MSc BIOTECHNOLOGY
CHOICE BASED CREDIT SYSTEM (CBCS)
DEPARTMENT OF GENETICS & BIOTECHNOLOGY, OSMANIA UNIVERSITY
Schedule for Instruction and Examination
(Proposed Scheme for Academic year 2016 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	Statistics, 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**

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

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

Unit 1: Restriction enzymes and cloning vectors

1.1 Host controlled restriction modification
1.2 Restriction endonucleases, types and classification
1.3 Modifying enzymes used in molecular cloning, methylases, polymerases, ligases, kinases, phosphatases and nucleases
1.4 Vectors for cloning (pUC18), expression vectors (pET)
1.5 Vectors for library preparation (lambda phage vectors, cosmids, BAC & YAC)
1.6 Host organisms used in r-DNA technology: E.coli, Yeast

Unit 2: Construction of Genomic and cDNA libraries

2.1 Introduction to cloning (conventional & recombination based)
2.2 Strategies for construction of genomic libraries
2.3 Chromosome walking and chromosome jumping for positional cloning of genes
2.4 Strategies for construction of cDNA libraries
2.5 Construction of subtractive and normalized cDNA libraries
2.6 PCR- principle, types and applications

Unit 3: Selection and characterization of recombinant clones

3.1 Genetic Selection- insertional inactivation and alpha complementation
3.2 Labeling of nucleic acids
3.3 Immunological probes
3.4 Selection of recombinant clones-hybridization techniques (southern, northern, western, south-western & zoo blot), colony hybridization & library screening, hybrid arrest & hybrid release translation
3.5 DNA sequencing methods- Maxam-Gilbert and Sanger's method, automated sequencing, multiplex sequencing
3.6 DNA arrays- principle, spotted DNA array; oligonucleotide chips

Unit 4: Advanced techniques and applications of recombinant DNA technology

4.1 Site directed mutagenesis and RNA interference
4.2 Knock-in and knock- out technology
4.3 Genome engineering technology- CRISPR-Cas system, TALENs & zinc finger, nucleases
4.4 Next generation sequencing- principle, types and applications
4.5 Applications of genetic engineering in agriculture & animal husbandry
4.6 Applications of genetic engineering in industry and medicine

PRACTICALS

BT 351 P: RECOMBINANT DNA TECHNOLOGY

1. Isolation of plasmid DNA
2. Genetic transformation of *E.coli* and selection of recombinant clones
3. Polymerase chain reaction
4. Restriction digestion and gel electrophoresis
5. Restriction mapping problems
6. In-vitro site directed mutagenesis by using PCR method

REFERENCE BOOKS

1. Principles of Gene Manipulation and Genomics- Sandy B. Primrose, Richard Twyman 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

Unit 1: Foundations of bioinformatics

1.1 Bioinformatics- a historical perspective
1.2 Bioinformatics data- nucleic acid sequence, protein sequence, protein structure, genome variation data, gene expression data, proteomic data, metabolic pathways and networks
1.3 Bioinformatics databases- what are databases, why databases, types of databases, file formats (Examples: genbank- DNA sequence, uniprot- protein sequence, PDB- Structure, CATH, SCOP- protein classification, unigene- transcripts, KEGG- metabolic pathway, dbSNP- variation, RAP-DB- genome-specific)
1.4 Database search engines (entrez and SRS)
1.5 Bioinformatics tools and resources- free online tools, downloadable free tools, software packages, bioinformatics web portals
1.6 Role of internet in bioinformatics

Unit 2: Sequence comparison methods

2.1 Basics of sequence alignment: match, mismatch, gaps, scoring an alignment (gap penalties (linear & affine gap penalties), sequence relationships (sequence identity, similarity, homology, orthologs, paralogs & xenologs)
2.2 DNA vs protein sequence alignment (permissible replacements, similarity score, Scoring matrices (PAM & BLOSUM))
2.3 Pairwise alignment: dot-matrix comparison of sequences, dynamic programming based pairwise alignment algorithms (global- Needleman and Wunch algorithm, local- Smith and Waterman algorithm)
2.4 Pairwise alignment based database searching-rigorous algorithms for database searching (Needleman-Wunch, Smith-Waterman), heuristic algorithms for database searching (FASTA algorithm and BLAST algorithm)
2.5 Multiple-sequence alignment (MSA): significance of MSA
2.6 Progressive and iterative based algorithms for multiple sequence alignment, consensus sequence, nucleotide distribution matrix, sequence profile and position specific scoring matrix, multiple sequence alignment based database searching (profile BLAST)

Unit 3: Genomic applications

3.1 Bioinformatics for genome sequencing, first and next generation methods of genome sequencing, de-novo and reference based genome sequencing, genome assembly (reads, contigs & scaffolds)

3.2 Transcript-profiling: expression microarrays (gene array & oligo array), transcriptome sequencing and RNA-seq analysis, small RNA sequencing and analysis

3.3 Genome annotation: finding repeats, gene finding in prokaryotes and eukaryotes, finding promoters and regulatory motifs

3.4 Genome maps and markers: identification of molecular markers (SSR, STS & SNP markers), linkage vs physical maps, displaying genome annotation using genome browsers

3.5 Bioinformatics for genome variation studies: identification of whole genome duplications and its implications, segmental duplication (copy number variation) identification and its implications, single nucleotide variation identification and its implications

3.6 Medical application of bioinformatics- understanding diseases and identification of disease genes, disease diagnostics, overview of drug discovery, pharmacogenomics

Unit 4: Proteomic and metabolomic applications

4.1 Protein profiling (2D gels, protein fingerprinting & identification), protein structure analysis

4.2 Protein classification: SCOP and CATH schemes of classification (motifs, domains, folds, class, architecture, family & super family)

4.3 Protein structure: structure visualization

4.4 Protein: secondary and tertiary structure prediction (homology modelling)

4.5 Phylogenetic analysis (distance matrix & UPGMA based tree construction)

4.6 Metabolic networks: metabolic pathways and metabolic reconstruction

PRACTICALS

BT 352 P: BIOINFORMATICS AND ITS APPLICATIONS

1. Bioedit as sequence handling tool
2. Understanding DNA/protein coding systems
3. Understanding file formats (FASTA, FastQ, BAM)
4. Exploring sequence databases (Genbank and Uniprot)
5. Exploring structure database (PDB and MMDB)
6. Key word and accession number based database search and downloading bioinformatics data
    a. Downloading DNA sequence data (Genbank/DDBJ/ENA)
    b. Downloading protein sequence data (Uniprot)
    c. Downloading protein structure data (PDB/MMDB) and visualization
    d. Downloading bioinformatics data from FTP servers (NCBI)
7. Pairwise (global and local) alignment of DNA sequences
8. Pairwise (global and local) alignment of protein sequences
9. Multiple sequence alignment of DNA and protein sequences using Clustal-W
10. Database searching with heuristic (FASTA and BLAST) and rigorous algorithms (Needleman-Wunch and Smith-Waterman algorithms)
11. Exploring genome specific databases (RAP-DB)
12. Exploring gene databases (entrez gene, gene cards)
13. Prediction of genes in prokaryotic and eukaryotic genomes
14. Prediction of SSRs in DNA sequence (SSRit)
15. Prediction of secondary structures of proteins online
16. Homology modelling online
17. RNA secondary structure prediction

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 discovery by S.C. Rastogi, Parag Rastogi, Namita Mendiratta

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

Unit 1: Plant tissue culture and its applications

1.1 Introduction and history of plant tissue culture
1.2 Media, growth regulators, callus, cell culture and plant regeneration; meristem culture and micropropogation of elite plants
1.3 Somaclonal variation, production of haploids and dihaploids and its applications
1.4 Anther culture, embryo culture and embryo rescue
1.5 Somatic hybridization- protoplast isolation, culture and fusion, development of somatic hybrids and cybrids
1.6 Cryopreservation for conservation of plant germplasm

Unit 2: 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 Factors influencing the in vitro production of secondary metabolites (physical and chemical factors)
2.3 Permeabilisation, elicitation and immobilisation of cells for enhanced production of secondary products
2.4 Organ cultures for production of secondary metabolites- leafy teratomas, hairy root cultures and adventitious roots
2.5 Pathway engineering for enhanced production of secondary metabolites
2.6 Biotransformation and production of novel compounds

Unit 3: Plant transgenic technology

3.1 Methods of gene transfer in plants- direct (particle bombardment) and indirect methods (Agrobacterium-mediated plant transformation)
3.2 Selection (reporter genes- scorable and selectable genes) and characterization of transformants
3.3 Strategies for chloroplast transformation and advantages
3.4 RNAi Technology- role of RNAi based gene silencing in crop improvement
3.5 Genome editing techniques- TALENs, zinc finger nuclease, CRISPR-Cas system

Unit 4: Applications of plant transgenic technology

4.1 Transgenic plants for insect/pest resistance and herbicide resistance
4.2 Transgenic plants for bacterial, fungal and viral resistance
4.3 Transgenic plants for drought, salt and heavy metal, temperature, flooding or submergence stress tolerance
4.4 Transgenic plants for production of biopharmaceuticals (edible vaccines, erythropoietin & α-interferon)
4.5 Transgenic plants for improvement of nutritional quality (oil, amino acids, vitamins & micronutrients)

PRACTICALS

BT 353 P (A): ADVANCES IN PLANT BIOTECHNOLOGY

1. Micro propagation of elite ornamental/agricultural plants/tree species
2. Induction of somatic embryos and preparation of synthetic seeds
3. Induction of hairy root cultures using *Agrobacterium rhizogenes* for the production of secondary metabolites
4. Preparation of recombinant plant expression vector with gene of interest
5. Genetic transformation of plant tissue using *Agrobacterium tumefaciens*
6. Confirmation of transgenic plants by PCR and southern blotting techniques

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

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

Unit 1: Fundamentals of Food and Nutrition

1.1 Introduction to food, nutrition, nutrient, malnutrition and balanced diet
1.2 Nutrient requirement and recommended dietary allowances (RDA)
1.3 Carbohydrates- classification, properties, functions and food sources of carbohydrates (sugar, starch, cellulose, glucans, hemicelluloses, gums, peptic substances & polysaccharides); recommended dietary allowances
1.4 Lipids- classification, properties, functions and food sources of lipids; recommended dietary allowances
1.5 Proteins- classification, properties, functions and food sources of proteins; recommended dietary allowances
1.6 Vitamins and Minerals- functions, food sources; recommended dietary allowances

Unit 2: Food processing and preservation

2.1 Scope and importance of food processing
2.2 Processing of cereals, pulses and oilseeds
2.3 Technology for improved process- baking, milk products, cheese making and alcohol production
2.4 Food spoilage- factors affecting, role of microorganisms, enzymes, toxins
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)
2.6 Chemical methods of preservation of foods- uses of sugar, salt, chemicals and antibiotics

Unit 3: Functional foods

3.1 Nutraceuticals- types, processing of nutraceutical products, therapeutic applications
3.2 Pharma foods- diabetic foods (sugar free), confectionaries, sodium free, lactose free, phenylalanine free and fibre rich foods - nutritional implications
3.3 Dietary supplements- fortification of nutrients in the processed foods & other dietary supplements, hyper nutritious foods (protein powders)
3.4 Fat free foods- PUFA oils n3, n6 fatty acids, fat free milk powder, low cholesterol oils and cholesterol free foods
3.5 Functional nano foods- benefits of nanotechnology for functional foods
3.6 Probiotics and prebiotics- sources and their health benefits

Unit 4: Food quality and safety management

4.1 Introduction, scope of food quality and food safety, food adulteration- adulteration in different foods
4.2 Evaluation of food quality- appearance, colour texture, viscosity, consistency, flavor defects and foreign matter
4.3 Methods of identification of microbial contamination (bacteria, fungi & virus) of food
4.4 Methods of identification of toxic chemicals (food additives, food preservatives, pesticides, dyes, etc.) of food
4.5 Nanotechnology driven food safety- nano packaging, nano sensors
4.6 Food standards and laws- national food safety and food standards regulations, prevention of food adulteration act, safety regulations of genetically modified foods

PRACTICALS

BT 353 P (B) - FOOD BIOTECHNOLOGY

1. Qualitative and quantitative analysis of carbohydrates and proteins in food
2. Estimation of glucose in human blood
3. Estimation of serum protein in human
4. Estimation of serum cholesterol in human
5. Preparation and evaluation of cheese or fermented product
6. Determination of fat content in milk
7. Estimation of vitamins- vitamin A, C and riboflavin
8. Determination of aflatoxin in food
9. Tests for pesticidal residues in food

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 Institute of Nutrition, Indian Council of Medical Research, 2010
4. Aurand, L.W. and Woods, A.E. 1973. Food Chemistry. AVI, Westport
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. Marcel Dekker, New York
7. Meyer, L.H. 1973. Food Chemistry. East-West Press Pvt. Ltd., New Delhi
8. Potter, N.N. 1978. Food Science. 3rd Ed. AVI, Westport
9. Fellows, P. and Ellis H. 1990. Food Processing Technology: Principles and Practice, New York
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. Pergamon Press, 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 Vegetable Products. 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

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

Unit 1: Animal tissue culture: principles and applications

1.1 Cell culture technique: cell culture media, sterilization techniques, cell lines, maintenance and cell adaptation
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
1.3 Cryopreservation- germplasm conservation
1.4 Mass culture of cells - types of cell lines, maintenance of cell lines, manipulation of cells- cell transfection (electroporation and chemical methods) and transduction, immobilization of cells and its application
1.5 Synchronization of cell cultures, production of secondary metabolites, biotransformation, scaling up of animal cell culture
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

Unit 2: Animal breeding and improvement

2.1 Conventional methods of animal Improvement- selective breeding, cross breeding
2.2 Principles of animal breeding; structure of the livestock breeding industry: dairy cattle, beef cattle, swine, sheep, poultry and aqua culture
2.3 Artificial insemination (AI) techniques; super ovulation
2.4 Estrus synchronization; embryo collection and transfer; semen collection, evaluation, storage, preservation
2.5 Somatic cell nuclear transfer and embryo sexing
2.6 Invitro maturation of oocytes, invitro fertilization, intracytoplasmic sperm injection (ICSI) and preservation of endangered species

Unit 3: Genetic tools and their applications

3.1 Basic concepts: genesis and importance of molecular techniques; physical and genetic map, current status of genome maps of livestock
3.2 Statistical techniques for analyzing molecular genetic data: quantitative trait loci (QTL) mapping and its application in animal breeding, genome scan, candidate gene approach, genomic selection
3.3 Fundamentals of animal genetics: aqua culture (shrimp, prawns and oyster) and cattle (sheep, buffalo and pig)
3.4 Molecular markers and their application in animal improvement- RFLP, RAPD, microsatellite/minisatellite markers, SNP Marker, DNA fingerprinting
3.5 DNA sequencing, genome sequencing, genomic library, polymerase chain reaction (PCR): its types (PCR-RFLP, AS-PCR) and applications in livestock development
3.6 Identification and isolation of genes of economic importance

Unit 4: Gene targeting and animal models

4.1 Mouse as a disease model (origin and evolution of mouse, mating & breeding)
4.2 Generation of transgenic, knock-out and knock-in mouse; spontaneous and inducible gene expression in mouse; double transgenics
4.3 Cancer models (carcinogenic injection; bone marrow transplantation; xenografts, retrovirus- lentivirus- & adenovirus-based models)
4.4 Neurodegenerative disease models (Alzheimers & Parkinsons)
4.5 Infectious (Leprosy) and metabolic disease (Obesity & Diabetes) models
4.6 Genome editing tools: zinc finger nucleases (ZFNs), TALENs and the CRISPR-Cas system

PRACTICALS

BT 354 P (A): ANIMAL BIOTECHNOLOGY

1. Laboratory animal breeding- breeding colonies of mice, rats, hamsters, guinea pigs and rabbits (demonstration); selection and mating methods/systems- monogamous, polygamous and others
2. Raising of polyclonal antibodies (demonstration)
3. Immunocytochemistry
    i. Antibody staining and chromogen detection
    ii. Immunofluorescence
4. Initiation of primary culture from chick embryo
5. Preparation of single cell suspension from spleen/liver/thymus
6. Establishment of primary cell culture: mouse splenocyte culture
7. Mammalian cell transfection (transient)
8. Immunofluorescence detection to check transfection efficiency (using fluorescence and confocal microscopes)

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 and specialized 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 molecular biology
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

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

Unit 1: Protein structural families

1.1. Introduction; basic structural principles: amino acids and their conformational accessibilities, chemical properties, active site residues
1.2. Dihedral angles propensity in the proteins, Ramachandran plot
1.3. Motifs of protein structures and their packing; schematic and topology diagrams
1.4. Families of protein structures: alpha, alpha/beta, beta, small, etc
1.5. Protein structure on the world wide web: different databases and their uses (PDB, SCOP & CATH)
1.6. DNA binding proteins

Unit 2: Protein folding and assembly

2.1 Protein folding pathways in prokaryotes and eukaryotes
2.2 Single and multiple folding pathways
2.3 Protein denaturation, renaturation of single domain and multi-domain proteins
2.4 Inclusion bodies and recovery of active proteins
2.5 Osmolyte assisted protein folding, structure of chaperones and role of chaperones in protein folding
2.6 Applications of bio-analytical techniques to study proteins (UV-visible, Fluorimetry, HPLC, LC-MS & CD)

Unit 3: Protein engineering

3.1 Strategies for protein engineering
3.2 Random and site-directed mutagenesis; various PCR based strategies
3.3 Role of low-fidelity enzymes in protein engineering
3.4 Gene shuffling and directed evolution of proteins
3.5 Protein backbone changes, antibody engineering
3.6 Applications of NMR, X-Ray diffraction & Cryo-EM to study protein conformations

Unit 4: Prediction and design of protein structures

4.1 Similar structure and function of homologous proteins
4.2 Multiple structural alignment
4.3 Homology and ab-initio method for protein structure prediction
4.4 Ligand design and protein docking
4.5 Structure based drug design and case studies, rational protein design
4.6 Phage display systems

PRACTCALS

BT 354 P (B): PROTEIN ENGINEERING

1. In-silico Site directed mutagenesis, energy minimizations and simulations
2. In-vitro site directed mutagenesis of enzymes by using PCR method
3. Over expression & optimization of targeted protein
4. Protein purification by using Ni-NTA affinity column chromatography
5. Protein purification by using Size exclusion column chromatography (AKTA)
6. Analysis of purified protein by electrophoresis
7. Analysis of purified protein by MALDI-TOF
8. Ligand-protein docking

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

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

1.2 Kinetic modelling, model structures, unstructured and structured kinetic models

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

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, 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

1.6 Mixing: mixing equipments, impellers, baffles, impeller types (axial flow and radial flow impellers), mechanism of mixing

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

2.2 Photobioreactors: laboratory and industrial scale photobioreactors, solar photobioreactors, wave bioreactor

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)

2.4 Continuous sterilization (direct & indirect), continuous sterilization system for fermentation media sterility using spiral heat exchangers

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

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

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)

3.2 Methods for disruption of cells, recovery of intracellular components: mechanical and non-mechanical (chemical & enzymatic methods), high-pressure homogenization, microfluidization

3.3 Concentration of biological products: evaporation (principles and equipments), membrane filtration, electrodiyalysis, pervaporation, perstraction,

3.4 Liquid-liquid extraction, aqueous two phase system (ATPS), precipitation, adsorption (break through curve), supercritical fluid 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)

3.6 Monitoring of downstream process and process integration: bioprocess monitoring, flow injection analysis (FIA)

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

4.2 Instrumentation and principles or measurement of temperature, flow rate, pressure, agitation shaft power, foam sensing, biomass, dissolved oxygen, pH, carbon dioxide etc

4.3 Deflection and thermal type paramagnetic oxygen analyzer for inlet/exhaust air

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

4.5 Application of computers in bioprocess engineering: data logging, analysis and control, computerized bioprocess control, bioprocess computers: limitations

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

PRACTICALS

BT 451 P: BIOPROCESS ENGINEERING

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
2. Determination of yield coefficient and evaluation of Monod model
3. Cell immobilization technique, biomass generation and harvesting of biological organism for analysis
4. Development of laboratory scale bioreactors: Know-how
5. Production of biotechnological products from immobilized yeast cells in packed bed bioreactor
6. Purification and identification of unknown compounds from a mixture of compounds using column chromatography and TLC
7. Extraction of protein from a crude bioprocess homogenate using aqueous two phase system (ATPS)
8. Extraction of protein from milk and papain homogenate using aqueous two phase system (ATPS)

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

SEMESTER-IV
THEORY PAPER-II
BT 402 T- MEDICAL BIOTECHNOLOGY

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
1.2 Single gene disorders- Sickle Cell Anaemia and Thalassemia; Polygenic diseases- Alzheimer's disease, Type 1 Diabetes; Mitochondrial diseases- MELAS, MERRF
1.3 Infectious disorders- Hepatitis and HIV
1.4 Identification of disease genes: Functional cloning- eg. Haemophilia, Positional cloning- eg. DMD; Candidate gene approach- eg. Marfan syndrome
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
1.6 Genomic imprinting- mechanisms, Prader-willi & Angelman syndrome

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
2.2 Diagnosis using protein and enzyme markers (PKU- Guthrie test, Dystrophy- Creatine kinase)
2.3 Diagnosis using monoclonal antibodies- hormonal disorders & infectious diseases
2.4 DNA/RNA based diagnosis- Hepatitis, CML– bcr/abl, HIV
2.5 Microarray technology- genomic and cDNA arrays, application to disease diagnosis
2.6 Genetic counselling- calculating risk & discussing the options

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
3.2 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
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)
3.4 Enzyme therapy- Gaucher disease; Hormone replacement therapy- Diabetes, Growth hormone deficiency; Cytokine therapy- Interferons
3.5 Pharmacogenomics- Single gene disorders (G6PD) and Multigenic diseases (CHD); Benefits of pharmacogenomics
3.6 DNA based vaccines- Dental caries; Subunit vaccines- Herpes simplex virus; Attenuated vaccines- Cholera; Vector vaccines- Rabies

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

4.2 Potential use of stem cells- Cell based therapies

4.3 Cell and tissue engineering- Characteristics of cells involved in tissue engineering; Types and characteristics of biomaterials

4.4 Bioartificial organs (Liver, Heart auricles, Blood vessels & Skin)

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

4.6 Drug delivery systems- criteria for drug delivery systems, drug delivery carriers, controlled release mechanisms, administration routes

PRACTICALS

BT 452 P: MEDICAL BIOTECHNOLOGY

1. Genotyping of candidate genes for diseases by RFLP, Microsatellite & VNTR analysis
2. Screening for known mutations by ARMS-PCR/ASO
3. Screening for unknown mutations by SSCP and sequencing
4. Detection for dynamic mutations- Trinucleotide repeat polymorphism
5. Identification of disease gene expression by Real-time PCR
6. Sequencing of cDNA and cloning in expression vectors
7. Detection of congenital abnormalities by triple test
8. Preparation of Ag nano particles and testing their anti microbial effect
9. Encapsulation of lymphocytes/ RBCs

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- Judit pongracz, 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- 4th Edition by Bernard R. Glick, Jacj J. Pasternack, Cheryl L. Pattern

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

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
1.2 Sources of pollution- domestic waste, agricultural waste, industrial effluents, municipal waste, eutrophication and algal blooms
1.3 Fossil fuels as energy source and their impact on environment
1.4 Climate change, greenhouse effect and global warming
1.5 Heavy metal, insecticide, pesticide and xenobiotic pollution and impact on environment
1.6 Environmental monitoring- Bioindicators

Unit 2: Biotechnological intervention for restoration of environment

2.1 Microbial treatment of waste water (sewage or industrial effluent)- aerobic and anaerobic methods
2.2 Solid waste management and composting of organic wastes
2.3 Bioremediation of heavy metals- biosorption and bioaccumulation
2.4 Microbial bioremediation of pesticides and xenobiotic compounds
2.5 Phytoremediation and its applications
2.6 Conservation of biodiversity

Unit 3: Biomass and biofuels

3.1 Biomass as renewable energy source
3.2 Types of biomass- plant, animal and microbial biomass
3.3 Energy crops for carbon sequestration
3.4 Animal waste and production of biogas
3.5 Production of biofuels: bioethanol, biohydrogen and biomethane
3.6 Production of biodiesel from plants and algae

Unit 4: Biofertilizers and biopesticides

4.1 Biofertilizers and their importance
4.2 Bacterial biofertilizers- nitrogen fixing and phosphate solubilizing bacteria; algal biofertilizers- blue-green algae and azolla; fungal biofertilizers- mycorrhizae
4.3 Integrated nutrient management
4.4 Biological control and development of biopesticides
4.5 Bacterial, fungal and viral biopesticides
4.6 Integrated pest management

PRACTICALS

BT 453 P (A): ENVIRONMENTAL BIOTECHNOLOGY

1. Estimation of biological oxygen demand in sewage samples
2. Estimation of chemical oxygen demand in sewage samples
3. Determination of total dissolved solids in water samples
4. Determination of coliforms to estimate quality of water samples
5. Isolation of xenobiotic degrading bacteria by selective enrichment technique
6. Estimation of heavy metals in water/soil by atomic absorption spectrophotometry
7. Production of microbial fertilizers
8. Preparation of formulations of microbial biopesticide

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 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. Biotechnology, IPRs and biodiversity by M.B. Rao and Manjula Guru (Pearson Education)

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

Unit 1: Introduction to pharmacology

1.1 Drugs- influencing factors
1.2 Drug concentration-response relationship
1.3 Receptor mechanisms of drug action and signal transduction mechanisms
1.4 Introduction to agonist, antagonist, competitive antagonist, partial antagonists
1.5 Therapeutic index, $LD_{50,}$ IC_{50}, ED_{50}
1.6 Drug toxicity and drug allergy

Unit 2: Principles of drug design

2.1 Denovo drug design techniques
2.2 Properties of drug likeliness, lipinski rule
2.3 In-silico calculation of ADME parameters
2.4 Structural activity relationships in drug designing
2.5 Lead optimization and validation
2.6 Molecular modeling, molecular docking and pharmacophore optimization

Unit 3: Pharmacokinetics and Pharmacodynamics

3.1 General principles of pharmacokinetics
3.2 Pharmacodynamics parameters like absorption, distribution, metabolism & excretion
3.3 Factors affecting drug action and enzyme inhibitory studies
3.4 Phases of clinical trails
3.5 Personalized medicine
3.6 Pharmaceutically important biotechnological products and their actions

Unit 4: Pharmacology-Applications

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

PRACTICALS

BT 453 P (B): BIOPHARMACOLOGY

1. Enzyme based inhibition activity IC_{50} calculation
2. Antioxidant activity of super oxide dismutase (SOD) and catalase
3. Drug cytotoxicity using a cell line (MTT assay)
4. Analysis of biological specifications for drug content and estimation of the pharmacokinetic parameters, Measures of bioavailability, C_{max}, t_{max}, and Area Under the Curve (AUC)
5. In-silico calculation of drug likeliness of small molecules by using lipinski rule and ADME parameters
6. In-silico optimization of pharmacophore
7. Anti-microbial plate assay
8. Anti-fungal plate assay

REFERENCE BOOKS

1. The Pharmacological Basis of Therapeutics by Goodman 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 Mery J.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

BT 404 T: PROJECT WORK

BT 454 P: PROJECT THESIS PRESENTATION