate classification and metabolism
   c. To comprehend metabolism of lipids, nucleic acids and amino acids
   d. To learn cellular signaling processes

2. **Course Outcomes (C.O):**
   a. Understanding the basics about bio-molecules, bio-energetics and enzymology
   b. Acquaintance with carbohydrate metabolism and networks
   c. Critically understanding biosynthesis of lipids nucleic acids and amino acids
   d. Understanding of how cells communicate and carryout physiological processes

Course Plan/ Schedule

Unit No.	Topics to be covered	No. of lectures
Unit-1	**Biomolecules, Bioenergetics and Enzymology**	
1.1	Importance of water in biological systems, p^H, Henderson-hasselbalch equation	2
1.2	Laws of thermodynamics, Gibbs free energy, Enthalpy, Entropy, Catalysis	2
1.3	Carbohydrates (Classification-monosaccharides, disaccharides, oligosaccharides & polysaccharides	3
1.4	Lipids (Classification-fatty acids, Nucleic acids, Amino acids, Proteins (Primary, secondary & tertiary structures)	4
1.5	Proteins (Primary, secondary & tertiary structures)	2
1.6	Enzymes and enzyme kinetics, Briggs-Haldane reaction, Michaelis-Menten equation Coenzymes, Cofactors, enzyme regulation	3
Unit -2	**Carbohydrate metabolism and networks**	
2.1	Glycolysis, TCA cycle and Electron transport chain	3
2.2	Gluconeogenesis, Glycogenesis and Glycogenolysis, Glucuronic acid cycle	3
2.3	Pentose phosphate pathway	2
2.4	Entner-Doudoroff pathway, Cori cycle	2
2.5	Photosynthesis, C3 & C4 cycle	3
2.6	Overview of Carbohydrates networks	3
Unit-3	**Biosynthesis and metabolism of lipids, Nucleic acids and amino acids**	
3.1	Hydrolysis of triacylglycerols	2
3.2	β-oxidation, Fatty acid biosynthesis, Cholesterol metabolism	3
3.3	Biosynthesis of amino acids, Amino acid degradation, Urea cycle	3
3.4	Prostaglandin biosynthesis	2
3.5	Nitrogen metabolism: Nitrate and ammonium assimilation	2
3.6	Biosynthesis and degradation of purines and pyrimidines	4
Unit-4	**Cell communication and Signalling pathways**	
4.1	Cell communication (autocrine and paracrine), Cell surface receptors in signal transduction	3

4.2	Second messengers and their role in signal transduction– cAMP, cGMP, phosphatidyl inositol derived second messengers, calcium as second messenger	4
4.3	G-protein coupled receptor– structure and function; GPCR signalling pathways; Ion channel receptors	3
4.4	Tyrosine kinase linked receptors (receptors for cytokines), JAK-STAT pathway	2
4.5	Receptors with intrinsic enzyme activity (RTK) and RTK signalling pathways	2
4.6	Wnt signalling pathway; Toll-like receptor signalling pathway	2

PRACTICALS
BT 152 P: BIOLOGICAL CHEMISTRY

S. No.	**Topics to be covered**	**No. of Hours**
1.	Qualitative tests of sugars, amino acids and lipids	4
2.	Estimation of total sugars by DNS method	4
3.	Estimation of proteins by Lowry's method	4
4.	Separation of amino acids by paper chromatography, thin layer chromatography (TLC)	4
5.	Separation of proteins by SDS-PAGE	4
6.	Enzyme assay- Catalase or Invertase	4
7.	Estimation of cholesterol by Zak and Henly's method	4
8.	Amylase activity assay	4
9.	Plate assay for enzymes	4
10.	Column chromatography- Gel filtration (size exclusion)	4

REFERENCE BOOKS

1. Lehninger's Principles of Biochemistry By: David L. Nelson and Cox
2. Biochemistry:-By: Rex Montgomery.
3. Harper's Biochemistry. By: Robert K. Murray.
4. Enzymes. By: Trevor Palmer.
5. Enzyme structure and mechanism By: AlanFersht
6. Principles of Biochemistry. By: Donald J. Voet, Judith G.Voet, Charlotte W.Pratt
7. Analytical Biochemistry By Cooper
8. Principles and techniques of Biochemistry and Molecular Biology Edited by Keith Wilson and John Walker
9. Experimental Biochemistry: A Student Companion by Sashidhar Beedu et al.
10. Practical Biochemistry By Plummer

THEORY PAPER -III
BT 103 T- MICROBIOLOGY

1. Course Objectives (C.Obj):

a. To learn about the general characteristics of microorganisms, microscopy, sterilization and containment
b. To learn about general characteristics of bacteria; bacterial isolation, growth, culturing and preservation
c. To learn about viruses and their general characteristics
d. To learn about algae, fungi & protozoa and their general characteristics

2. Course Outcomes (C.O):

a. Understanding the basics of microbiology and microbial classification
b. To culture different bacteria and know how to preserve them
c. Acquaintance with culturing of viruses and viral pathogenesis
d. Critical understanding of general characteristics and classification of algae, fungi and protozoa

Course Plan/Schedule

Unit No.	Topics to be covered	No. of lectures
Unit-1	**General characteristics of microorganisms**	
1.1	Microbiology- historical perspective	3
1.2	Microscopy and Applications- Principles and working of bright field, Fluorescent, and Electron microscopes	2
1.3	Classification of microorganisms	2
1.4	Concept and methods of sterilization and their application in industry- dry heat, moist heat, radiation methods, filtration methods, chemical methods	3
1.5	Concept of containment facility	3
1.6	Types of antimicrobial agents and development of resistance by microorganisms to various chemicals	3
Unit-2	**Bacteria and their characteristics**	
2.1	General characteristics of bacteria Identification methods for bacteria- conventional (simple staining methods, differential staining, structural staining and special staining method), molecular based approaches	2
2.2	General methods for isolation of bacteria- plating methods (streak, spread and pour plate methods); serial dilution.	2
2.3	Bacterial growth- typical growth curve- batch and continuous cultures, synchronous cultures; Measurement of bacterial growth- measurement of cell number and cell mass; factors influencing bacterial growth- temperature, pH.	3
2.4	Pure cultures- concept of pure culture, methods of pure culture, Enrichment culturing techniques, single cell isolation and pure culture development	3
2.5	Methods of preservation of microbial cultures– repeated subculturing, preservation at low temperature, sterile soil preservation, mineral oil preservation, deep freezing and liquid nitrogen preservation, freeze-drying (lyophilization).	3
2.6	Diseases caused by bacteria in humans (Staphylococcus, Streptococcus, Mycobacterium tuberculosis)	3

Unit-3	**Viruses and their characteristics**	
3.1	General characteristics of viruses	2
3.2	Classification of viruses and important characters of each group	3
3.3	Structure and replication of Bacteriophage (T2), Lambda phage-Lytic and Lysogenic cycles	3
3.4	Isolation and Purification of viruses by Filtration, Precipitation and Centrifugation	3
3.5	Methods of cultivation of viruses- in animal cell inoculation, Chick embryo, tissue culture; Bacteriophage cultivation; cell culture method.	2
3.6	Structure and general characteristics of important viruses (TMV, HIV, Hepaptitis virus, Polio virus, Prions) and Importance of viruses in biotechnology	3
Unit-4	**Algae, fungi & protozoa and their characteristics**	
4.1	General characteristics, vegetative & reproductive structure of Algae (Cyanophyta, Cholorophyta, Phacophyta, Rhodophyta)	3
4.2	Economic importance of algae	3
4.3	General characteristics of Fungi (Phycomycetes, Bacidiomycetes, Ascomycetes, Deuteromycetes)	3
4.4	Fungi as pathogens of humans, plants and animals	3
4.5	General characteristics of Protozoa	3
4.6	Protozoan as pathogens of humans (Entamoeba, Plasmodium)	1

PRACTICALS
BT 153 P: MICROBIOLOGY

. No.	**Topics to be covered**	**No. of Hours**
1	Microscopic observation, Staining and identification of bacteria, fungi and algae	4
2	Preparation of routine microbiological media	4
3	Sterilization methods (Autoclaving, hot air oven, radiation and filtration)	4
4	Isolation of bacteria	4
5	Isolation of fungi and algae	4
6	Preservation and maintenance of microbial cultures	4
7	Culturing of microorganisms: Tube culture (slant/broth), plate culture, flask culture	4
8	Study for bacterial growth curve	4

REFERENCE BOOKS

1. Microbiology by M.J. Pelzar, E.S.N. Cfan and N.R. Kreig, McGraw Hill Publ.
2. Introductory Microbiology by J. Heritage, E.G.V. Erans, R.A. Killington, Cambridge
3. University Press.
4. General Microbiology by H.G.Schlegel Cambridge University Press.
5. General Microbiology by Stanier, R.Y, J.L. Ingrahm, M.L. Wheel is & P.R. Painter.
6. Microbiology– Concepts and Application. John Wiley and Sons, New York

THEORY PAPER - IV
BT 104 T- BIOSTATISTICS, LABORATORY MANAGEMENT & SAFETY, ENTREPRENEURSHIP

1. Course Objectives (C.Obj.):

a. To understand the significance of sampling & data alignment
b. To understand the concept of applying appropriate test statistics
c. To learn Laboratory Management & Safety
d. To know the importance of Entrepreneurship

2. Course Outcomes (C.O):

a. Learn to estimate appropriate descriptive measures for a data in a given study
b. design
c. Help in derive inferences based on the statistical comparisons
d. Good laboratory practice
e. How to be a successful entrepreneur

Course Plan/Schedule

Unit No.	Topics to be covered	No. of lectures
Unit-1	**Descriptive Statistics**	
1.1	Random sample- Methods of sampling, study design, sample size, effect of sampling bias	2
1.2	Types of variables (qualitative, quantitative and categorical)- data alignment and representation-Frequency distribution-Histogram, Frequency polygon, Pie Chart-Bar diagram	3
1.3	Measures of central tendency- mean, median, mode	2
1.4	Point and interval estimates - Measures of Dispersion – coefficients – moment – skewness - kurtosis	3
1.5	Concepts of probability – types of events (dependent, independent and Mutually exclusive) – laws of probability (Addition & multiplication) – Bayesian theorem & its applications	3
1.6	Probability distributions & applications – Normal, Binomial and Poisson	3
Unit-2	**Inferential Statistics**	
2.1	Concept of Test of hypothesis, Null & Alternative hypothesis, level of significance, p-value, Class limits, Class intervals	3
2.2	Large Sample Tests- Z-test of Means	2
2.3	Small sample test - T-test for Means	2
2.4	Chi square test & its applications	3
2.5	Analysis of Variance and Co-variance, One-Way ANOVA, Two-way ANOVA	3
2.6	Simple regression and correlation - Test of regression coefficient and correlation Coefficient	3
Unit-3	**Laboratory Management & Safety**	
3.1	Administration of Laboratories, Laboratory design, Security measures, laboratory bio security concepts, Laboratory Information management system (LIMS)	2
3.2	Laboratory safety- good laboratory practice (GLP), Biosafety levels, Safety policies	3
3.3	Basic principles of quality control (QC) and quality assurance	3

	(QA)	
3.4	Handling of Hazardous compounds- chemicals, solvents, poisons, isotopes, explosives and biological strains (Bacterial, Fungal etc.)	3
3.5	Storage of hazardous material	2
3.6	Disposal of biological and radioisotope wastes	3
Unit-4	**Entrepreneurship**	
4.1	Concept, definition, structure and theories of entrepreneurship	3
4.2	Types of start-ups	3
4.3	Types of entrepreneurship, environment, process of entrepreneurial development	3
4.4	Entrepreneurial culture, entrepreneurial leadership	3
4.5	Product planning and development -Project management, Search for business idea, Concept of projects, Project identification, Formulation, Design and network analysis, Project report and project appraisal	3
4.6	Promoting bio-entrepreneurship.	1

PRACTICALS:
BT 154 P: BIOSTATISTICS

S. No.	Topics to be covered	No. of Hours
1.	Estimation of mean, median and mode for grouped and ungrouped data	4
2.	Variance, standard deviation and standard error	4
3.	Problems on Probability distribution- Binomial, Normal, Poisson distributions	4
4.	Problems on Chi square test	4
5.	Large sample test (Z-test)	4
6.	Small sample test (T-test)	4
7.	Calculation of correlation and regression coefficients	4
8.	Problems on ANOVA	4

REFERENCE BOOKS

1. Quantitative Genetics By Falconer
2. Biostatistics By Vishweswara Rao
3. Biostatistics By Khan and Khanum
4. Fundamentals of Biostatistics By P.H. Rao and Janardhan
5. Population Genetics By V. Venugopal and Pratibha Nallari
6. Biostatistical Methods in Agriculture Biology and Medicine By Khan and Khanum
7. Guides to entrepreneurship in biotechnology by P. Ponnumurugan, J Robinson and B. Kalpana
8. Guidelines for entrepreneurship development program for biotechnology graduates by P. Ponnumurugan and Nithya. B
9. CRC handbook of laboratory safety by A. Keith Furr

SEMESTER- II
THEORY PAPER- I
BT 201 T-MOLECULAR BIOLOGY-THE GENOME

1. Course Objectives (C.Obj):

a. To give insights into genome organization of prokaryotes and eukaryotes
b. To impart knowledge on the process of genome replication in prokaryotes and eukaryotes
c. To enable basic understanding of DNA damage and repair pathways
d. To give insights into genome rearrangements and recombination mechanisms

2. Course Outcomes (C.O):

a. Knowledge on organization of prokaryotic and eukaryotic genome
b. Understanding of DNA replication in prokaryotes and eukaryotes
c. Comprehension of DNA damage and repair pathways involved
d. Knowledge of mechanisms of DNA recombination and genome rearrangements and their role in genome evolution

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Genome Organization**	
1.1	Historical perspective: DNA as a genetic material, structure of DNA, Genome size, C-value paradox	3
1.2	Organization of prokaryotic genome and eukaryotic nuclear genome (Chromosome number, Gene size, Gene density)	2
1.3	Unique sequences, repeated sequences – interspersed and tandem repeats; satellite DNA, mini satellites and microsatellites	3
1.4	Gene families (Clustered and Dispersive – Hemoglobin gene and Histone gene clusters)	3
1.5	Pseudogenes– processed and unprocessed	2
1.6	Organization of Mitochondrial and Chloroplast genomes	3
UNIT 2	**Genome Replication**	
2.1	DNA Replication– enzymes involved in the replication of DNA, Origin of replication fork	3
2.2	Replication of Prokaryotic genome and plasmid DNA	2
2.3	Replication of nuclear genome of eukaryotes, mitochondrial and chloroplast	3
2.4	Regulation of genome replication (Prokaryotes and Eukaryotes)	3
2.5	Replication associated errors	3
2.6	Inhibitors of DNA replication	2
UNIT 3	**DNA Damage and Repair**	
3.1	Spontaneous and Induced mutations, physical and chemical mutagens	2
3.2	DNA damages (oxidative damages, depurinations, depyrimidinations, O^6-methylguanines, cytosine deamination, single and double strand breaks)	3
3.3	Types of mutagenesis–transition, transversion, frameshifts, missense and non-sense mutations	2
3.4	Repair mechanisms– Photo-reactivation, Excision repair (base excision repair, nucleotide excision repair), mismatch repair,	4

	SOS repair, recombination repair	
3.5	Proof reading activity of DNA polymerases, Direct reversal of damaged DNA, Post-replication repair	2
3.6	Cellular responses to DNA damage, DNA repair defects and disorders	3
UNIT 4	**Genome Rearrangements and Recombination**	
4.1	Homologous recombination (Holliday junctions, rec BCD pathways), Site-specific recombination, Non-Homologous recombination	3
4.2	Mechanism and Regulation of Meiotic Recombination, Whole genome duplication	3
4.3	Mechanism of Gene Duplication and Amplification: Insertion, deletion and translocation of sequences (Eg: flip-flop inversion, yeast mating type, Tetrahymena DNA)	3
4.4	Transposable genetic elements: Types of mobile elements, mechanisms of transposition, Transposable elements in prokaryotes and eukaryotes	3
4.5	Retrotransposon class I and class II, Retrogenes, Transposons and their role in genome evolution	2
4.6	DNA rearrangements and Genome instability	2

PRACTICALS

BT 251 P- MOLECULAR BIOLOGY– THE GENOME

S. No.	Topics to be covered	No. of hours
1	Isolation of Genomic DNA from bacteria	4
2	Isolation of Genomic DNA from plants	4
3	Isolation of Genomic DNA from human blood	4
4	Determine purity of DNA by agarose gel electrophoresis	4
5	Determination of melting temperature of DNA	4
6	Re-association Kinetics and estimation of Cot values	4
7	Induction of mutations by chemical agents	4
8	Determination of DNA damage by Comet assay	4

REFERENCE BOOKS

1. Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff,Keith Roberts and Peter Walter.
2. Molecular Biology of the Gene by J.D. Watson, N.H. Hopkins, J.W, Robertis, A.
3. Steitz& A.M. Weiner, Benjamin Cummings Publ. California
4. Molecular Cell Biology Lodish, H., Baltimore, D; Fesk, A, Zipursky S.L., Matsudaride, P. and Darnel American Scientific Books. W.H. Freeman, NewYork
5. Genes VII. Benjamin Lewis, OxfordUniv. Press, Oxford
6. Molecular Biology by D, FreifelderNarosa Publishing house New York, Delhi
7. Advance Molecular Biology Twyman, R.M., Bios Scientific publishers Oxford
8. Molecular Biology by T.A. Brown
9. Essentials of Molecular Biology. D. Freifelder, Panima publishing co-operation
10. Genes & Genomes – A changing perspective by Singer &Berr, Universal Science Books, California.
11. DNA Damage Repair, Repair Mechanisms and Aging by Allison E. Thomas Nova Science Publisher's, 2010.
12. Chromosomal Translocations and Genome Rearrangements in Cancer by Janet D. Rowley, Michelle M. Le Beau, Terence H. Rabbitts Springer International Publishing, 2015.

THEORY PAPER– II
BT 202 T– MOLECULAR BIOLOGY– GENES TO PROTEINS

1. Course Objectives (C.Obj):

a. To give an overview and impart conceptual understanding of prokaryotic and eukaryotic genes and their organization
b. To give molecular insights into transcription and RNA processing
c. To highlight the important mechanisms and components, their role in translation
d. To create a understanding about gene regulation and epigenetics

2. Course Outcomes(C.O):

a. Lay foundation to gene and gene organization
b. Acquire knowledge about translation
c. Provide understanding of the core principles of genetic code and protein synthesis
d. Facilitates understanding the gene regulation and epigenetics

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Prokaryotic and Eukaryotic genes**	
1.1	Structure of Prokaryotic gene, operons, polycistronic mRNA, inducible operon (Lac operon), repressible operon (Trp operon)	3
1.2	Fine structure of eukaryotic gene (Core and proximal promoters & enhancers, exons, introns, UTRs), monocistronic mRNA	3
1.3	Number of genes: prokaryotic gene number (parasitic and non– parasitic), eukaryotic gene number (unicellular, multicellular, humans & male specific genes)	2
1.4	Essential genes– Proportion and distribution in the genome (prokaryotes and eukaryotes)	3
1.5	Functional RNA genes (rRNA, tRNA)	2
1.6	Regulatory small RNA coding genes (snoRNA, snRNA, miRNAs, lnc RNAs)	3
UNIT 2	**Transcription and RNA processing**	
2.1	Transcription factors, activators, specific factors (Zinc fingers, Leucine zippers, helix loop helix and homeodomain); Types of RNA polymerases	3
2.2	Transcription in prokaryotes (components; initiation, elongation and termination of transcription)	3
2.3	Transcription in eukaryotes (components; initiation, elongation and termination of transcription	3
2.4	Post-transcriptional processing, 5'-capping and poly-adenylation.	3
2.5	RNA editing and processing, Splicing mechanism-alternate splicing, self-splicing & trans-splicing	3
2.6	Transcription inhibitors and their applications	1
UNIT 3	**Translation and Post translational modifications**	

3.1	Properties of genetic code (universal code, degeneracy, redundancy)	2
3.2	Correspondence of amino acid sequence with nucleotide sequence in DNA (Single letter code for amino acids)	1
3.3	Translation machinery in prokaryotes, initiation (IF-1, IF-2,IF-3) (t-RNA charging, disassociation & assembly of ribosomal subunits)	2
3.4	Elongation (EF-Tu, EF-Ts, EF-G) (translocation, t-RNA identity, aminoacyl t-RNA, peptide bond formation), termination (RF-1, RF-2, RF-3) (termination codons)	2
3.5	Translation mechanism in eukaryotes, initiation (factors, assembly of ribosomes), elongation, termination	2
3.6	Translational activators and inhibitors	2
3.7	Post translational modifications of proteins: glycosylation, lipidation, acetylation, ubiquitination, protein splicing, chaperones, modification of amino acids, disulphide bond formation, peptide bond cleavage and isomerization	3
UNIT 4	**Regulation of Gene expression and Epigenetics**	
4.1	Control of gene expression at transcription and translation level, co-ordinated regulation of gene expression	2
4.2	Regulation of gene expression in eukaryotes- genes controlling yeast mating type, regulation of Xenopus 5s rRNA in oocytes, using a strategically placed enhancer as genetic switch – chicken globin genes	3
4.3	Gene regulation exerted at the level of translation – silk fibroin gene, regulation at splice site selection – Drosophila sex determination	3
4.4	Gene regulation in eukaryotes (antisense RNA & RNAi)	2
4.5	Role of chromatin in regulating gene expression and gene silencing, DNA methylation, histone modification (acetylation, deacetylation, analysis of epigenetic modifications, epigenetic memory)	2
4.6	Genome wide mapping of chromatin factors and modifications	2
4.7	Role of nutrition and environment in epigenetic modifications	2

PRACTICALS

BT 252 P (B)- MOLECULAR BIOLOGY– GENES TO PROTEINS

S.No	Topics to be covered	No.of hours
1	Isolation of plasmid DNA from bacteria	4
2	Determination of purity and concentration of DNA– Spectrophotometric method	4

3	Induction of lac operon	4
4	Protein overexpression and isolation	4
5	Protein analysis by SDS electrophoresis	4
6	Isolation of mRNA from blood/tissue	4
7	cDNA synthesis	4
8	Gene expression analysis by qRTPCR	4

REFERENCE BOOKS

1. Molecular Biology of the Gene by J.D. Watson, N.H. Hopkins, J.W, Robertis
2. A.Steitz& A.M. Weiner, Benjamin Cummings Publ. California
3. Genes VII. Benjamin Lewin, Oxford Univ. Press, Oxford
4. Molecular Biology by D. FreifelderNarosa Publishing house New York, Delhi,
5. Molecular Cell Biology H.Lodish, D.Baltimore, A.Fesk,S.L.Zipursky, P.Matsudaride and Darnel American Scientific Books. W.H. Freeman, New York
6. Advance Molecular Biology R.M.Twyman, Bios Scientific publishers Oxford
7. Molecular Biology by T.A. Brown
8. Essentials of Molecular Biology. D. Freifelder, Panima publishing co-operation

SEMESTER- II
THEORY PAPER- III
BT 203 T- IMMUNOLOGY

1. **Course Objectives (C.Obj):**
   a. To give an overview of different types of immunities, cells & organs involved in the immune system and to provide the insights into immunogenicity and antigenicity
   b. To understand the structure and function of immunoglobulins and their generation
   c. To gain knowledge on structure and function of Major Histocompatibility Complex
   d. To provide the comprehensive understanding of the cell mediated immune responses & in-depth knowledge about autoimmunity & immunodeficiency disorders.

2. **Course Outcomes (C.O):**
   a. Basic understanding and importance of the immune system
   b. The importance and applications of immunoglobulins in therapeutics can be known
   c. Appreciate the importance of MHC in organ transplantation
   d. Knowledge about the cell mediated immune responses and creates awareness regarding autoimmune and immunodeficiency disorders.

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Basics principles of Immunology**	
1.1	Immunity– Types of Immunity, Innate immunity- Anatomic barriers, physiological barriers, phagocytic barriers, microbial antagonism, inflammation; Acquired Immunity– characteristics	3
1.2	Cells of the Immune System– lymphoid cells (B & T-Lymphocytes; T cell subsets; NK cells), Mononuclear phagocytes (monocytes, macrophages), Granulocytes (neutrophils, eosinophils, basophils, mast cells, dendritic cells); haematopoiesis and differentiation	3
1.3	Organs of the immune system: primary lymphoid organs (Bone marrow and Thymus); secondary lymphoid organs (lymph nodes, spleen, mucosal-associated lymphoid tissue and cutaneous asscociated lymphoid tissue)	3
1.4	Antigens– Immunogenicity versus Antigenicity, Factors that influenceimmunogenicity, Epitopes– Properties of B cell epitopes and T cell epitopes, Haptens	3
1.5	Complement system– functions and components of complement system; complement activation; regulation of complement system	2
1.6	Deficiencies of innate immune mechanisms– Chronic Granulomatous Disease (CGD), Leukocyte-adhesion deficiency	2
UNIT 2	**B-cell development and Immunoglobulins: Structure and Functions**	
2.1	Basic structure of Immunoglobulins– The role of multiple myeloma in understanding Ig structure; Fine structure of Immunoglobulins– Immunoglobulin domains-variable region and constant region domains; isotypes, allotypes, idiotypes	3

2.2	Immunoglobulin classes– IgG, IgM, IgA, IgD and IgE; functions of Ig classes; effector functions of antibodies, Organization and expression of immunoglobulin light and heavy chain genes	3
2.3	B-cell activation and proliferation by Thymus Independent and Thymus Dependent antigens; invivo sites for induction of humoral response; B-cell differentiation, class switching and generation of plasma cells and memory cells	3
2.4	Antigen antibody interactions and applications (immunodiffusion tests, ELISA Sandwich, Indirect, Dot; Western Blot, Flow cytometry, immunoprecipitation, immunoelectrophoresis, immunoflourescence, immunoelectron microscopy)	3
2.5	Polyclonal antibodies; Monoclonal Antibodies– Production of Monoclonal Antibodies– Formation and selection of hybrid cells; Antibody engineering– human antibodies from phage display; antibodies in immunotherapy– Targeting of therapeutic immunomolecules	3
2.6	B-cell immunodeficiency disorders– X-linked agammaglobulinemia, selectiveimmunoglobulin deficiency	1
UNIT 3	**Major Histocompatibility Complex (MHC) and Tumor Immunology**	
3.1	General organization and inheritance of MHC; MHC Haplotypes	3
3.2	The structure of MHC class I and class II molecules; organization of MHC class I and class II genes, peptide binding of MHC molecules	2
3.3	Polymorphism of MHC class I and class II molecules; cellular distribution of MHC molecules; MHC molecules and immune responsiveness and disease susceptibility	3
3.4	Types of grafts; Mechanism of graft rejection; immunological basis of graft rejection; Graft versus host reactions	3
3.5	Human leukocyte antigen (HLA) typing by mixed lymphocyte reaction (MLR), microcytotoxicity tests and by PCR; Role of HLA typing in organ transplantation	3
3.6	Tumors of the immune system– Tumor antigens, Immune response to tumors, tumor escape mechanisms; Cancer immunotherapy approaches	2
UNIT 4	**Cell-mediated Immune Responses**	
4.1	Antigen processing by antigen presenting cells; the structure and functions of T cell receptors (TCR); the TCR-peptide-MHC tri-molecular complexes	3
4.2	Cytokines– properties; cytokine receptors; Th1 and Th2 type of cytokines; Therapeutic uses of cytokines	3
4.3	Cell-mediated immune response: General properties of effector Tcells; Direct cytotoxic response; experimental assessment of cell-mediated cytotoxicity	3
4.4	Hypersensitivity– types; Delayed Type Hypersensitivity (DTH) and cytokines involved in DTH	2
4.5	Auto-immunity– mechanisms and auto-immune diseases-Insulin Dependent Diabetes; Rheumatoid Arthritis, Auto-	3

	immune Thyroid disease, Systemic lupus erythematosus (SLE)	
4.6	T cell primary immunodeficiency disorders– Severe combined immunodeficiency (SCID), Di George syndrome; Secondary immunodeficiency disorders- acquired immune deficiency syndrome (AIDS)	2

P**RACTICALS**
BT 253 T- IMMUNOLOGY

S.No	**Topics to be covered**	**No.of hours**
1	ABO blood typing, Micro-hemagglutination Test	4
2	Double diffusion	4
3	Single Radial Immunodiffusion	4
4	Dot ELISA	4
5	Western Blot by Enzyme-conjugated antibody	4
6	Sandwich Enzyme Linked Immunosorbent Assay	4
7	Cell-viability test by Trypan Blue	4
8	Principle and procedure for enumeration of specific cell types by Fluorescent Activated Cell Sorter (FACS)	4

REFERENCE BOOKS

1. Essential Immunology– By I. Roitt, Publ: Blackwell
2. Immunology– By G. Reever& I. Todd, Publ: Blackwell
3. Immuno diagnostics– By S.C. Rastogi, Publ: New Age
4. Immunology: By Richard A. Golds, Thomas J Kindt, Barbaraa A. Osborne,Janis Kuby
5. Fundamental immunology– By William E.Paul.
6. Basic Immunology– By Bhoosreddy G.L. and Wadher B.J.
7. Text book of immunology– By Baruj Benacerraf

THEORY PAPER- IV
BT 204 T- MICROBIAL TECHNOLOGY

1. **Course Objectives (C.Obj):**
   a. To give an overview of the fundamentals of microbial technology
   b. To give basic understanding of fermentation processes
   c. To create an understanding about microbial products
   d. To highlight important applications of microbial technology

2. **Course Outcomes(C.O):**
   a. Lay foundation to basics in microbial technology
   b. Acquire knowledge of fermentation technology
   c. Provide understanding of various products of industrial importance
   d. Facilitates understanding the importance of microbial technology in industry

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Fundamentals of Microbial technology**	
1.1	General concepts of microbial technology, principles of exploitation of micro-organisms and their products, Industrial microorganisms– Bacteria, Algae and Fungi	3
1.2	Screening of microorganisms for industrial products	2
1.3	Isolation and preservation of microorganisms for industrial products; isolation, selection and improvement of microbial cultures	3
1.4	Strain development– strategies of strain improvement, mutation, selection and recombination	2
1.5	Use of recombinant DNA technology and protoplast fusion techniques for strain improvement, problems associated with strain improvement	3
1.6	Improvement of characters other than products and their application in the industry	3
UNIT 2	**Processes for Microbial Fermentation**	
2.1	Brief history of fermentation; Fermentation–general concepts; Fermentation design–Overview of aerobic and anaerobic fermentation process; Submerged and solid state fermentation	3
2.2	Factors affecting submerged and solid state fermentation (SSF); Substrates used in SSF and their advantages; Applications of fermentation	3
2.3	Importance of media in fermentation; media types: components and formulations	2
2.4	Substrates with sources for Carbon and Nitrogen, inoculum development	2
2.5	Storage of cultures for repeated fermentations, production of microbial biomass	3
2.6	Factors affecting fermentation process	3
UNIT 3	**Microbial products and Food additives**	
3.1	Organic acids– Citric acid, Lactic acid, Acetic acid, Gluconic acid	2

3.2	Amino acids– Glutamic acid, Lysine, Aspartic acid	2
3.3	Enzymes– Proteases, Amylases, Lipases, Cellulases & Pectinases; Enzyme Biosensors	3
3.4	Food fermentations and food produced by microbes; Dairy products– Cheese, Yoghurt; Other products-bread, cheese, vinegar, fermented dairy products	3
3.5	Oriental fermented foods, microbial cells as food-single cell proteins; production of alcohol and fermented beverages, beer and wine	3
3.6	Microbial and Chemical safety of food products; Food quality & control: Analysis offood	3
UNIT 4	**Applications of Microbial technology**	
4.1	Health care: Production of antibiotics–penicillin, streptomycin and erythromycin	3
4.2	Production of therapeutic drugs, recombinant vaccines–BCG, Hepatitis-B	3
4.3	Monoclonal antibodies, Insulin, Vitamins–B12, D & C, Riboflavin, Cyanocobalamin	3
4.4	Biofuel and Biodiesel production, methane, alcohol, hydrogen	3
4.5	Biomining–Extraction of Cu, Au and U from ore	2
4.6	Bioplastics (biopolymers), Bioremediation	2

PRACTICALS:
BT 254 P: MICROBIAL TECHNOLOGY

S.No.	Topics to be covered	No.of hours
1	Production of Organic acids	4
2	Production and estimation of alcohol	4
3	Screening for amylase producing organisms	4
4	Production and assay of amylase activity	4
5	Preparation of wine from grapes	4
6	Production of penicillin/ampicillin	4
7 8.	Production of antibiotics from bacteria	4

REFERENCE BOOKS

1. Text Book of Biotechnology–By H.K. Das (Wiley Publications)
2. Biotechnology–By H.J. Rehm and G. Reed.VIH Publications, Germany
3. Biogas Technology- By B.T. Nijaguna
4. Biotechnology- By K. Trehan
5.Industrial Microbiology- By L.E. Casida
6.Food Microbiology- By M.R. Adams and M.O. Moss
7.Introduction to Biotechnology- By P.K. Gupta
8.Essentials of Biotechnology for Students- By Satya N. Das
9.Bioethics– Readings and Cases- By B.A. Brody and H. T. Engelhardt. Jr. (Pearson Education)
10. Bioprocess Engineering-By Shuler (Pearson Education)
11. Essentials of Biotechnology-By Irfan Ali Khan and Atiya Khanum (UkaazPublications)
12. Gene, Genomics and Genetic Engineering- By Irfan Ali Khan and Atiya Khanum(Ukaaz Publications)

MSC BIOTECHNOLOGY-II YEAR
SEMESTER-III
THEORY PAPER-I
BT 301 T- RECOMBINANT DNA TECHNOLOGY

1. **Course Objectives: (C.Obj):**
   a. To learn about the basic components of molecular cloning
   b. Understand molecular techniques related to genetic engineering
   c. To learn nucleic acid and protein blotting techniques
   d. To comprehend latest molecular biology techniques and their applications

2. **Course Outcomes: (C.O):**
   a. Understanding the fundamentals of cloning processes and components involved
   b. Comprehension of various molecular biological techniques and their applications
   c. Acquaintance with recombinant DNA and DNA sequencing techniques
   d. Knowledge regarding the use of rDNA techniques in modern biology, medicine and agriculture

Course Plan/Schedule

Unit No.	Topics to be covered	No. of lectures
Unit-1	**Restriction enzymes and cloning vectors**	
1.1	Host controlled restriction modification	2
1.2	Restriction endonucleases, types and classification	2
1.3	Modifying enzymes used in molecular cloning, methylases, polymerases, ligases, kinases, phosphatases and nucleases	3
1.4	Vectors for cloning (pUC18), expression vectors (pET)	3
1.5	Vectors for library preparation (lambda phage vectors, cosmids, BAC & YAC)	3
1.6	Host organisms used in r-DNA technology: E.coli, Yeast	3
Unit-2	**Construction of Genomic and cDNA libraries**	
2.1	Introduction to cloning (conventional & recombination based)	2
2.2	Strategies for construction of genomic libraries	3
2.3	Chromosome walking and chromosome jumping for positional cloning of genes	3
2.4	Strategies for construction of cDNA libraries	3
2.5	Construction of subtractive and normalized cDNA libraries	3
2.6	PCR- principle, types (multiplex, nested and touch-down PCR) and applications	2
Unit-3	**Selection and characterization of recombinant clones**	
3.1	Genetic Selection- insertional inactivation and alpha complementation	2
3.2	Labeling of nucleic acids	2

3.3	Immunological probes	2
3.4	Selection of recombinant clones-hybridization techniques (Southern, Northern, Western, South-Western & Zoo blot), colony hybridization & library screening, hybrid arrest & hybrid release translation	4
3.5	DNA sequencing methods- Maxam-Gilbert and Sanger's method, Next-Generation Sequencing technologies and theirapplications	4
3.6	DNA arrays- principle, spotted DNA array; oligonucleotide chips	2
Unit-4	**Applications of recombinant DNA technology**	
4.1	Site directed mutagenesis and RNA interference	3
4.2	Knock-in and knock- out technology	3
4.3	Genome engineering technologies	3
4.4	Next generation sequencing- principle, types and applications	3
4.5	Applications of genetic engineering in agriculture & animalhusbandry	2
4.6	Applications of genetic engineering in industry and medicine	2

PRACTICALS
BT 351 P: RECOMBINANT DNA TECHNOLOGY

S.No.	Topics to be covered	No. of hours
1	Isolation of plasmid DNA	4
2	Restriction digestion and gel electrophoresis	4
3	Preparation of competent cells	4
4	Genetic transformation and selection of recombinant clones	4
5	Polymerase chain reaction for screening recombinant clones	4
6	Site-directed mutagenesis	4
7	Restriction mapping and problems	4
8	DNA sequence analysis and problems	4

REFERENCE BOOKS

1. Principles of Gene Manipulation and Genomics- Sandy B. Primrose, RichardTwyman 7th Edition; Blackwell Publishing
2. Gene Cloning and DNA Analysis: An Introduction- T. A. Brown - John Wiley & Sons
3. An Introduction to Genetic Engineering- Desmond S.T. Nicholl – Cambridge University Press
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA -Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten- ASM Press
5. Molecular Cloning: A Laboratory Manual (Cold Spring Harbor)- M. R. Green, J.Sambrook

SEMESTER-III
THEORY PAPER-II
BT 302 T- BIOINFORMATICS AND ITS APPLICATIONS

1. Course Objectives: (C.Obj)

a. To introduce bioinformatics to accomplish solid understanding of scope of bioinformatics.
b. To explain the underlying basic principles of sequence analysis, and apply the samefor analysing nucleic acid and protein sequences.
c. To provide an introduction to advanced areas such as sequencing, gene identification,genome wide analysis and drug discovery.
d. To impart an in depth understanding of proteomics and metabolomics.

2. Course Outcomes: (C.O)

a. Enable to explore bioinformatics web portals, databases and tools.
b. Gain familiarity to sequence comparisons with algorithms and matrices to locaterelated sequences from databases
c. Perform various *insilico* analysis for gene structure and function prediction, targetidentification for drug designing
d. Gain insights to interpret the output from proteomic tools to make meaningfulpredictions.

Course Plan/Schedule:

Unit Number	**Topics to be covered**	**No. of lectures**
Unit-1	**Foundations of bioinformatics**	
1.1	Bioinformatics- a historical perspective	2
1.2	a. Bioinformatics data- nucleic acid sequence, protein sequence,protein structure. b. Genome variation data, gene expression data, proteomic data,metabolic pathways and networks	2
1.3	Bioinformatics databases- what are databases, why databases,types of databases.	2
1.4	File formats (Examples: genbank- DNA sequence, uniprot-protein sequence, PDBStructure).	2
1.5	CATH, SCOP- protein classification, unigene- transcripts, KEGGmetabolic pathway, dbSNP- variation, RAP-DB-genome-specific.	2
1.6	Database search engines (entrez and SRS)	2
1.7	CATH, SCOP- protein classification, unigene- transcripts, KEGGmetabolic pathway, dbSNP- variation, RAP-DB-genome-specific.	2
1.8	Database search engines (entrez and SRS)	2
1.9	a. Bioinformatics tools and resources- free online tools,downloadable free tools. b. Software packages	3

	c. Bioinformatics web portals	
1.10	Role of internet in bioinformatics	1
Unit-2	**Sequence comparison methods**	
2.1	Basics of sequence alignment: match, mismatch, gaps, scoring analignment gap penalties (linear & affine gap penalties).	2
2.2	Sequence relationships (sequence identity, similarity, homology,orthologs, paralogs&xenologs)	2
2.3	a. DNA vs protein sequence alignment (permissiblereplacements, similarity score. b. Scoring matrices (PAM & BLOSUM)	2
2.4	Pairwise alignment: dot-matrix comparison of sequences.	1
2.5	Dynamic programming based pairwise alignment algorithms (global- Needleman and Wunch algorithm, local- Smith and Waterman algorithm)	2
2.6	Pairwise alignment based database searching-rigorous algorithmsfor database searching (Needleman-Wunch, Smith-Waterman).	1
2.7	Heuristic algorithms for database searching (FASTA algorithmand BLAST algorithm)	2
2.8	Multiple-sequence alignment (MSA): significance of MSA	1
2.9	Progressive and iterative based algorithms for multiple sequencealignment.	1
2.10	Consensus sequence, nucleotide distribution matrix, sequenceprofile and position specific scoring matrix.	1
2.11	Multiple sequence alignment based database searching (profileBLAST)	1
Unit-3	**Genomic applications**	
3.1	Bioinformatics for genome sequencing.	1
3.2	First and next generation methods of genome sequencing.	1
3.3	De-novo and reference based genome sequencing, genomeassembly (reads, contigs& scaffolds)	1
3.4	a.Transcript-profiling: expression microarrays (gene array&oligo array). b. Transcriptome sequencing and RNA-seq analysis, small RNAsequencing and analysis	2
3.5	Genome annotation: finding repeats, gene finding in prokaryotesand eukaryotes, finding promoters and regulatory motifs	2
3.6	Genome maps and markers: identification of molecular markers(SSR, STS & SNP markers), linkage vs physical maps.	2
3.7	Displaying genome annotation using genome browsers	1
3.8	Bioinformatics for genome variation studies: identification ofwhole genome duplications and its implications.	1
3.9	Segmental duplication (copy number variation) identification andits implications.	1
3.10	Single nucleotide variation identification and its implications	1
3.11	Medical application of bioinformatics- understanding diseases	1

	and identification of disease genes, disease diagnostics.	
3.12	Overview of drug discovery and pharmacogenomics	2
Unit-4	**Proteomic and Metabolomic applications**	
4.1	Protein profiling (2D gels, protein fingerprinting &identification).	2
4.2	Protein structure analysis	1
4.3	Protein classification: SCOP and CATH schemes of classification (motifs, domains, folds, class, architecture, family& super family)	2
4.4	Protein structure: structure visualization	2
4.5	Protein -Secondary structure prediction -Tertiary structure prediction (homology modelling)	3
4.6	Phylogenetic analysis - Distance matrix based tree construction - UPGMA based tree construction	3
4.7	Metabolic networks. - Metabolic pathways - Metabolic reconstruction	3

PRACTICALS

BT 352 P: BIOINFORMATICS AND ITS APPLICATIONS

S.No	Topics to be covered	No.of hours
1	Bioedit as sequence handling tool	4
2	Understanding DNA/protein coding systems	1
3	Understanding file formats (FASTA, FastQ, BAM)	1
4	Exploring sequence databases (Genbank and Uniprot)	2
5	Exploring structure database (PDB and MMDB)	2
6	Downloading DNA sequence data (Genbank/DDBJ/ENA)	2
7	Downloading protein sequence data (Uniprot)	1
8	Downloading protein structure data (PDB/MMDB) and visualization	2
9	Downloading bioinformatics data from FTP servers (NCBI)	1
10	Pairwise (global and local) alignment of DNA sequences	1
11	Pairwise (global and local) alignment of protein sequences	1
12	Multiple sequence alignment of DNA and protein sequences using Clustal-W	2
13	Database searching with heuristic (FASTA and BLAST).	2
14	Rigorous algorithms (Needleman-Wunch and Smith-Waterman algorithms)	2
15	Exploring genome specific databases (RAP-DB)	1
16	Exploring gene databases (entrez gene, gene cards)	1
17	Prediction of genes in prokaryotic and eukaryotic genomes	2

18	Prediction of SSRs in DNA sequence (SSRit)	1
19	Prediction of secondary structures of proteins online	1
20	Homology modelling online	1
21	RNA secondary structure prediction	1

REFERENCE BOOKS

1. Introduction to bioinformatics by Aurther M lesk
2. Developing bioinformatics computer skills by Cynthia Gibas, Per Jambeck
3. Chemoinformatics: a textbook by Johann Gasteiger
4. Bioinformatics second edition by David M mount
5. Essential bioinformatics by Jin Xiong
6. Bioinformatics computing by Bryan Bergeron
7. Bioinformatics: concepts, skills & applications by R.S. Rastogi
8. Bioinformatics: methods and applications genomics, proteomics and drug discoveryby S.C. Rastogi, ParagRastogi, NamitaMendiratta

PAPER-III (ELECTIVE)
BT 303 T (A) - ADVANCES IN PLANT BIOTECHNOLOGY

1. Course Objectives: (C.Obj.)

a. To acquaint the principles & techniques of plant tissue culture and their applications
b. To introduce *in vitro* plant cell & tissue cultures and associated techniques for enhanced production of secondary metabolites
c. To acquaint the principles & techniques of plant transgenic technology with respect to genetic transformation, detection and characterization of transformants, gene expression and gene silencing; gene editing techniques
d. To illustrate the applications of plant transgenic technology

2. Course Outcomes: (C.O)

a. Understanding the aspects of *in vitro* regeneration and applications related to crop improvement and plant germplasm conservation
b. Critically understanding the advantages of *in vitro* plant cell & tissue cultures and associated techniques for enhanced production of secondary metabolites
c. Understanding the principles and techniques of plant transgenic technology, gene silencing and gene editing techniques
d. Critically understanding the applications & limitations of plant transgenic technology in developing crops that are biotic & abiotic stress tolerant, with enhanced nutritional quality and improved post harvest qualities and producing therapeutic compounds etc.

Course Plan/Schedule:

Unit No.	Topics to be covered	No. Lectures
Unit I	**Plant tissue culture and its applications**	
1.1	Introduction and history of plant tissue culture	2
1.2	Media, growth regulators, callus, cell culture and plant regeneration; Meristem culture and micropropagation of elite plants	4
1.3	Somaclonal variation, production of haploids and dihaploids and its applications	2
1.4	Anther culture, embryo culture and embryo rescue	2
1.5	Somatic hybridization- protoplast isolation, culture and fusion, development of somatic hybrids and cybrids	4
1.6	Cryopreservation for conservation of plant germplasm	2
Unit II	***In vitro* production of plant secondary metabolites**	
2.1	Advantages of cultured plant cells and tissues as a source of secondary plant products	2

2.2	Factors influencing the *in vitro* production of secondary metabolites (physical and chemical factors)	4
2.3	Permeabilization, elicitation and immobilization of cells for enhanced production of secondary metabolites	4
2.4	Organ cultures for production of secondary metabolites- leafy teratomas, hairy root cultures and adventitious roots	2
2.5	Pathway engineering for enhanced production of secondary metabolites	2
2.6	Biotransformation and production of novel compounds	2
Unit III	**Plant transgenic technology**	
3.1	Direct gene transfer methods in plants (particle bombardment, electroporation)	4
3.2	Indirect gene transfer methods (*Agrobacterium*-mediated transformation) and viral methods in plants	4
3.3	Selection (reporter genes- scorable and selectable genes) and characterization of transformants	2
3.4	Strategies for chloroplast transformation and its advantages	2
3.5	RNAi Technology- role of RNAi based gene silencing in crop improvement	2
3.6	Genome editing techniques- CRISPR-Cas system	2
Unit IV	**Applications of plant transgenic technology**	
4.1	Transgenic plants for insect/pest resistance, Nematode resistance	2
4.2	Transgenic plants for herbicide resistance	1
4.3	Transgenic plants for bacterial, fungal and viral resistance	4
4.4	Transgenic plants for drought, salt and heavy metal, temperature, flooding or submergence stress tolerance	4
4.5	Transgenic plants for production of bio-pharmaceuticals (edible vaccines, erythropoietin & α-interferon) – Molecular Pharming	2
4.6	Transgenic plants for improvement of nutritional quality (oil, amino acids, vitamins -A & E & micronutrients-Iron & Zinc	3

PRACTICALS

BT 353 P (A): ADVANCES IN PLANT BIOTECHNOLOGY

S.No	**Name of Experiment**	**No. of Hours**
1.	Micropropagation of elite ornamental/agricultural plants/tree species	8
2.	Induction of somatic embryos and preparation of synthetic seeds	4
3.	Induction of hairy root cultures using *Agrobacterium rhizogenes*for the production of secondary metabolites	4
4.	Preparation of recombinant plant expression vector with gene of interest	4
5.	Genetic transformation of plant tissue using *Agrobacterium tumefaciens*	4

6.	Confirmation of transgenic plants by PCR and Southern blotting techniques	8

REFERENCE BOOKS

1. Plant tissue culture and its biotechnological applications by W. Barz, E. Reinhard, M.H. Zenk
2. Plant tissue culture by Akio Fujiwara
3. Frontiers of plant tissue culture by Trevor A. Thorpe
4. In vitro haploid production in higher plants by S. Mohan Jain, S.K. Sopory, R.E. Veilleux
5. Plant tissue culture: theory and practice by S.S. Bhojwani and A. Razdan
6. Plant cell, tissue and organ culture, applied and fundamental aspects by Y.P.S. Bajaj and A. Reinhard

PAPER-III (ELECTIVE)
BT 303 T (B)-FOOD BIOTECHNOLOGY

1. Course Objectives: (C.Obj.):

a. To acquaint with the fundamentals of food and nutrition
b. To acquaint with the principles, techniques and importance of food processing
c. To introduce the various functional foods – nutraceuticals, pharma foods, dietarysupplements etc and their importance
d. To acquaint with various methods of evaluation of food quality, identification ofmicrobial contamination and toxic chemicals food safety standards and laws

2. Course Outcomes: (C.O.):

a. Understanding the fundamental aspects of food and nutrition
b. Critically understanding the principles, techniques of food processing
c. Understanding the scope, technology and importance of functional foods
d. Critically understanding the importance of evaluation of food quality and food safetymanagement

Course Plan/Schedule:

Unit No.	Topics to be covered	No. Lectures
Unit -1	**Fundamentals of Food and Nutrition**	
1.1	Introduction to food, nutrition, nutrient, malnutrition and balanceddiet	2
1.2	Nutrient requirement and recommended dietary allowances (RDA)	4
1.3	Carbohydrates- classification, properties, functions and food sources of carbohydrates (sugar, starch, cellulose, glucans, hemicelluloses, gums, peptic substances & polysaccharides); recommended dietary allowances	2
1.4	Lipids- classification, properties, functions and food sources oflipids; recommended dietary allowances	2
1.5	Proteins- classification, properties, functions and food sources ofproteins; recommended dietary allowances	4
1.6	Vitamins and Minerals- functions, food sources; recommendeddietary allowances	2
Unit -2	**Food processing and preservation**	
2.1	Scope and importance of food processing	2
2.2	Processing of cereals, pulses and oilseeds	4
2.3	Technology for improved process- baking, milk products, cheesemaking and alcohol production	4
2.4	Food spoilage- factors affecting, role of microorganisms,enzymes, toxins	2

2.5	Food preservation by heating (drying, osmotic dehydration, blanching, canning, Pasteurization & sterilization), freezing (refrigeration & freeze-drying), non-thermal preservation (ultra- filtration, microwave processing & irradiation)	2
2.6	Chemical methods of preservation of foods- uses of sugar, salt,chemicals and antibiotics	2
Unit -3	**Functional foods**	
3.1	Nutraceuticals- types, processing of nutraceutical products,therapeutic applications	2
3.2	Pharma foods- diabetic foods (sugar free), confectionaries, sodium free, lactose free, phenylalanine free and fibre rich foods - nutritional implications	4
3.3	Dietary supplements- fortification of nutrients in the processed foods & other dietary supplements, hyper nutritious foods (proteinpowders)	4
3.4	Fat free foods- PUFA oils n3, n6 fatty acids, fat free milk powder,low cholesterol oils and cholesterol free foods	2
3.5	Functional nano foods- benefits of nanotechnology for functionalfoods	2
3.6	Probiotics and prebiotics- sources and their health benefits	2
Unit -4	**Food quality and safety management**	
4.1	Introduction, scope of food quality and food safety, food adulteration- adulteration in different foods	2
4.2	Evaluation of food quality- appearance, colour texture, viscosity,consistency, flavour defects and foreign matter	2
4.3	Methods of identification of microbial contamination (bacteria,fungi & virus) of food	2
4.4	Methods of identification of toxic chemicals (food additives, foodpreservatives, pesticides, dyes, etc.) of food	4
4.5	Nanotechnology driven food safety- nano packaging, nano sensors	2
4.6	Food standards and laws- national food safety and food standardsregulations, prevention of food adulteration act, safety regulations of genetically modified foods	4

PRACTICALS
BT 353 P (B) - FOOD BIOTECHNOLOGY

S.No	**Name of Experiment**	**No. of Hours**
1.	Qualitative and quantitative analysis of carbohydrates and proteins in food	8
2.	Preparation and evaluation of cheese or fermented product	4
3.	Determination of fat content in milk	4
4.	Estimation of vitamins- vitamin A, C and riboflavin	4
5.	Determination of aflatoxin in food	4
6.	Tests for pesticidal residues in food	8

REFERENCE BOOKS

1. Swaminathan M.S. Dr. Hand Book of Food and Nutrition
2. Sumati R. Mudambi and M.V, Rajgopal. Fundamentals of Food and Nutrition
3. Nutrient Requirements and Recommended Dietary Allowances for Indians. National Instituteof Nutrition, Indian Council of Medical Research, 2010
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5. Birch, G.G., Cameron, A.G. and Spencer, M. 1986. Food Science, 3rd Ed. Pergamon Press,New York.
6. Fennema, O.R. Ed. 1976. Principles of Food Science: Part-I Food Chemistry. MarcelDekker,New York
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10. Jelen, P. 1985. Introduction to Food Processing. Prentice Hall, Reston Virginia, USA
11. Lewis, M.J. 1990. Physical Properties of Food and Food Processing Systems.Woodhead
12. Stanburry P.P. and Whitaker, A. 1984. Principles of Fermentation Technology.PergamonPress, Oxford UK
13. Rosenthal, I. 1991. Milk and Milk Products. VCH, New York
14. Warner, J.M. 1976. Principles of Dairy Processing.Wiley Eastern Ltd. New Delhi
15. Krammer, A. and Twigg, B.A. 1970. Quality Control for the Food Industry.3rd Edn. AVI,Westport
16. Pattee, H.E. Ed. 1985. Evaluation of Quality of Fruits and Vegetables. AVI, Westport
17. Ranganna, S. 1986. Handbook of Analysis and Quality Control for Fruits and VegetableProducts. Tata McGraw Hill, New Delhi
18. Joshi, V.K. and Pandey, A. Ed. 1999. Biotechnology.Food Fermentation, (2 Vol. set).Education Publ. New Delhi
19. Knorr, D. 1982. Food Biotechnology. Marcel Dekker, New York
20. InteasAlli: Food Quality Assurance: Principles and practices, CRC Press LLC
21. Knechtes P.L.: Food Safety: Theory and Practice, Jones and Bartlett Learning, USA
22. R.A Garg: The Food Safety and Standard Act, 2006 along with Rules and regulation,(2011) Commercial Law Publisher (India) Pvt. Ltd

PAPER-IV (ELECTIVE)
BT 304 T (A)-ANIMAL BIOTECHNOLOGY

1. **Course Objectives: (C.Obj):**
   a. To learn the technique of cell culture and its applications
   b. Understand various classical and modern methods of animal improvement
   c. To learn biotechniques involved in the creation of genetically modified organisms
   d. To comprehend the importance and use of mouse as a disease model
2. **Course Outcomes: (C.O):**
   a. Understanding the basics of cell culture technique and its utility in biotechnology
   b. Comprehension of animal breeding methods and techniques
   c. Acquaintance with modern techniques to create transgenic, knock-out and knock-in animals
   d. Knowledge regarding the use of mouse to model a disease and its utility in biotechnology

Course Plan/Schedule

Unit No.	Topics to be covered	No. of lectures
Unit-1	**Animal tissue culture: principles and applications**	
1.1	Cell culture technique: cell culture media, sterilizationtechniques, cell lines, maintenance and cell adaptation	3
1.2	Characteristics of cells in culture, methods of separation of various cell types, contact inhibition, anchorage dependence, stem cell culture, embryonic stem cell culture and 3D cell culture	2
1.3	Cryopreservation- germplasm conservation	2
1.4	Manipulation of cells- cell transfection (electroporation and chemical methods) and transduction	3
1.5	Synchronization of cell cultures, production of secondary metabolites, biotransformation, scaling up of animal cell culture	3
1.6	Commercial applications of cell culture: tissue culture as a screening system, diagnostic tests, mass production of biologically important compounds (e.g. vaccines), harvesting of products, purification, assays and tissue engineering	3
Unit-2	**Animal breeding and improvement**	
2.1	Conventional methods of animal Improvement- selectivebreeding, cross breeding	2

2.2	Principles of animal breeding; structure of the livestock breeding industry: dairy cattle, beef cattle, swine, sheep, poultry and aqua culture	2
2.3	Animal improvement techniques: Semen collection and artificial insemination,estrus synchronization, super ovulation, *in vitro* maturation of oocytes, *in vitro* fertilization, embryo collection and transfer, intracytoplasmic sperm injection,somatic cell nuclear transfer and embryo sexing	3
2.4	Identification and isolation of genes of economic importance: physical and genetic maps, candidate gene approach	3
2.5	Molecular markers and their application in animal improvement-RFLP, RAPD, microsatellite/minisatellite markers, SNP Marker, DNA fingerprinting	3
2.6	Genetic tools and their applications: PCR, southern blotting, northern blotting, DNA sequencing	3
Unit-3	**Gene targeting in animals**	
3.1	Mouse as a disease model	2
3.2	Generation of transgenic animals and their applications	3
3.3	Creation of knock-out mouse and its applications	3
3.4	Generation of knock-in mouse and its applications	3
3.5	Double transgenics, double knock-outs and their utility in deciphering biology	2
3.6	Spontaneous and inducible gene expression, tissue-specific gene expression in mouse	3
Unit-4	**Murine models of disease**	
4.1	Cancer models (carcinogen injection; bone marrow transplantation; xenografts)	3
4.2	Cancer models (retrovirus- lentivirus- & adenovirus-based models)	3
4.3	Neurodegenerative disease models (Alzheimers and parkinsons)	3
4.4	Infectious disease models (bacterial, fungal and viral diseases)	3
4.5	Metabolic disease models (Diabetes and obeisity)	3
4.6	Genome editing tools: zinc finger nucleases (ZFNs), TALENs and the CRISPR-Cas system	1

PRACTICALS
BT 354 P (A): ANIMAL BIOTECHNOLOGY

S.No.	Name of the experiment	No. of hours
1	Culturing of suspension and adherent cells	8
2	Sterile cell culture techniques, freezing and thawing of cells	8
3	Cell counting, cell viability assays	8
4	Mammalian cell transfection (transient)	8
5	Testing of gene expression by western blotting	8
6	Testing of gene expression by fluorescence microscopy	8
7	Testing of gene expression by PCR	8
8	Testing of pharmacological activity of cancer drugs	8

REFERENCE BOOKS

1. Practical animal breeding. Blackwell Science.
2. Houdebine L.M. Animal transgenesis and cloning.Wiley Publishers.
3. R. Ian Freshney. Culture of animal cells: a manual of basic technique andspecialized applications.
4. Akano IE. DNA technology. IAP Academic Press.
5. Micklos DA, Fryer GA &Crotty DA. DNA science.Cold Spring Harbour.
6. Setlow JK. Genetic Engineering - Principles and methods. Springer.
7. Hare WCD & Elizabeth L Singh. Cytogenetics in animal reproduction.CABI.
8. Stine GJ. The new human genetics.Wm C Brown Publ.
9. Summer AT &Chandley AC. Chromosome today. Chapman & Hall.
10. Falconer DS & Mackay TFC. An introduction to quantitative genetics.Longman.
11. Jain JP. Statistical techniques in quantitative genetics. Tata McGraw-Hill.
12. Pirchner F. Population genetics in animal breeding. S. Chand.
13. Plumer. Practical biochemistry
14. Sambrook et al. Molecular cloning Volume 1, 2, 3.
15. Wilson K. and Walker J. Principles and techniques of biochemistry and molecularbiology
16. Harlow Ed and Lane D. Antibodies: a laboratory manual
17. Cell biology techniques: formulated by indian society of cell biology
18. Pasternack and Glick. Molecular biotechnology

THEORY PAPER-IV (ELECTIVE)
BT 304 T (B)-PROTEIN ENGINEERING

1. Course Objectives: (C.Obj.):

a. To give an overview and impart conceptual understanding of protein structure.
b. To give molecular insights into protein folding pathways and describe the range oftechniques developed over recent years to study proteins.
c. To highlight advancements in protein engineering and their application to study protein conformations.
d. To create a deeper understanding of the significance of prediction and design ofprotein structures using bioinformatics tools

2. Course Outcomes: (C.O):

a. Enables understanding and exploring protein characteristics that lay foundation to protein engineering studies.
b. Acquire knowledge of protein folding mechanisms and familiarize with bioanalytical techniques.
c. Provide an advanced understanding of the core principles and applications of various important techniques employed for protein structure conformation studies.
d. Facilitate to carry out various *insilico* studies to build protein models and study protein ligand interactions that aid in drug design.

Course Plan/Schedule

Unit No.	Topics to be covered	No. of lectures
Unit-1	**Protein structural families**	
1.1	Introduction; basic structural principles: amino acids and their conformational accessibilities	2
1.2	Amino acids: chemical properties, active site residues	2
1.3	Dihedral angles propensity in the proteins	2
1.4	Ramachandran plot	1
1.5	Motifs of protein structures and their packing; schematic andtopology diagrams	2
1.6	Families of protein structures: alpha, alpha/beta, beta, small, etc	2
1.7	Protein structure on the world wide web: different databases andtheir uses-PDB, SCOP, CATH	3
1.8	DNA binding proteins	2
Unit-2	**Protein folding and assembly**	
2.1	Protein folding pathways in prokaryotes and eukaryotes	2
2.2	Single and multiple folding pathways	2
2.3	Protein denaturation, renaturation of single domain and multi-domain proteins	2
2.4	Inclusion bodies and recovery of active proteins	2
2.5	Osmolyte assisted protein folding	2

2.6	Structure of chaperones and role of chaperones in protein folding	2
2.7	Applications of bio-analytical techniques to study proteins -UV-visible-Flourimetry-HPLC-LC-MS & CD	4
Unit-3	**Protein engineering**	
3.1	Strategies for protein engineering	2
3.2	Random and site-directed mutagenesis	2
3.3	Mutagenesis using various PCR based strategies	2
3.4	Role of low-fidelity enzymes in protein engineering	2
3.5	Gene shuffling and directed evolution of proteins	2
3.6	Protein backbone changes, antibody engineering	2
3.7	Applications of NMR, X-Ray diffraction & Cryo-EM to study protein conformations	4
Unit-4	**Prediction and design of protein structures**	
4.1	Similar structure and function of homologous proteins	2
4.2	Multiple structural alignment	2
4.3	Homology method for protein structure prediction	2
4.4	Ab-initio method for protein structure prediction	2
4.5	Ligand design and protein docking	2
4.6	Structure based drug design and case studies	2
4.7	Rational protein design	2
4.8	Phage display systems	2

PRACTICALS
BT 354 P (B): PROTEIN ENGINEERING

S.No	Name of the experiment	No. of hours
1	*In-silico* Site directed mutagenesis, energy minimizations andsimulations	4
2	*In-vitro* site directed mutagenesis of enzymes by using PCR method	4
3	Over expression & optimization of targeted protein	4
4	Protein purification by using Ni-NTA affinity column chromatography	4
5	Protein purification by using Size exclusion column chromatography(AKTA)	4
6	Analysis of purified protein by electrophoresis	4
7	Analysis of purified protein by MALDI-TOF	4
8	Ligand-protein docking	4

REFERENCE BOOKS

1. Introduction to protein structure, Garland Press. Carl Branden and John Tooze, Structure and mechanism in protein science. Alan Fersht, Freeman
2. Protein engineering in industrial biotechnology, Academic Publishers. Ed. Lilia Alberghina, Harwood
3. Understanding Enzymes. T. Palmer, Prentice Hall
4. Modelling Biological Systems, Springer. Haefner

SEMESTER IV
THEORY PAPER- I
BT 401 T- BIOPROCESS ENGINEERING

1. **Course Objectives: (C.Obj.):**
   a. To impart information and knowledge on fundamental principles of bioprocess engineering
   b. To enlighten students mind on the upstream bioprocess infrastructure, knowhow and considerations
   c. To enable the students downstream process, unit operations and product recovery
   d. To introduce students to bioprocess instrumentation, measurement, control and automation

2. **Course Outcomes: (C.O):**
   a. Acquiring knowledge and acutance on fundamental principles of bioprocess engineering, models, kinetics and mass balances
   b. Comprehensive understanding on upstream bioprocess infrastructure, knowhow, transport phenomenon, fluid dynamics and mixing. Thoughtful insight and gaining thorough knowledge on bioreactor design configuration, features, media and air sterilization, and cell immobilization technology
   c. Gain of detailed knowledge on downstream processing: a multi stage operation, unit operations: solid liquid separation: filtration, centrifugation. methods for disruption of cells for product recovery, concentration of biological products, purification of product: chromatography methods, monitoring of downstream process and process integration
   d. Understanding of comprehensive expertise on bioprocess control and automation which includes fundamentals of bioprocess control, instrumentation and principles or measurement, deflection and thermal type paramagnetic oxygen analyzer, basic control system, automation and control system: control loops, application of computers in bioprocess engineering, artificial neural network and role, neural network computers in bioprocess control and process economics

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Fundamentals of bioprocess engineering**	
1.1	Introduction to bioprocess engineering, bioprocess development and interdisciplinary connections, bioprocess kinetics: quantitative description of bioprocess, Malthus law, defining rates and yield coefficients	3
1.2	Kinetic modeling, model structures, unstructured and structured kinetic models	2
1.3	Material balances: modes of operation of bioreactors (batch, continuous, fed-batch or semi-batch) mass balances for ideal bioreactors, general dynamic mass balance equations, specific mass balance equations for different modes of operation with dynamic state variables, dilution rate, productivity and reactor volume, energy balances: basic energy concepts	3
1.4	Transport phenomenon in bioprocess system: mass transfer (gas-liquid, liquid-liquid, liquid-solid, gas-solid, gas-liquid-solid), mass transfer steps, mass transfer equations, oxygen transfer, transfer steps,	3

	oxygen transfer equations, volumetric oxygen transfer coefficient (Kla), measurement of Kla, heat transfer principles, heat transfer mass balance, heat generation and exchange, heat removal	
1.5	Fluid dynamics and mixing: fluid types, Newtonian and non-Newtonian fluid, Newton's law of viscous flow, flow curve, shear stress and shear rate	3
1.6	Mixing: mixing equipments, impellers, baffles, impeller types (axial flow and radial flow impellers), mechanism of mixing	2
UNIT 2	**Upstream bioprocess infrastructure, knowhow and considerations**	
2.1	Designing of bioreactors: bioreactor types (stirring and non stirring), design configurations, STR, BCR, ALB and FBR. Criteria of positioning baffles agitators and spargers, bioreactor vessel design features, construction inputs, designs of bioreactors for sterile operations, pipe work valve types and filters, steam traps, clean- in-place issues	4
2.2	Photobioreactors: laboratory and industrial scale photobioreactors, solar photobioreactors, wave bioreactor	2
2.3	Sterilization of media and air for bioprocess. Liquid media sterilization, kinetics of sterilization, del factor, heating, holding and cooling cycles, design of sterilization process (batch and continuous), design of sterilization cycles (Richard's graphical integration rapid method)	3
2.4	Continuous sterilization (direct & indirect), continuous sterilization system for fermentation media sterility using spiral heat exchangers	2
2.5	Filter sterilization: mechanism, interception, filter types, absolute (fixed) and depth (non-fixed) filters, construction of depth filter types, zeta potential, hydrophilic membrane cartridges, hydrophobic membrane cartridges, construction, theory of depth filter	3
2.6	Cell immobilization, merits and demerits. cell immobilization strategies, active and passive immobilization (bio-films), microencapsulation (special immobilization system: beads, coated bead & hollow sphere), methods in microencapsulation, dropping methods, coaxial dropping, binding (adsorption, cross-linking, covalent binding), passive immobilization: biological films formation process, diffusion limitations in immobilized system, overall cell immobilization applications	2
UNIT 3	**Downstream process, unit operations and product recovery**	
3.1	Downstream processing: a multi stage operation, unit operations: solid liquid separation: filtration (batch, continuous), clarification, filter aids, flocculation, floatation/foam separation, centrifugation (batch, continuous), (principle, theory &equipments)	3
3.2	Methods for disruption of cells, recovery of intracellular components: mechanical and non-mechanical (chemical & enzymatic methods), high-pressure homogenization, microfluidization	2
3.3	Concentration of biological products: evaporation (principles and equipments), membrane filtration, electrodialysis, pervaporation, perstraction	3
3.4	Liquid-liquid extraction, aqueous two phase system (ATPS), precipitation, adsorption (break through curve), supercritical fluid	2

	extraction (SFE)	
3.5	Purification of product: chromatography methods and types, product formulation: principles and equipments, drying and types of dryers and lyophilization (sublimation, triple point)	3
3.6	Monitoring of downstream process and process integration: bioprocess monitoring, flow injection analysis (FIA)	3
UNIT 4	**Bioprocess instrumentation, measurement, control and automation**	
4.1	Fundamentals of bioprocess control, physical, chemical and biological sensors, classes of sensors: in-line, on-line and off- line sensors	3
4.2	Instrumentation and principles or measurement of temperature, flow rate, pressure, agitation shaft power, foam sensing, biomass, dissolved oxygen, pH, carbon dioxide etc	3
4.3	Deflection and thermal type paramagnetic oxygen analyzer for inlet/exhaust air	2
4.4	Basic control system, automation and control system: control loops (open and closed), controllers, manual control, automatic control, cascade control, ratio control, complex control systems, cascade feedback control, proportional, integral and derivative (PID) control	3
4.5	Application of computers in bioprocess engineering: data logging, analysis and control, computerized bioprocess control, bioprocess computers: limitations	2
4.6	Artificial neural network and role neural network computers in bioprocess control process economics, requisites for setting up of a biotech company: stating point of discussion, cost benefit analysis	3

PRACTICALS
BT 451 P: BIOPROCESS ENGINEERING

S.No	Name of Experiment	No. of Hours
1.	Bioprocess description in quantitative terms, calculation of doubling time, estimation of specific growth rate of target organism, preparation of growth curve. Evaluation of Malthus law	4
2.	Determination of yield coefficient and evaluation of Monod model	4
3.	Cell immobilization technique, biomass generation and harvesting of biological organism for analysis	4
4.	Development of laboratory scale bioreactors: Know-how	4
5.	Production of biotechnological products from immobilized yeast cells in packed bed bioreactor	4
6.	Purification and identification of unknown compounds from a mixture of compounds using column chromatography and TLC	4
7.	Extraction of protein from a crude bioprocess homogenate using aqueous two phase system (ATPS)	4
8.	Extraction of protein from milk and papain homogenate using aqueous two phase system (ATPS)	4

REFERENCE BOOKS

1. Bioprocess Engineering Principles by P. M. Doran
2. Bioprocess Engineering Basic Concepts by Kargi and Shuler
3. Fundamentals of Biochemical Engineering by Bailey and Ollis
4. Introduction to Biochemical Engineering Principles by D. G. Rao
5. Bioreaction Engineering Principles by Jens Høiriis Nielsen, John Villadsen, Gunnar Lidén
6. Principles of Fermentation Technology by P.F. Stansbury, A. Whitaker and S. J. Hall
7. Basic Biotechnology by C. Ratledge and Bjorn Kristiansen
8. Bioprocess Engineering by Bjorn K, Lydersen, Nacy, D'Elia, Nelson

PAPER- II
BT 402 T -MEDICAL BIOTECHNOLOGY

1. Course Objectives (C.Obj):

a. To discuss about the human genetic disorders and their molecular basis.
b. To explain about different approaches for disease diagnosis and prevention.
c. To give insights on different strategies and approaches for disease therapy
d. To provide knowledge on advanced therapeutic approaches, regenerative medicine and Nanotechnology

2. Course Outcomes (C.O):

a. Understand the molecular aspects of genetic diseases
b. Gain knowledge on genetic counseling and testing for disease diagnosis and prevention
c. Comprehension on conventional and advanced approaches for disease therapy and management
d. Gain insights on applications of regenerative medicine and nanotechnology for diagnostics and therapeutics.

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Molecular basis of disease**	
1.1	Chromosomal disorders- Numerical disorders e.g. Trisomies and Monosomies, Structural disorders e.g. Deletions, Duplications, Translocations and Inversions	2
1.2	Single gene disorders- Sickle Cell Anaemia and Thalassemia; Polygenic diseases-Alzheimer's disease, Type 1 Diabetes; Mitochondrial diseases- MELAS, MERRF	3
1.3	Infectious disorders- Hepatitis and HIV	2
1.4	Identification of disease genes: Functional cloning- eg. Haemophilia, Positional cloning- eg. DMD; Candidate gene approach- eg. Marfan syndrome	3
1.5	Molecular pathology of genetic diseases- Gain of function mutations- Pittsburg variant of alpha 1 antitrypsin; Loss of function mutations- PAX-3 gene; Gene dosage effect- PMP22, Collagen gene; Dynamic mutations- Fragile- X syndrome, Myotonic dystrophy	4
1.6	Genomic imprinting- mechanisms, Prader-willi & Angelman syndrome	2
UNIT 2	**Techniques for disease diagnosis**	
2.1	Prenatal diagnosis- indications for prenatal diagnosis; pre-implantation genetic diagnosis; invasive techniques- amniocentesis, fetoscopy, chorionic villi sampling (CVS); non-invasive techniques- ultrasonography, X-ray, TIFA, maternal serum screening and fetal cells in maternal blood	3
2.2	Diagnosis using protein and enzyme markers (PKU- Guthrie test, Dystrophy- Creatine kinase)	2

2.3	Diagnosis using monoclonal antibodies- hormonal disorders & infectious diseases	2
2.4	DNA/RNA based diagnosis- Hepatitis, CML– bcr/abl, HIV	3
2.5	Microarray technology- genomic and cDNA arrays, application to disease diagnosis	3
2.6	Genetic counseling- calculating risk & discussing the options	3
UNIT 3	**Therapeutics and Management of diseases**	
3.1	Gene therapy- Ex-vivo, Invivo, Insitu gene therapy; Strategies of Gene Therapy- Gene augmentation, Prodrug therapy/Suicide gene, TFO, Antisense therapy, SmaRT, Ribozymes, Protein aptamers, Intrabodies	3
3.2	Vectors used in gene therapy: Biological vectors- Retrovirus, Adenoviruses, Herpes; Synthetic vectors- Liposomes, Receptor mediated gene transfer; Gene therapy trials: ADA deficiency, Cystic fibrosis, Solid tumours, HIV, Parkinson disease	2
3.3	RNA interference and its applications in prevention of cancer and generation of antiviral drugs; Therapeutic genome editing- ZFN, CRISPR-Cas gene editing technology (HIV), TALENS (Leukaemia)	3
3.4	Enzyme therapy- Gaucher disease; Hormone replacement therapy- Diabetes, Growth hormone deficiency; Cytokine therapy- Interferons	3
3.5	Pharmacogenomics- Single gene disorders (G6PD) and Multigenic diseases (CHD); Benefits of pharmacogenomics	3
3.6	DNA based vaccines- Dental caries; Subunit vaccines- Herpes simplex virus; Attenuated vaccines- Cholera; Vector vaccines- Rabies	2
UNIT 4	**Regenerative medicine, Nanotechnology and Drug delivery systems**	
4.1	Regenerative medicine: Stem cells- Embryonic and Adult stem cells, Totipotent, Pluripotent and Multipotent cells, Characteristics and properties of stem cells	4
4.2	Potential use of stem cells- Cell based therapies	3
4.3	Cell and tissue engineering- Characteristics of cells involved in tissue engineering; Types and characteristics of biomaterials	3
4.4	Bioartificial organs (Liver, Heart auricles, Blood vessels & Skin)	2
4.5	Nanomedicine: Nanomaterials in medicine- quantum dots, dendrimers, peptide nanotubes, smart drugs, nanopore sensors, nanopore immune isolation devices, nano robots (microbivores, respirocyte), DNA based nano devices; Nanomedicine in cancer	2
4.6	Drug delivery systems- criteria for drug delivery systems, drug delivery carriers, controlled release mechanisms, administration routes	2

PRACTICALS
BT 452 P: MEDICAL BIOTECHNOLOGY

S. No.	Name of Experiment	No. of Hours
1	Genotyping of candidate genes for diseases by RFLP, Microsatellite & VNTR analysis	4
2	Screening for known mutations by ARMS-PCR/ASO	4
3	Screening for unknown mutations by SSCP and sequencing	4
4	Detection for dynamic mutations- Trinucleotide repeat polymorphism	4
5	Identification of disease gene expression by Real-time PCR	4
6	Sequencing of cDNA and cloning in expression vectors	4
7	Detection of congenital abnormalities by triple test	4
8	Preparation of Ag nanoparticles and testing their anti microbial effect	4
9	Encapsulation of lymphocytes/ RBCs	4

REFERENCE BOOKS:

1. Introduction to Human Molecular Genetics- J.J Pasternak, John Wiley Publishers
2. Human Molecular Genetics- Tom Strachen and A P Read, Bios Scientific Publishers
3. Human Genetics Molecular Evolution- Mc Conkey
4. Recombinant DNA Technology- AEH Emery
5. Principles and Practice of Medical Genetics, I, II, III Volumes by AEH Edts. Emery
6. Medical Biotechnology- Pratibha Nallari, V. Venugopal Rao- Oxford Press
7. Medical Biotechnology 1st Edition- Juditpongracz, Mary Keen
8. Medical Biotechnology by Bernard R. Glick, Terry L. Delovitch, Cheryl L. Pattern. ASM press, 2014
9. Molecular Biotechnology-Principles and Applications of Recombinant DNA- 4thEdition by Bernard R. Glick, Jacj J. Pasternack, Cheryl L. Pattern

THEORY PAPER- III (ELECTIVE)
BT 403 T (A) -ENVIRONMENTAL BIOTECHNOLOGY

1. Course Objectives (C.Obj):

a. To discuss types and different sources of Environmental pollution
b. To acquaint with biotechnological interventions for restoration of environment
c. To explain the significance and potential of biomass and biofuels
d. To demonstrate the scope and applications of biofertilizers and biopesticides

2. Course Outcomes (C.O):

a. Understanding the impact of fossil fuel burning, industrial effluents and Xenobiotics on Environmental pollution.
b. Critically understanding the advantages of microbial bioremediation, phytoremediation and biodiversity conservation for pollution abatement
c. Understanding the production & potential of Biomass and Biofuels as a renewable source of energy
d. Critically understanding the applications & limitations of biofertilizers and biopesticides

Course Plan/Schedule:

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Environmental Pollution**	
1.1	Introduction to environmental pollution, types of pollution - air, water and soil pollutions, classification of pollutants- inorganic, organic and biotic pollutants	3
1.2	Sources of pollution- domestic waste, agricultural waste, industrial effluents, municipal waste, Eutrophication and Algal blooms	3
1.3	Fossil fuels as energy source and their impact on environment	2
1.4	Climate change, Greenhouse effect and Global warming	2
1.5	Heavy metal, pesticide and Xenobiotic pollution and their impact on environment	4
1.6	Environmental monitoring – Methods of assessing pollution (BOD,COD), Bioindicators	2
UNIT 2	**Biotechnological intervention for restoration of environment**	
2.1	Microbial treatment of waste water (sewage & industrial effluent) - aerobic and anaerobic methods	3
2.2	Solid waste, Sources & management of solid waste – landfill, combustion, incineration and composting	3
2.3	Bioremediation Concept, types of Bioremediation - *in situ* and *ex situ* bioremediation	2
2.4	Microbial bioremediation of heavy metals (biotransformation, biosorption & bioaccumulation) and Xenobiotic compounds (biotransformation & biodegradation)	4
2.5	Phytoremediation concept, types and its applications	2
2.6	Biodiversity Concept, Conservation of biodiversity – *In situ* and *Ex situ* conservation	2
UNIT 3	**Biomass and Biofuels**	

3.1	Biomass as renewable energy source	2
3.2	Plant biomass – Starch, Pectin, Cellulose (Energy Crops)	3
3.3	Animal biomass (Chitin) and Microbial biomass (Algal and Fungal biomass)	3
3.4	Production of Bioethanol from plant feed stocks	4
3.5	Production of Biodiesel from plants and algae	2
3.6	Production of Biohydrogen and Biomethane	2
UNIT 4	**Biofertilizers and biopesticides**	
4.1	Biofertilizers concept - Biological Nitrogen Fixation, Phosphate Solubilisation; Biofertilizers production technology, Advantages of Biofertilizers	3
4.2	Bacterial biofertilizers- nitrogen fixing (free living and symbiotic) & phosphate solubilising bacteria; algal biofertilizers- blue green algae &Azolla; fungal biofertilizers- Mycorrhizae	3
4.3	Integrated nutrient management - Concept, Components, Advantages & Disadvantages	2
4.4	Biological control of pests; Biopesticides concept Biopesticides production technology, Advantages of Biopesticides	3
4.5	Microbial Biopesticides - Bacterial (*Bacillus thuringiensis*), Fungal (*Trichoderma sp*.) and Viral (Nucleopolyhedrosis virus) biopesticides; Plant based biopesticides; Biochemical pesticides	3
4.6	Integrated pest management - Concept, Components, Advantages & Disadvantages	2

PRACTICALS
BT 453 P (A): ENVIRONMENTAL BIOTECHNOLOGY

S. No.	Name of Experiment	No. of Hours
1.	Estimation of Biological Oxygen Demand in sewage samples	4
2.	Estimation of Chemical Oxygen Demand in sewage samples	4
3.	Determination of total dissolved solids in polluted water samples	4
4.	Determination of Coliforms to estimate quality of water samples	4
5.	Determination of microbial degradation of organic waste	4
6.	Isolation of Xenobiotic degrading bacteria by selective enrichment technique from soil	4
7.	Production of fertilizers	4
8.	Preparation of formulations of biopesticide	4

REFERENCE BOOKS

1. Environmental Biotechnology by M. H. Fulekar (Science Publishers, UK)
2. Text book of biotechnology by H.K. Das (Wiley Publications)
3. Biotechnology by H.J. Rehm and G. Reed. (VIH Publications, Germany)
4. Biogas Technology By Nijaguna
5. Biotechnology by K. Trehan
6. Industrial Microbiology By L.E. Casida
7. Food Microbiology by M.R. Adams and M.O. Moss
8. Introduction to biotechnology by P.K. Gupta
9. Essentials of biotechnology for students by Satya N. Das
10. Biotechnology, IPRs and biodiversity by M.B. Rao and Manjula Guru (Pearson Education)

THEORY PAPER- III (ELECTIVE)
BT 403 T (B) – BIOPHARMACOLOGY

1. Course Objectives (C.Obj):

a. To introduce basic concepts of Biopharmacology and principles of pharmacodynamics related to drug-receptor interactions.
b. To explain the underlying basic principles of *insilico* drug design and apply the same for lead optimization and validation.
c. To understand basic principles of pharmacokinetics and apply pharmacodynamics to clinical practice.
d. To impart an in depth understanding of pharmacological principles involved in various therapies.

2. Course Outcomes (C.O):

a. Enable to understand the drug metabolic pathways and therapeutic value of drugs.
b. Perform various *insilico* analysis for lead and pharmacophore optimization.
c. Well acquainted with the structural activity relationship and factors affecting the lead molecules.
d. Helps in correlating between pharmacology of a disease and its cure

Course Plan/Schedule

Unit Number	Topics to be covered	No. of lectures
UNIT 1	**Introduction to Pharmacology**	
1.1	Drugs- influencing factors	2
1.2	Drug concentration – response relationship	2
1.3	Receptor mechanisms of drug action and signal transduction mechanisms	2
1.4	Introduction to agonist, antagonist, competitive antagonist, partial antagonists	2
1.5	Therapeutic index, LD50, IC50, ED50	3
1.6	Drug toxicity and drug allergy	3
UNIT 2	**Principles of drug design**	
2.1	Denovo drug design techniques	3
2.2	Properties of drug likeliness, lipinski rule	2
2.3	In-silico calculation of ADME parameters	2
2.4	Structural activity relationships in drug designing	3
2.5	Lead optimization and validation	2
2.6	Molecular modeling, molecular docking and pharmacophore optimization	3
UNIT 3	**Biopharmaceutics**	
3.1	General principles of pharmacokinetics	2
3.2	Pharmacodynamics parameters like absorption, distribution, metabolism and excretion	2
3.3	Factors affecting drug action and enzyme inhibitory studies	3
3.4	Phases of clinical trails	2
3.5	Personalized medicine	2
3.6	Pharmaceutically important biotechnological products and their actions	3

UNIT 4	Principles of Pharmacotherapeutics	
4.1	Introduction to main drug classes	2
4.2	Principles of autonomic and peripheral nervous system pharmacology	2
4.3	Principles of cardiovascular pharmacology	2
4.4	Principles of pharmacology of the central nervous system	2
4.5	Principles of anti-cancer drug therapy	3
4.6	Immunopharmacology	3

PRACTICALS
BT 453P(B):BIOPHARMACOLOGY

S.No.	Name of the experiment	No.of hours
1	Enzyme based inhibition activity IC_{50} calculation	4
2	Antioxidant activity of super oxide dismutase (SOD) and catalase	4
3	Drug cytotoxicity using a cell line (MTT assay)	4
4	Analysis of biological specifications for drug content and estimation of the pharmacokinetic parameters, Measures of bioavailability, Cmax, tmax, and Area Under the Curve (AUC)	4
5	*In-silico* calculation of drug likeliness of small molecules by using lipinski rule and ADME parameters	4
6	*In-silico* optimization of pharmacophore	4
7	Anti-microbial plate assay	4
8	Anti-fungal plate assay	4

REFERENCE BOOKS

1. The Pharmacological Basis of Therapeutics byGoodman and Gilman
2. Textbook of Pharmacology by Rang and Dale
3. Quientessence of Medical Pharmacology by C.Chowdary
4. Lippincott's illustrated reviews - Pharmacology by Richard D.Howland and MeryJ.Mylek
5. Essentials of medical pharmacology by K.D.Tripathi
6. Pharmacology and Pharmacotherapeutics by R.S.Satoskar, S.D.Bhanderkar and S.S.Ainapure