MANGALORE UNIVERSITY
CHOICE BASED CREDIT SYSTEM (CBCS)
Syllabus for M.Sc. Biotechnology 2016-

FIRST SEMESTER

Paper Code	COURSE	Teaching hours per week	Credits	Marks		Total
				IA*	Exam	
	HARD CORE COURSES - THEORY					
BT 1.1	Biochemistry and Biophysics	4	4	30	70	**100**
BT 1.2	Molecular Genetics	4	4	30	70	**100**
BT 1.3	Microbiology	4	4	30	70	**100**
	SOFT CORE COURSES -THEORY					
BT 1.4.1	Enzymology	3	3	30	70	**100**
BT 1.4.2	Cell Biology					
	PRACTICALS					
BT 1.1.1	Biochemistry	4	2	15	35	**50**
BT 1.2.1	Molecular Genetics	4	2	15	35	**50**
BT 1.3.1	Microbiology	4	2	15	35	**50**
BT 1.4.1.1	Enzymology	4	2	15	35	**50**
BT 1.4.2.1	Cell Biology					
	Total		**23**			**600**

SECOND SEMESTER

Paper Code	COURSE	Teaching hours per week	Credits	Marks		Total
				IA*	Exam	
	HARD CORE COURSES -THEORY					
BT 2.1	Molecular Biology	4	4	30	70	**100**
BT 2.2	Genetic Engineering	4	4	30	70	**100**
	SOFT CORE COURSES -THEORY (CHOOSE TWO)					
BT 2.3.1	Bioprocess Technology	3	3	30	70	**100**
BT 2.3.2	Bioanalytical Techniques					
BT 2.4.1	Radiation Biology	3	3	30	70	**100**
BT 2.4.2	Signal Transduction					
	PRACTICALS					
BT 2.1.1	Molecular Biology	4	2	15	35	**50**
BT 2.2.1	Genetic Engineering	4	2	15	35	**50**
BT 2.3.1.1	Bioprocess Technology	4	2	15	35	**50**
BT 2.3.2.1	Bioanalytical Techniques					
BT 2.4.1.1	Radiation Biology	4	2	15	35	**50**
BT 2.4.2.1	Signal Transduction					
	OPEN ELECTIVES					
BT 2.5	Fundamental Biotechnology	3	3	30	70	**100**
BT 2.6	Food Biotechnology					
	Total		**25**			**700**

THIRD SEMESTER

Paper Code	Paper Title	Teaching hours per week	Credits	Marks		Total
				IA*	Exam	
	HARD CORE PAPERS -THEORY					
BT 3.1	Bioprocess Technology	4	4	30	70	**100**
BT 3.2	Microbial Technology	4	4	30	70	**100**
BT 3.3	Bioinformatics and Biostatistics	4	4	30	70	**100**
	SOFT CORE PAPERS -THEORY					
BT 3.4.1	Plant Biotechnology	3	3	30	70	**100**
BT 3.4.2	Metabolism					
	PRACTICALS					
BT 3.1.1	Bioprocess Technology	4	2	15	35	**50**
BT 3.2.1	Microbial Biotechnology	4	2	15	35	**50**
BT 3.4.1.1	Plant Biotechnology	4	2	15	35	**50**
BT 3.4.2.1	Metabolism		2	15	35	**50**
	OPEN ELECTIVES					
BT 3.5	Nanobiotechnology	3	3	30	70	**100**
BT 3.6	Medical Biotechnology					
	Total		**26**			**700**

FOURTH SEMESTER

Paper Code	Paper Title	Teaching hours per week	Credits	Marks		Total
				IA*	Exam	
	HARD CORE PAPERS –THEORY					
BT 4.1	Animal Biotechnology	4	4	30	70	**100**
BT 4.2	Environmental Biotechnology	4	4	30	70	**100**
	PRACTICALS					
BT 4.1.1	Animal Biotechnology	4	2	15	35	**50**
BT 4.2.1	Environmental Biotechnology	4	2	15	35	**50**
	PROJECT WORK					
BT 4.3	Project Work and Dissertation	4	4	30	70	**100**
			16			**400**
Grand Total			**90**			**2400**

IA includes Seminar/Assignment (per course), tests (per course), MCQs (per course) = 30

Schematic of Course distribution and Credits of M.Sc. Biotechnology Programme with practicals and open electives

SEM	HARD CORE COURSES			SOFT CORE COURSES			OPEN ELECTIVES	PROJECT	TOTAL
	No of Courses	Credits	Total Credits	No of Courses	Credits	Total Credits	Total Credits		
I	**3Th+3Pr**	**4+2**	**18**	**1Th+1Pr**	**3+2**	**5**			**23**
II	**2Th+2Pr**	**4+2**	**12**	**2Th+2Pr**	**3+2**	**10**	**3**		**25**
III	**2Th+2Pr**	**4+2**	**12**	**2Th+1Pr**	**3+2**	**8**	**3**		**23**
IV	**2Th+2Pr**	**4+2**	**12**	**1Th+1Pr**	**3+2**	**5**		**4**	**16**
Total			**54=58%**			**28=30%**	**6**	**4**	**92**

BT 1.1 BIOCHEMISTRY AND BIOPHYSICS Hours: 52

UNIT I (13 hrs)

Chemical bonds. Thermodynamic principles, free energy, enthalpy and entropy, chemical equilibrium, reaction kinetics, redox processes. ATP as an energy currency in the cell and other high energy compounds. Standard free energy, coupled reaction. pH and buffer concept. Carbohydrates: stereochemistry, general reactions, classification, polysaccharides: structure, function - relation (e.g. Starch and cellulose). Carbohydrate metabolism: Glycolysis, inter conversion of various monosaccharides, pathway of citric acid cycle, anaplerotic reaction, gluconeogenesis and pentose phosphate pathway.

UNIT II (13 hrs)

Classification of amino acids, general reactions, titration curves. Amino acids - deamination, transamination, transdeamination, decarboxylation, urea cycle, ketogenic and glucogenic amino acids. Metabolism of aromatic amino acids, histidine, cysteine and serine. Peptide bonds, conformational properties of polypeptides: primary, secondary, tertiary and quaternary structures. Globular and fibrous proteins. Protein structure: α-keratin, silk fibroin, Myoglobin, collagen, hemoglobin. Protein folding: denaturation, effects of temperature and solvent on the thermodynamics of protein folding and unfolding equilibrium.

UNIT III (13 hrs)

Nucleic acid chemistry, bases, base-pairing rules, Watson-Crick model of DNA, Properties of DNA-denaturation, renaturation, melting temperature, hyperchromicity, different structural forms of DNA. Different types of RNAs, general chemical reactions of RNA and DNA. Nucleic acid metabolism: Biosynthesis - de novo and salvage pathways, catabolism of purines and pyrimidines.

UNIT IV (13 hrs)

Lipid classification, triacyl glycerol, phospholipids, sphingolipids, cholesterol and liposomes; prostaglandins, leukotrienes, thromboxanes, Plasma lipoproteins. Biosynthesis of fatty acids, cholesterol biosynthesis, ketone body formation, interconversion of phospholipids. Oxidation of fatty acids, α, β & ω types. Energetics of β oxidation. Biological functions of fat-soluble vitamins: A, D, E and K. Water soluble vitamins: coenzymes.

References

1) Biochemistry. Berg JM., Tymoczko JL. and Stryer L., Freeman & Co., New York, 2002
2) Biochemistry. Zubay GL., Macmillan Publ., 1988
3) Harper's Biochemistry. Murray RK., Harper HA., Appleton &Lange Medical Publ., 1985
4) Lehninger Principles of Biochemistry. Nelson DL. and Cox MM. WH Freeman Publ., 2000
5) Text book of biochemistry with clinical correlations. Devlin TM. John Wiley and Sons., 2011
6) Basic concepts of analytical chemistry. Khopkar SM. New Age International Publ. New Delhi, 1998

BT 1.2 MOLECULAR GENETICS Hours: 52

UNIT I (13 hrs)

Mendelian genetics, symbols and terminology, principle of segregation, principle of independent assortment, multiple alleles, interaction of genes, pleiotropy; Deviations and exceptions to Mendelian ratios – variation of dominance, multiple alleles, sex-linkage, linkage and crossing over and chromosome mapping. Sex determination, dosage compensation and extrachromosomal inheritance (e.g. *Chlamydomonas*, snail, *Neurospora* and yeast).

UNIT II (13 hrs)

Identification of DNA as genetic material, experiments of Griffith, Avery MacLeod and McCarthy. Molecular mutation (mechanisms of missense, nonsense, transition, transversion and frame-shift mutation, lethal mutation, origin of spontaneous mutation and control)

Recombination in bacteria: Transformation, transduction and conjugation. DNA damage – mechanical and chemical; types of DNA repair, photo-reactivation, base excision, recombination, mismatch, SOS.

UNIT III (13 hrs)

C-value paradox, co-linearity of genes, split genes, gene families.Study of model systems: *Drosophila, Arabidopsis* and human beings.Chromosome analysis, karyotyping, cytogenetic mapping, Fluorescent In-situ Hybridization (FISH) Technique, Comparative genomic hybridization. Human Cytogenetics: Human karyotype construction. Mendelian and chromosome based heritable diseases and syndromes (colour blindness, retinoblastoma, haemophilia, cystic fibrosis, sickle cell anaemia, Down's syndrome, Klinefelters's syndrome, Turner's syndrome, Edward's syndrome and Cri-du-chat syndrome), Prenatal diagnosis (amniocentesis and chorionic villus sampling). Genetic counseling.

UNIT IV (13 hrs)

Transposable elements, Discovery, types and their significance in bacteria and Eukaryotes.

Population and evolutionary genetics: Genetic variation, Hardy-Weinberg equilibrium, inbreeding, outbreeding and changes in allelic frequency. Epigenetics, functional perturbation, knockdown (interference RNA, small interference RNA), knockout technology, micro RNA.Genetics and evolution.

References

1) Basic Genetics. Hartl D.L. & Jones E.W.Jones&Bartlett Pub., 1998
2) Genes. Lewin B., Oxford Univ. Press, 2000
3) Mobile Genetic Elements. Shapilo N.Y., Academic press, 1983
4) Microbial Genetics. Maloy S.R.,Cronan J., &Freifelder D., Jones and Bartlett Pub., 1994
5) Molecular Biology of Gene. Watson J.D. et al., Benjamin Cumming Pub., 2013
6) Molecular Genetics of Bacteria. Dale, J.W. John Wiley and sons, 2010
7) Principle of Genetics – Gardner E.J., et al., John Wiley and sons Pub., 1975
8) Molecular Genetics of Bacteria. Dale JW. John Wiley and Sons., 2004
9) Principle of Genetics. Gardner EJ., Simmons MJ. and Snustad DP., Wiley Pub., 2006

BT 1.3 MICROBIOLOGY Hours: 52

UNIT I (13 hrs)

Historical perspectives, origin and evolution of microorganisms, principles of classifications, numerical and molecular taxonomy, Comparative morphology, structure and reproduction in archaebacteria, eubacteria, cyanobacteria, yeast and fungi. Microbial nutrition, nutritional grouping of microorganism; Growth kinetics, factors affecting growth and death; methods of isolation, enumeration, cultivation and preservation of microorganisms.

UNIT II (13 hrs)

Microbial metabolism: Microbial respiration, aerobic and anaerobic respiration, fermentation, Bacterial photosynthesis. General account of symbiosis, mutualism, antagonism, parasitism and commensalism in microorganisms. Nucleic acid metabolism: Biosynthesis – *de novo* and salvage pathways, catabolism of purines and pyrimidines.

UNIT III (13 hrs)

Classification, morphology, ultrastructure and life cycle of plant viruses, animal viruses and bacteriophages DNA viruses: Herpes virus, Adenovirus, WTV; RNA viruses: Polio, Influenza, Retroviruses (HIV); Bacteriophages: lambda phage, bacteriophage MU, M13, T3, T4.

UNIT IV (13 hrs)

Plant microbe interactions: Rhizosphere, mycorrhizas, rhizobia, diazotrophs and endophytes. Plant pathogen interactions: *Phytophthora*, *Agrobacterium* and TMV. Animal microbe interactions: Tuberculosis, dermatophytes, Rabies, Mycoplasma and Rickettsiae, typhoid, leprosy, cholera; Antibiotics: types, mode of action and drug resistance (Cholera, *Salmonella* and *Staphylococcus*), antimicrobial therapy. Principles of microbial spoilage of food, Methods of food preservation by physical (freezing, canning, pasteurization and irradiation) and chemical (preservatives, lactic antagonism) methods. Microbial food poisoning (botulism, mycotoxins, algal toxins, cholera and salmonellasis).

References

1. Biology of microorganisms. Brock, T.B.& Madigan, M.T., Prentice Hall, 1996
2. Elements of microbiology. Pelczar, M.J. & Chan E.C.S. Mac Graw Hill New York., 1993
3. General Microbiology. Schlegel, H.G., Cambridge Univ. Press, 1993
4. Microbial biology. Rosenberg, E. & Cohen, I.R. Saunders Coll. Pub., 1983
5. The microbial world. Stanier, R.Y.et al., Prentice Hall New Delhi, 2008
6. Microbiology: Principles and explorations, 8th Ed., Black JG, Wiley, 2004
7. Prescott's microbiology. Willey J., Sherwood L., Woolverton C.J., McGraw Hill, 2010
8. Burrows textbook of microbiology. Burrows W. and Freeman BA. WB Saunders Co., 1973
9. Introduction to modern virology. Dimmock NJ., Easton AJ. and Leppard KN., Blackwell Publ. 2006
10. Food microbiology. Frazier WC and Westhoff DC. 4th Ed., Tata McGraw-Hill, 1987

BT 1.4.1 ENZYMOLOGY (SOFT COURE COURSE) Hours: 39

UNIT I (13 hrs)

Enzyme nomenclature and classification, isolation of enzymes, extraction of soluble and membrane bound enzymes, purification of enzyme- criteria for purification, assay of enzymes. Structure and general properties of enzymes, active site and specificity of enzymes, Enzyme substrate complex, theories of enzyme catalysis, proximity and orientation, acid-base catalysis. Nucleophilic and electrophlic reaction of enzymes, factors affecting enzyme activity, temperature, pH, time substrate concentration. Isozymes, co-enzymes, metalloenzymes, multifunctional and multienzyme complexes -PDC.

UNIT II (13 hrs)

Kinetics of enzyme catalysed reactions, free energy of enzyme reactions, presteady state, steady state kinetics, Michaelis Mente**n** equation for steady state and equilibrium state, Lineweaver-Burk, Eddie-Hofstee and Hanes plot, Cornish Bowden plot, fast kinetics to elucidate the intermediates and rate limiting steps. Multiple substrate reaction types with specific examples (bisubstrate). Enzyme inhibitors – types of inhibitors, mechanism of enzyme inhibition, competitive, non-competitive, uncompetitive and inhibition. Suicide inhibition, allosteric and irreversible inhibition – significance. Mixed kinetics of reversible inhibition, transition state analogs.

UNIT III (13 hrs)

Allosteric enzymes and metabolic regulation, sigmoid kinetics, steady-state metabolic pathway, concerted and sequential models to explain the sigmoid nature of allosteric enzymes. Regulation of metabolic pathway by control of enzyme activity. Zymogen, substrate analogues and their uses. Mechanism of action of lysozyme, chymotrypsin, aspartate transcarbamylase, Alcohol dehydrogenase, RNA as enzyme. Synthetic enzymes, Ribozymes, Abzymes, clinical and industrial application of enzymes, enzymes and inborn errors of metabolism, enzymes as reagents in clinical chemistry, (Analytical tools), Enzyme engineering (Protein engineering), Immobilization of enzyme and their applications

References

1. Enzyme Biochemistry, Biotechnology and Clinical Chemistry. Palmer T., Harwood Pub., 2001
2. Enzyme Technology. Chaplin M.F. & Bucke C., Cambridge Univ. Press, 1990
3. Fundamentals of Enzymology. Price, N.C. & Stevens, L., Oxford Pub., 1999
4. Immobilized Enzymes and Cells. A. Rosevear et al., IOP Pub., 1987
5. Industrial Enzymes and their Applications. Uhlig H. John Wiley and sons, 1998
6. Thermostability of Enzymes. Gupta M.N., Narosa Pub., 1993

BT 1.4.2 CELL BIOLOGY (SOFT COURE COURSE) Hours: 39

Unit I (13 hrs)

Introduction; Prokaryotic and eukaryotic cells; Difference between plant and animal cells. Membrane structure: Different models of membrane structure - Lipid bilayer, membrane proteins, membrane carbohydrate, transport across biomembranes, Mechanisms of endocytosis and exocytosis, Ion channels, Electrical properties of membranes; Nerve impulse transmission. Chemical composition of cell walls, cross linkage, porosity, tensile strength, turgor modifications in special types of cells, plasmodesmata, fluid transport between cells.

Unit II (13 hrs)

Principle and applications of Light: (Phase contrast, differential interference contrast, fluorescence, Confocal) and Electron Microscopy. Subcellular Organization: Ultrastructural organization and functions of Golgi complex, endoplasmic reticulum, mitochondria, chloroplast, peroxisomes, lysosomes, ribosomes, nucleus and nucleolus.

Unit III (13 hrs)

Structure, organization and types of eukaryotic chromosomes, Heterochromatin, euchromatin, telomeres, types of chromosomes, polytene chromosomes and lampbrush chromosomes. Chromosome dynamics during cell division: Mitosis, meiosis, microtubules, centrosome, centromere, kinetochore, metaphase and anaphase movements, motor proteins, cytokinesis. Cell cycle and its regulation. Apoptosis.

References

1. Molecular Biology of the Cell. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D., Garland Publishing Inc., 2002
2. The Cell. A Molecular Approach. Cooper, G.M. Sunderland: Sinauer Associates, Inc., 2000
3. Cell and Molecular Biology. De Robertis, E.D.P. & De Robertis, E. M.F. B.I. Waverly Pvt. Ltd., 1971
4. Gilbert, S.F. Developmental Biology. Sunderland (MA): Sinauer Associates, Inc., 2000
5. Molecular cell Biology. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira P. &Baltimore, D. WH Freeman & Co., 2000
6. Cell and Molecular Biology. Concepts and experiments. Karp, G., John Harris, D., Wiley & sons, 1999
7. Principles of Cell and Molecular Biology. Kleinsmith, L. J. & Kish, V.M., Harper Collins Publishers, 1995

PRACTICALS (HARD CORE COURSES)

BT 1.1.1 BIOCHEMISTRY AND BIOPHYSICS

GLP, Safety practices
Titration of amino acid Glycine
Qualitative analysis of amino acids, proteins, sugars, lipids
Extraction of casein from milk by isoelectric precipitation
Estimations of proteins by Biuret method
Estimation of sugars by DNS method
Animal Handling techniques for biochemical assays

BT1.2.1 MOLECULAR GENETICS

Morphological features of *Drosophila*
Mounting genital plate and sex comb in *Drosophila*
Isolation and staining of salivary gland chromosomes in *Drosophila*
Mutants of *Drosophila*
Micronucleus test in mice
Banding techniques and karyotyping
Demonstration of Barr bodies in buccal cells
Study of human blood groups
Chromatographic separation of eye pigments in *Drosophila*
Problems on quantitative inheritance
Problems on gene frequencies in population

BT 1.3.1 MICROBIOLOGY

Microscopic observations of microorganisms
Microbial staining techniques (simple and differential staining, cell wall, endospores, intracellular lipids, acid-fast, flagella, viability)
Microbial motility tests
Sterilization techniques
Microbial culture media and their preparation
Isolation techniques
Maintenance of microorganisms (stock culture and subculture)
Microbial characterization based on biochemical tests
Quantitative and quantitative assessment of microflora in soil, water, air and food
Milk microbiology
Studies on bacteria, fungi and actinomycetes
Studies on symbiotic association of microorganisms

PRACTICALS (SOFT COURSE COURSES)

BT 1.4.1.1 ENZYMOLOGY

Extraction, isolation and purification of soluble and membrane bound enzymes
Enzyme assays
Study of enzyme kinetics (effect of substrate concentration, pH, temperature and metal ions)
Determination of K_m and V_{max}
Mechanism of enzyme inhibition
Mechanism of action of lysozyme, chymotrypsin polymerases
Immobilization of enzymes and their applications

OR

BT 1.4.1.2 CELL BIOLOGY

Microscopy, micrometry, microtomy
Study of mitosis and meiosis in plants and animals
Preparation of mitotic chromosomes and karyotyping
Staining techniques: Staining blood cells, total count and differential count
Histology and differential staining (cellular organelles and components)
Brushborder membrane
Studies on nerve impulses
Isolation of RNA and DNA
Estimation of RNA and DNA

BT 2.1 MOLECULAR BIOLOGY Hours: 52

Unit I (13 hrs)

Central Dogma of molecular biology. DNA Replication: Semiconservative mechanism, prokaryotic and eukaryotic DNA replication, Ok**a**zaki fragments; enzymology and control of DNA replication; inhibitors of replication; Replication in Øx 174, M-13, T-phages and Lambda phages.

Unit II (13 hrs)

Transcription: Prokaryotic and Eukaryotic Transcription.-RNA polymerase sub units, different sigma factors, initiation, elongation and termination - rho dependent and independent; antitermination, control by antisense RNA; attenuation and other influences of translational apparatus on the process of transcription, eukaryotic promoters, enhancers, transcription factors, various protein motifs involved in DNA protein interaction during transcription. RNA processing enzymes, modification in RNA: 5'-Cap formation; Transcription termination; 3'-end processing and polyadenylation; Splicing; RNA Editing, Nuclear export of mRNA; mRNA stability. Different modes of mRNA, tRNA, and rRNA splicing, role of various snRNPs.

Unit III (13 hrs)

Translation in Prokaryotes and Eukaryotes: Genetic code, initiation of translation, chain elongation, Termination, post-translational modification and structure determination and involvement of different translational factors at different stages of the process. Folding of polypeptides; involvement of molecular chaperon, Protein splicing. Inhibitors of translation, translational control mechanism. Organization of prokaryotic and eukaryotic genomes. Regulation of gene expression in prokaryote and eukaryotes, operon concept, catabolic repression, repressible enzyme systems, control by attenuation, positive control, gene regulation in eukaryotes, transcriptional regulation, post-transcriptional regulation. Environmental regulation of gene expression.

Unit IV (13 hrs)

Carcinogenic agents and molecular biology of cancer: Abnormal cell growth: mechanism of transformation of cells. Genetic basis of Cancer, Physical and chemical carcinogenic agents; Viral and cellular oncogenes, tumor suppressor genes, Telomerases and their role in cancer. Developmental Biology: Gene action during oogenesis, transcriptional role of oocyte lamp brush chromosomes, ribosomal RNA synthesis during oogenesis, spermatogenesis, Germ cells and fertilization, Molecular and cellular biology of fertilization: acrosome reaction and signal transduction, monospermy and species-specificity. Egg activation, cleavage morphogenetic movements, Genetic basis of differentiation, molecular genetics of pattern formation - in *Drosophila*, *C.elegans*, *Xenopus* and mouse. Nuclear cytoplasmic interactions during development.

References

1) Molecular Biology of the Cell. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. Garland Publishing, Inc., 2002
2) The Cell - A Molecular Approach. Cooper, G.M. Sunderland: Sinauer Associates, Inc, 2000
3) Cell and Molecular Biology. De Robertis, E.D.P. and De Robertis, E.M.F. B.I. Waverly Pvt. Ltd., 1971
4) Developmental Biology. Gilbert, S.F. Sinauer Associates, Inc., 2000
5) Molecular cell Biology. Lodish, H., Berk, A., Zipursky, S.L. et al. WH. Freeman and Co, 2000
6) Cell & Molecular Biology – Concepts & experiments. Karp, G., Harris, D., Wiley & sons, 1999

7) Principles of Cell and Molecular Biology. Kleinsmith, L.J. & Kish, V.M. McLaughlin, S., Trost, K., Mac Elree, E., Harper Collins Publishers, 1995
8) Genes VII. Lewin, B. Oxford University Press, 2000
9) Molecular biology: genes to proteins. Tropp BE., Jones & Bartlett , 2010
10) Essential of Molecular biology. Freifelder D., Jones & Bartlett, 1985
11) Molecular Biology of Gene. Watson JD., Baker TA., Bell SP., et al., Pearson Edu. Inc. 2013
12) Molecular Biotechnology: Principles and applications of recombinant DNA. Glick BR. and Pasternak JJ. ASM Press, Washington, 2009

BT 2.2 GENETIC ENGINEERING Hours: 52

UNIT I (13 hrs)

Restriction – modification systems, Restriction enzymes – type I, II and III, specificity, sticky ends and blunt ends, isoschizomers. Double digests. DNA ligases, optimum ligation conditions. Enzymes to modify the terminals of DNA- Alkaline phosphatase, polynucleotide kinase, DNase I, S1 nuclease, DNA polymerase and Klenow fragment, Terminal nucleotidyl transferase, RNase H and DNA topoisomerase. Use of linkers, adapters and homopolymer tailing. Other methods of joining DNA molecules: TA cloning of PCR products, Construction of genomic libraries, construction of cDNA libraries, methods of cDNA synthesis; PCR: Design, optimization, types and applications.

UNIT II (13 hrs)

Essential features of vectors for transforming bacteria and yeast, animals and plants. Special vectors: Shuttle vectors, expression vectors, Construction of Artificial chromosomes vectors BACs, YACs and MACs. Cosmids, phagemids and phasmids. Fusion vectors. Viral vectors. Techniques of introducing genes in Prokaryotes and eukaryotes: transformation, calcium phosphate method, DEAE- Dextran method, protoplast fusion/somatic cell hybridization. Liposome mediated transfer, microinjection, electroporation and gene gun.

UNIT III (13 hrs)

Identifying the right clones: Direct screening: Insertional inactivation of marker gene, visual screening, plaque phenotype. Indirect screening: Immunological techniques, Hybrid arrest translation, Hybrid select translation. Screening using probes: Construction of gene probes, hybridization and labeling. Nucleic acid hybridization – Southern blotting, colony hybridization, dot blot; Chromosome walking and chromosome jumping.DNA sequencing: Maxim and Gilbert's method, Sanger and Coulson's method, Messing's shot gun method, Automated sequencers; Analysis of genetic variation: Single nucleotide polymorphism, conserved and variable domains, RFLP, AFLP, EST, STS, SCAR, SSCP. DNA finger printing. Genome sequencing: overview, strategies (e.g. Human genome project).

UNIT VII (13 hrs)

Mapping of DNA: Restriction mapping, DNA footprinting, mapping by somatic cell hybridization. Use of transposons in gene mapping. Analysis of gene expression: Analysis of transcription by Northern blot, RNase protection assay, Primer extension assay, *in-situ* hybridization. Comparing transcriptomes: Differential screening, subtractive hybridization, array based methods; Implication of Genetic engineering. Methods of studying promoter, reporter genes, locating the promoter, regulatory elements and DNA-binding proteins. Translational analysis: Screening expression libraries with antibodies – Western Blot, two-dimensional electrophoresis. Manipulating gene expression: Transcriptional fusions, translational fusions, *In-vitro* mutagenesis: Oligonucleotide directed mutagenesis, deletions, Insertional mutagenesis, direct single base mutagenesis.

References

1) From Genes to Clones, Winnacker E.L., Panima Educational Book agency, 1987,
2) Genes VII, Lewin, Oxford University Press, 2000
3) Principles of Gene Manipulation. Primrose S.B., &Twyman R.M. Blackwell scientific Pub. 2006.
4) Recombinant DNA Technology. Watson J.D. et al., Scientific American Book Series, 2006

5) Genetics: a molecular approach. Brown TA., Stanley Thornes Publ. 1999
6) An introduction to genetic engineering. Nicoll DST., Cambridge Univ Press., 2012
7) Principles of Genome Analysis and Genomics. Primrose SB., Twyman RM., Blackwell Publ. 2002

BT 2.3.1 BIOPROCESS TECHNOLOGY (SOFT CORE COURSE) Hours: 39

UNIT I (13 hrs)

Basic principles in bioprocess, advantages of bioprocess over chemical process. Isolation and improvement of industrially important strains. Design of fermentation media, inoculum development. Sterilization – Sterilization of medium, air and fermenters. Thermal death kinetics. Design of fermenter- criteria for ideal fermenter, aeration, agitation, valves, baffles, heat exchanges. Types of fermenters: Waidhof-type fermenter, tower fermenter, cylindroconical vessels, air-lift fermenter, deep-jet fermenter, the cyclone column, the packed tower, rotating disc fermenter and photobioreactors. Animal cell culture fermenter-stirred fermenter, microcarrier, encapsulation, hollow fiber chambers, packed glass bead reactors. Cell immobilization techniques. Stability of microbial reactors.

UNIT II (13 hrs)

Types of fermentation processes: submerged fermentation, surface or solid substrate fermentation, batch fermentation, continuous fermentation, kinetics of fermentation processes. Transport phenomenon in bioprocesses- mass transfer, Mass transfer co-efficient for gases and liquids, oxygen transfer co-efficient, biological heat transfer and heat transfer coefficients. Online acquisition: Bioprocess control and monitoring of variables such as temperature, agitation, pressure, pH, PID control, use of computers in bioprocess control systems (data logging, analysis and control).

UNIT IV (13hrs)

Downstream processing of biological molecules: Separation of cells, foam separation, flocculation, filtration, centrifugation (Basket and bowl centrifugation), cell lysis methods, physical and chemical methods. Large scale separation techniques like Distillation, solvent extraction, liquid-liquid extraction, chromatographic techniques, membrane filtration, ultra filtration, reverse osmosis, crystallization, spray drying, drum drying, freeze drying, whole broth processing. Application of cells in bioprocess (LAB, PAB, yeast, mixed cultures, plant and animal cells). Biosensors: construction and application, fermentation economics.

References

1. Biochemical Engineering fundamentals, Bailey J., Bailey J. & Ollis D.F., McGraw-Hill Pub., 1986
2. Chemical Engineering. J.M Coulson &J.F. Richardson, Pregamon Press, 2002
3. Comprehensive Biotechnology. Volumes 1, 2, 3 & 4. Moo-Young M., Pergamon Press, 2011
4. Fundamentals of Biotechnology. Prave P.et al., Wiley-Blackwell Pub., 1987
5. Principles of Fermentation Technology. Stanbury P.F. et al Pergamon Press, 1984

BT 2.3.1 BIOANALYTICAL TECHNIQUES (SOFT CORE COURSE) Hours: 39

UNIT II (13 hrs)

Principle, instrumentation and applications of separation techniques for different biomolecules and applications: Chromatography – paper, TLC, Gel filtration, ion exchange, affinity, HPLC and GC. Electrophoresis - gel, agarose-gel, PAGE, SDS-PAGE, Iso-electric focusing.

UNIT III (13 hrs)

Physical techniques in structural analysis of biomolecules and applications: Spectroscopy: principle, instrumentation and application of UV-visible, fluorescent, CD, NMR, ESR spectroscopy, Atomic absorption spectroscopy, Plasma emission spectroscopy, X-ray diffraction, Mass spectroscopy.

UNIT III (13 hrs)

Principle, instrumentation and applications of Centrifugation and ultracentrifugation. Radioisotope techniques - nature of radiation sources, radioactive decay, units of radiation, detection and measurement of radioactivity, GM and scintillation counters and autoradiography. Principles of nanotechnology - Nanostructures, nanoparticles and their properties. Applications. Green synthesis of nanoparticles.

References

1) Principles of instrumental analysis. Skooge DA., Holler FJ., Crouch SR., Thompson Brooks Publ., 1988
2) Basic concepts of analytical chemistry. Khopkar SM. New Age International Publ. New Delhi, 1998
3) Principles and Techniques of Biochemistry and Molecular Biology, K. Wilson and J. Walker (Eds.) 6th Ed., Cambridge Univ. Press, 2005

BT 2.4.1 RADIATION BIOLOGY (SOFT CORE COURSE) Hours 39

UNIT I (13 hrs)

Electromagnetic radiation: Ionizing and non-ionizing radiation. Radiation sources: Natural and artificial sources. Radioactivity: units of radiation, different types of radiation, radioactive decay, half-life, biological half-life and mean life. Radiation detectors and monitors; GM and Scintillation counters. Radiation exposure and dose, absorbed dose, equivalent dose, effective dose, committed equivalent dose, collective equivalent dose, biological effectiveness, tissue equivalence.

UNIT II (13 hrs)

Radioisotopes: Good Laboratory Practices in a radioisotope laboratory; Safe-handling of radioisotopes with special emphasis on isotopes used in biotechnology ^{32}P, ^{35}S, ^{14}C, ^{3}H, ^{125}I. classification of radioisotope laboratories, units of radiation dose, measuring devices. Applications of radiation in medicine, industry, agriculture. Diagnostic techniques using radioisotopes and radiotracers, Cancer therapy, autoradiography techniques, gamma knife radiosurgery, radioimmunoassay (RIA) and immunoradiometric assay (IRMA).

UNIT III (13 hrs)

Mechanism of direct and indirect action of radiation at cellular level. Nature of radiation damage at molecular, subcellular and cellular level. DNA damage and chromosomal aberrations. Mitotic catastrophe. Radiation damage: Lethal and sublethal damage, Cell survival curves, Effect of different radiation species and radiation dose/dose rate. Radiation effects on important organs of the human body: deterministic and stochastic effects; possible recovery pathways.

References

1) Radiation Biophysics – EL Alpen, Academic Press, 1997
2) Radiation Biology: Handbook for teachers and Students, IAEA, online
3) Basic and Clinical Radiobiology – Joiner M. and van der Kogel A. (ed) UK, online
4) Nuclear and Radiochemistry. Friedlander G., Kennedy JW., Macias ES., et al John Wiley and sons., 1981
5) Principles and Techniques of Biochemistry and Molecular Biology. Wilson K. and Walker J. (Eds.) 6th Ed., Cambridge Univ. Press., 2005

BT 2.4.2 SIGNAL TRANSDUCTION (SOFT CORE COURSE) Hours 39

Unit I

Cell signaling: Various types of cell signaling-endocrine, paracrine, juxtacrine and autocrine. Hormones and growth factors, neurotransmitters, peptide hormones, steroid hormones, eicosanoids, vitamins, gases etc as cell signaling molecules. Synaptic transmission in neurons – post synaptic receptors, depolarization, hyperpolarization, repolarization. Cellular responses to environmental signals in plants and animals. Plant hormones, signaling and signal transduction in plants. Thyroid hormone and steroid hormone signaling pathways – nuclear steroid receptor superfamily – mode of action.

Unit II

Receptors - types of cell surface receptors. Basic tenets and mechanisms of signal transduction, GPCR, G proteins, Protein tyrosine kinase receptors, Cytokine receptors, Protein Serine, Threonine kinases, protein tyrosine phosphatases, guanylyl cyclases, Nucleotide exchange factors, Phosphorylation and dephoshorylation. Second messengers - cAMP, cGMP, Calcium and phospholipids – DAG, IP_3, PIP_2. Downstream signaling molecules mTOR, Akt, Ras, Raf. Plant hormone action. Differences between yeast and mammalian pathways.

Unit III

Cell signaling cascades: during development – Wnt, Notch, Hedgdehog; during phases of the cell cycle, cell proliferation and apoptosis – mitogen activated protein (MAP) kinase pathway, TNF, TGF beta, Fas ligand-induced cascades; in response to extracellular signaling (ERK). Cell signaling in neurons – long term potentiation, long term depression. Cell signaling in the immune system and in cancer. Cross-talk between signaling pathways. JAK-STAT pathway, NF-kappa B signaling.

References

1. Molecular Biology of the Cell. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D., Garland Publishing Inc., 2002
2. The Cell. A Molecular Approach. Cooper, G.M. Sunderland: Sinauer Associates, Inc., 2000
3. Cell and Molecular Biology. De Robertis, E.D.P. & De Robertis, E. M.F. B.I. Waverly Pvt. Ltd., 1971
4. Gilbert, S.F. Developmental Biology. Sunderland (MA): Sinauer Associates, Inc., 2000
5. Molecular cell Biology. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira P. &Baltimore, D. WH Freeman & Co., 2000
6. Cell and Molecular Biology. Concepts and experiments. Karp, G., John Harris, D., Wiley & sons, 1999
7. Principles of Cell and Molecular Biology. Kleinsmith, L. J. & Kish, V.M., Harper Collins Publishers, 1995

PRACTICALS (HARD CORE COURSES)

BT 2.1.1 MOLECULAR BIOLOGY

Autoradiography to study the structure of molecules
Induction of tumors and its prevention
Structure of sperms and eggs
Spermatogenesis (e.g. grass hoppers)
Chick and *Drosophila* developmental stages
Histological identification of germ layers of developing embryos
Induced breeding in fishes

BT2.2.1 GENETIC ENGINEERING

Isolation of DNA and RNA from bacteria, plants and yeasts
Southern and Northern blotting techniques
Western blotting
Studies on DNA replication
Studies on vectors
Ti plasmid
Probes
Chromosome mapping
Sequencing
PCR techniques
Construction of DNA libraries
Genomics and Proteomics
Study of mutagenesis

PRACTICALS (SOFT CORE COURSES)

BT 2.3.1.1 BIOPROCESS TECHNOLOGY

Isolation of microbes of industrial importance
Instrumentation in bioprocess technology
Growth and death kinetics of microbial cultures
Cell encapsulation (immobilization) techniques and uses
Pilot-scale production of microbial (or plants or animal) cell products
Downstream processing techniques
Lyophilization
Biosensors

BT 2.3.2.1 BIOANALYTICAL TECHNIQUES

Paper Chromatography of amino acids
TLC of sugars
Spectroscopic estimation of proteins by Lowry's method
Spectroscopic estimation of proteins by Bradford's method
Spectroscopic estimation of sugars by Folin-Wu method
Separation of subcellular constituents
HPLC
X-ray Diffraction
Atomic Absorption Spectroscopy

BT 2.4.1.1. RADIATION BIOLOGY

Radiation in food preservation
Radiation for waste water treatment.
Irradiation effects on seed germination, growth and other parameters in plants
Radioimmunoassay
Working of GM and Scintillation counters
Radiation exposure studies - Micronuclei assay
Radiation sterilization - microbial decontamination

BT 2.4.2.1 SIGNAL TRANSDUCTION

Immunocytochemistry
Western Blotting
Cell cycle in fission yeast
Cell cycle in budding yeast
Cell cycle arrest studies in mitosis

BT 2.5 FUNDAMENTAL BIOTECHNOLOGY (OPEN ELECTIVE) Hours: 39

UNIT I (13hrs)

Origin of life. Microbial,diversity – bacteria, viruses, fungi; Beneficial and harmful microbes. Normal microflora associated with humans and animals. Microbes in human and animal nutrition (e.g. ruminants and non-ruminants) and health. Interactions between microbes, plants and animals. Microbial biotechnology: Fermentation (e.g. ethanol, enzymes, hormones, biogas, biofuels, vitamins), Antibiotics and probiotics.

UNIT II (13hrs)

Plant biotechnology: Genetic manipulation (GM) of plants, GM plants (e.g. BT cotton, BT brinjal, Golden rice, Flvr-savr tomato), GM foods, Farmers Rights, Seed terminator technology. Litigations related to life (e.g. neem, Basmathi rice, turmeric). Nutraceuticals. Plant tissue culture, synthetic seeds. Plant health and diseases. Edible vaccines. Plant-microbe associations, interactions (e.g. symbiosis, mutualism) and benefits. Plant cells to generate biochemicals and medicines. Micropropagation. Environmental Biotechnology: Revegetation and energy plantations (e.g. Neem, *Jatropha*, *Pongamia*). Bioremediation (plant and microbial). Microbes in mining. Waste processing and utilization.

UNIT III (13 HRS)

Animal biotechnology: Transgenic animals (e.g. mice, sheep, fish). *In vitro* fertilization and (IVF) and embryo transfer (ET), test-tube babies. Ethical issues (e.g. human and animal rights, surrogate mother). Animal cloning -Somatic and therapeutic cloning. Animal cell culture and organ culture. Animal cells as source of biochemicals (e.g. vaccines, hormones). Animals as bioreactors (e.g. mice**).**

References

1. Biology of microorganisms. Brock, T.B. & Madigan, M.T., Prentice Hall, 1996
2. Basic Biotechnology. Ratledge, C. & Kristiansen, B., Cambridge Univ. Press, 2006
3. Microbial Ecology. Atlas, R.M.& Bartha, R. Benjamin Cummings, 1997
4. Microbial Biotechnology. Glazer, A.G., WH Freeman & Co., 1994
5. Biotechnology of Higher Plants. Russell, G.E. Intercept Pub., 1988
6. Plant Biotechnology. Mantell, S.H.& Smith, H. Cambridge University Press, 1983
7. Animal Transgenesis and Cloning. Houdebine,L.-M. John Wiley & Sons, 2003
8. Gene VII. Lewin,B., Oxford University Press, 2000
9. Environmental Biotechnology. Jogdand, S.N., Himalaya Publishing House, 2012

BT 2.6 FOOD BIOTECHNOLOGY (OPEN ELECTIVE) Hours 39

UNIT I (13hrs)

Food chemistry – Carbohydrates, amino acids, proteins, lipids, vitamins - water soluble and fat soluble, macro- and micro-nutrients. Digestion, absorption and metabolism. Nutraceuticals, probiotics, antioxidants, vitamins, organic acids, single cell proteins. rDNA technology: cell culture, recombinant proteins, large scale production and applications. Genetically modified foods, transgenic plants, genetic engineering of animals for trait improvement. Food microbiology - Food spoilage – Source of contamination – microorganisms – bacteria, yeast, mould affecting various food items (milk, bread, canned food, vegetables and fruits, meats, egg, fish, poultry). Enzymes used in food industry – microbial production of enzymes (proteases, amylases, invertases, pectinase, xylanase), immobilization, applications, production of organic acids using microbial production of novel sweeteners.

UNIT II (13hrs)

Food preservation – Functional and fermented foods - Bakery and cereal products, preservation of fruits and vegetables – dehydration, pickling. Low temperature processing and storage – chilling, cold storage. High temperature processing – drying, heat sterilization. Irradiation – types and source of irradiation, impact of radiation on foods, irradiation of packing material, health consequences of irradiated food. Chemical preservation – organic, inorganic preservatives, Sulphur dioxide, Benzoic acid, Sorbic acid, antioxidants, cleaning, sanitizing, fungicidal agents. High concentration – sugar and salt concentrates. Biopreservatives, ohmic heating, microwave, hurdle technology

UNIT III (13hrs)

Food processing - Definition of shelf life, perishable foods, semi perishable foods, shelf stable foods. Fermentation of beer and wine – bottom, top fermentation systems, continuous fermentation, treatment. cheese production. Milk – pasteurization, fermented and non-fermented milk products. Canning and bottling of fruits and vegetables – process, containers, lacquering, spoilage. Layout of food processing unit and components – grinders, mixers, sterilizers, dryers, cold storage. Packaging materials – origin, types, characteristics. Packaging techniques. Quality standards – Food Safety Act, FSSAI, ISO series, national laws and regulations: PFA, FPO, BIS and Agmark and international laws and regulations. FAO and CODEX Alimentarius

References

1. Basic Food Microbiology- Banawart GJ. AVI Publ., 1979
2. Food chemistry - Fennema (Owen R) ed. Marcel Dekker Inc., 1996
3. Food microbiology - Frazier WC and Westhoff DC. Tata Mcgraw Hill., 1978
4. Food Biotechnology - Knorr D. Marcel Dekker Inc., 1993
5. Modern Food Microbiology - Jay J. M, Loessner MJ & Golden DA., Springer Publ., 2005
6. Handbook of food analysis- Mollet (Leo M.L.) ed. 3rd Ed., CRC press, 2015