MANGALORE UNIVERSITY
DEPARTMENT OF BIOSCIENCES
M.Sc. BIOTECHNOLOGY

Scheme and Syllabus for two-year (four semester) M.Sc. in Biotechnology under Choice-based Credit System (CBCS)

Preamble:
As per guidelines of the UGC and Higher Education Council, Government of Karnataka, the Board of Studies in Biotechnology, Mangalore University framed a new syllabus according to the regulations governing the Choice-based Credit System for the two-year (four semester) M.Sc. Degree Programmes in 2016. The syllabus has now been revised.

The M.Sc. programme in Biotechnology under CBCS scheme has a total of 90 credits consisting of hard core courses (including project work) for 58 credits (64%) and soft core courses with choice for 26 credits (29%) and open elective courses with choice for a total of 6 credits.

Program outcome:
PO 1 To engage and to involve the student in a challenging curriculum of the state-of-the-art in Biotechnology through a systematic study of the basics that support excellence in competitive examinations and lend competence to its application in the medical, agriculture, industrial, pharmaceutical, environmental sectors through value-based education towards sustainable development.
PO 2 The student is equipped with the required soft, transferable and technical skills through adequate practical sessions, test your learning though periodic tests, self study by means of assignments and presentation skills through seminars, all essential for careers in the industry, academia or entrepreneurship.

Program specific outcomes:
PSO 1 State-of-the-art, up-dated knowledge in the field of Biotechnology
PSO 2 Laboratory-based skill training in biosafety and good laboratory practices
PSO 3 Independent work in the lab through project work
PSO 4 Edge in competitive exams through a challenging academic programme.
PSO 5 Exposure to labs/institutes through Summer Training/Research/Internship Programme
PSO 6 Develop a job profile for R&D, QC, QA etc in companies
PSO 7 Develop entrepreneurial know-how

M.Sc. BIOTECHNOLOGY PROGRAM
CONTENTS

FIRST SEMESTER	**Hrs/week**	**Credits**
HARD CORE COURSES		
BTH 401 Biochemistry and Biophysics	4	4
BTH 402 Molecular Genetics	4	4
BTH 403 Microbiology	4	4
SOFT CORE COURSES (Any One to be opted)		
BTS 404 Enzymology	3	3
BTS 405 Cell Biology	3	3
PRACTICAL COURSES		
BTP 406 Biochemistry	4	2
BTP 407 Molecular Genetics	4	2
BTP 408 Microbiology	4	2
BTP 409 Enzymology	4	2
BTP 410 Cell Biology	4	2
SECOND SEMESTER		
HARD CORE COURSES		
BTH 451 Molecular Biology	4	4
BTH 452 Genetic Engineering	4	4
SOFT CORE COURSES (Any Two to be opted)		
BTS 453 Bioprocess Technology	3	3
BTS 454 Bioanalytical Techniques	3	3
BTS 455 Radiation Biology	3	3
BTS 456 Signal Transduction	3	3
PRACTICAL COURSES		
BTP 457 Molecular Biology	4	2
BTP 458 Genetic Engineering	4	2
BTP 459 Bioprocess Technology	4	2
BTP 460 Radiation Biology	4	2
BTP 461 Signal Transduction	4	2
OPEN ELECTIVE COURSES (Any One to be opted)		
BTE 462 Biotechnology in daily life	3	3
BTE 463 Food security	3	3
THIRD SEMESTER		
HARD CORE COURSES		
BTH 501 Microbial Biotechnology	4	4
BTH 502 Plant Biotechnology	4	4
SOFT CORE COURSES (Any Two to be opted)		
BTS 503 Immunotechnology	3	3
BTS 504 Bioinformatics and Biostatistics	3	3
BTS 505 Medical Biotechnology	3	3
PRACTICAL COURSES		
BTP 506 Microbial Biotechnology	4	2
BTP 507 Plant Biotechnology	4	2
BTP 508 Immunotechnology	4	2
BTP 509 Research Methodology and Bioinformatics	3	2
BTP 510 Medical Biotechnology	3	2

OPEN ELECTIVE COURSES (Any One to be opted)		
BTE 511 Environmental Management	3	3
BTE 512 Advances in Medicine	3	3

FOURTH SEMESTER

HARD CORE COURSES		
BTH 551 Animal Biotechnology	4	4
BTH 552 Environmental Biotechnology	4	4
SOFT CORE COURSES (Any One to be opted)		
BTS 553 Biotechnology Entrepreneurship	3	3
BTS 554 Nanobiotechnology	3	3
BTS 555 Pharmacology and Drug development		
PRACTICAL COURSES		
BTP 556 Animal Biotechnology	4	2
BTP 557 Environmental Biotechnology	4	2
PROJECT WORK		
BTP 558 Project Work (Dissertation & Viva)	4	4

MANGALORE UNIVERSITY
CHOICE BASED CREDIT SYSTEM (CBCS)
Scheme and Syllabus for M.Sc. Biotechnology

FIRST SEMESTER

Paper Code	COURSE TITLE	Teaching Hrs/week	Exam Hrs	Marks		Total	Credits
				IA*	Exam		
HARD CORE COURSES - THEORY							
BTH401	Biochemistry and Biophysics	4	3	30	70	**100**	4
BTH402	Molecular Genetics	4	3	30	70	**100**	4
BTH 403	Microbiology	4	3	30	70	**100**	4
SOFT CORE COURSES –THEORY (CHOOSE ANY ONE)							
BTS 404	Enzymology	3	3	30	70	**100**	3
BTS 405	Cell Biology						
PRACTICALS							
BTP 406	Biochemistry	4	3	15	35	**50**	2
BTP 407	Molecular Genetics	4	3	15	35	**50**	2
BTP 408	Microbiology	4	3	15	35	**50**	2
BTP 409	Enzymology	4	3	15	35	**50**	2
BTP 410	Cell Biology						
Total						**600**	**23**

SECOND SEMESTER

Paper Code	COURSE TITLE	Teaching Hrs/week	Exam Hrs.	Marks		Total	Credits
				IA*	Exam		
HARD CORE COURSES -THEORY							
BTH 451	Molecular Biology	4	3	30	70	**100**	4
BTH 452	Genetic Engineering	4	3	30	70	**100**	4
SOFT CORE COURSES -THEORY (CHOOSE ANY TWO)							
BTS 453	Bioprocess Technology	3	3	30	70	**100**	3
BTS 454	Bioanalytical Techniques	3	3	30	70	**100**	3
BTS 455	Radiation Biology						
BTS 456	Signal Transduction						
PRACTICALS							
BTP 457	Molecular Biology	4	3	15	35	**50**	2
BTP 458	Genetic Engineering	4	3	15	35	**50**	2
BTP 459	Bioprocess Technology	4	3	15	35	**50**	2
BTP 460	Radiation Biology						
BTP 461	Signal Transduction						
OPEN ELECTIVES (CHOOSE ANY ONE)							
BTE 462	Biotechnology in daily life	3	3	30	70	**100**	3
BTE 463	Food Security						
Total						**650**	**23**

THIRD SEMESTER

Paper Code	COURSE TITLE	Teaching Hrs/week	Exam Hrs.	Marks		Total	Credits
				IA*	Exam		
HARD CORE COURSES -THEORY							
BTH 501	Microbial Biotechnology	4	3	30	70	**100**	4
BTH 502	Plant Biotechnology	4	3	30	70	**100**	4
SOFT CORE COURSES -THEORY (CHOOSE ANY TWO)							
BTS 503	Immunotechnology	3	3	30	70	**100**	3
BTS 504	Research Methodology and Bioinformatics	3	3	30	70	**100**	3
BTS 505	Medical Biotechnology						
PRACTICALS							
BTP 506	Microbial Biotechnology	4	3	15	35	**50**	2
BTP 507	Plant Biotechnology	4	3	15	35	**50**	2
BTP 508	Immunotechnology	4	3	15	35	**50**	2
BTP 509	Research Methodology and Bioinformatics	4	3	15	35	**50**	2
BTP 510	Medical Biotechnology						
OPEN ELECTIVES (CHOOSE ANY ONE)							
BTE 511	Environmental Management	3	3	30	70	**100**	3
BTE 512	Advances in Medicine						
Total						**700**	**25**

FOURTH SEMESTER

Paper Code	COURSE TITLE	Teaching Hrs/week	Exam Hrs.	Marks		Total	Credits
				IA*	Exam		
HARD CORE COURSES –THEORY							
BTH 551	Animal Biotechnology	4	3	30	70	**100**	4
BTH 552	Environmental Biotechnology	4	3	30	70	**100**	4
SOFT CORE COURSES -THEORY (CHOOSE ANY ONE)							
BTS 553	Biotechnology Entrepreneurship	3	3	30	70	**100**	3
BTS 554	Nanobiotechnology						
BTS 555	Pharmacology and Drug Development						
PRACTICALS							
BTP 556	Animal Biotechnology	4	3	15	35	**50**	2
BTP 557	Environmental Biotechnology	4	3	15	35	**50**	2
PROJECT WORK							
BTP 558	Project Work with Dissertation and Viva	4	4	30	70	**100**	4
Total						**500**	**19**
Grand Total						**2450**	**90**

IA includes Seminar/Assignment (per Course), Internal Tests (per Course), Objective Test [MCQs, Fill in the blanks, True/False, Problem solving, Analytical questions, Calculations, Definitions] (per Course) = 30

Schemeof M.Sc. Biotechnology Programme (CBCS)

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+1Pr	3+2	8	3		23
III	2Th+2Pr	4+2	12	2Th+2Pr	3+2	10	3		25
IV	2Th+2Pr	4+2	12	1Th	3	3		4	19
Total			54=60%			26=29%	6	4	90

NOTE:

BASIS FOR INTERNAL ASSESSMENT: Internal Assessment marks in theory papers shall be awarded on the basis of theory test (70 Marks), Objective Test (MCQs)(15 Marks), Seminars and Assignments (15 Marks). The marks obtained shall be reduced to 30. The tests may be conducted 14 weeks after the start of a Semester. Practical Internal Assessment marks shall be based on practical test and records. 60 marks for Practical test and 10 marks for Class record. The marks obtained shall be reduced to 30. The test may be conducted 14 weeks after the start of a Semester. 70 marks for project work (Report/Dissertation and Presentation/Viva).

THEORY QUESTION PAPER PATTERN: Question Papers in all the four semesters consists of three sections (Model question paper enclosed). Section I: Write short notes on any ten out of twelve: (10x2=20 Marks) Section II: Write explanatory notes on any five out of seven: (5x6=30 Marks). Section III: Write long answers on any two out of four: (2x10=20 Marks). Questions are to be drawn from all the units of the syllabus by giving equal weightage to all the units.

PRACTICAL QUESTION PAPER PATTERN: 30 marks for practical exam proper (Major experiment-10 marks, Minor experiments/Problem solving-05+05 marks, Identify and Comment on-4x2.5=10 marks) and 05 marks for Class record. The Project work may be conducted either in the Department or any other Institution or in an Industry. Project Report/Dissertation and Presentation/Viva carry 70 marks.

I SEMESTER

BTH 401 BIOCHEMISTRY AND BIOPHYSICS Hours: 52

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand chemical bonds, thermodynamic principles and their applications in biological systems, and importance of pH and buffers in the cells.

CO 2. Elucidate diversity and function of major groups of biomolecules- carbohydrates, proteins, and lipids along with nucleic acids.

CO 3. Differentiate catabolic and anabolic pathways of carbohydrates, amino acids, nucleic acids and lipids.

CO 4. Analyze diverse structures seen in proteins including its secondary, tertiary and quaternary structure.

UNIT I (13 hrs)

Chemical bonds and intramolecular interactions. Thermodynamic principles, free energy, enthalpy and entropy, chemical equilibrium, chemical 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 and calculations in buffer preparation. 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

BTH402 **MOLECULAR GENETICS** **Hours: 52**

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand Mendelian laws of inheritance, deviations and exceptions to these laws.
CO 2. Elucidate various types of recombination in Bacteria including transformation, transduction and conjugation
CO 3. Comprehend various types of mutations at the molecular level and types of DNA repair to fix the mutations upon DNA damage.
CO 4. Learn about mobile genetic elements-transposable elements, mechanism of translocation and their distribution from prokaryotes to higher organism.
CO 5. Understand population genetics, and about genotype and allelotype frequency calculation.
CO 6. Differentiate between forward and reverse genetics along with gene silencing techniques and gene knockout

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

BTH 403 **MICROBIOLOGY** **Hours: 52**

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Develop theoretical knowledge about origin and evolution of microorganisms,

CO 2. Learn comparative morphology, structure and reproduction in bacteria, Cyanobacteria, yeast, fungi and viruses

CO 3. Acquire knowledge on interactions of microorganisms with plants and animals, various diseases caused by microorganisms in humans and the role of antibiotics in controlling the diseases

CO 4. Learn about the role of microorganisms in spoilage of food and various methods of food preservation.

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.

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, Corona, 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 Rickettsia, 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 salmonellosis).

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

BTS 404 ENZYMOLOGY (SOFT CORE COURSE) Hours: 40

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Learn about enzymes, their nomenclature, classification, isolation, purification, properties etc.

CO 2. Comprehend kinetics of enzyme catalysed reaction, multi-substrate reactions and inhibitors.

CO 3. Acquire knowledge about Allosteric enzymes, sigmoid kinetics and nature,

CO 4. Understand the mechanism of action of various enzymes, protein engineering, immobilization of enzymes.

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. Specific activity and molar activity. 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 electrophilic 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 Menten 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 (14hrs)

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, kinetics of immobilized enzymes 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

BTS 405 CELL BIOLOGY (SOFT CORE COURSE) Hours: 40

Course outcome

After successful completion of the course, students will be able to:

CO 1. Have a primer on cell membrane structure and function, prokaryotic and eukaryotic cells, membrane structure, transport, electrical properties and composition.
CO 2. Learn principles of techniques used to study cellular ultrastructure such as advanced microscopic techniques
CO 3. Understand sub-cellular organization
CO 4. Unravel chromatin and chromosomes
CO 5. Comprehend the fascinating world of cell division, mitosis, meiosis, cell cycle, molecular mechanisms that regulate life and death of a cell.

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 (14hrs)

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. Developmental Biology. Gilbert, S.F., 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)

BTP 406 BIOCHEMISTRY AND BIOPHYSICS

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Have hands-on training and develop practical skills
CO 2. Work independently
CO 3. Perform assays and various techniques used in Biochemistry and Biophysics
CO 4. Execute application-based learning

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

BTP 407 MOLECULAR GENETICS

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Have hands-on training and practical skills in Molecular genetics
CO 2. Use model organisms in molecular genetics
CO 3. Solve genetics-based problems
CO 4. Perform banding techniques and karyotyping

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

BTP 408 MICROBIOLOGY

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Have hands-on training and practical skills in microbiology
CO 2. Use safety equipment in microbiology
CO 3. Develop skills in isolation and culture of microorganisms from different sources
CO 4. Carry out staining and identification of microorganisms

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 CORE COURSES)

BTP 409 ENZYMOLOGY

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Acquire hands-on training in enzymology practicals
CO 2. Understand enzyme kinetics using suitable examples
CO 3. Apply enzymes in industry
CO 4. Learn advantages of immobilization of enzymes

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

BTP 410 CELL BIOLOGY

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Acquire practical skills in cell biology
CO 2. Learn preparation of slides
CO 3. Acquire skills in quantitative assays of biomolecules
CO 4. Learn separation of subcellular organelles using centrifugation

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

II SEMESTER

BTH 451 **MOLECULAR BIOLOGY** **Hours: 52**

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand the processes involved in the central dogma of molecular biology i.e. replication, transcription and translation in both prokaryotic and eukaryotic systems.
CO 2. Comprehend translational modifications, transport and inhibition.
CO 3. Learn about control and regulation of gene expressions and operon models are discussed.
CO 4. Elucidate mechanisms and agents of cancer.
CO 5. Acquire knowledge in developmental biology and cell signalling.

Unit I (13 hrs)

Central Dogma of molecular biology and its modifications. 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. 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 II (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 chaperons. Protein splicing. Inhibitors of translation, translational control mechanism. Organization of prokaryotic and eukaryotic genomes. Regulation of gene expression in prokaryotes 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 III (13 hrs)

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, 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 (in brief). Nuclear cytoplasmic interactions during development.

Unit IV (13 hrs)

Cell signaling: Various types of cell signaling-endocrine, paracrine, juxtacrine and autocrine. Signaling molecules – hormones, growth factors, neurotransmitters, gases, lipids, peptides, Cellular responses to environmental signals in plants and animals; Receptors - extra cellular (G-protein coupled receptors, Ion channel receptors, Tyrosine kinase linked receptors & Receptors with intrinsic enzyme activity (RTK) and Intracellular receptors (cytosolic and nuclear receptors). Mechanisms of signal transduction and second messengers - Ca^{2+}, IP_3, DAG, cAMP & cGMP. Signalling pathways during development. Integrating cells into tissues: Cell adhesion, Cell junctions; Extracellular matrix, extracellular matrix receptors and 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. 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

BTH 452 GENETIC ENGINEERING Hours: 52

Course outcome

After successful completion of the course, students will be able to:

CO 1. Use the various tools and strategies utilized in the construction and production of recombinant DNA molecules *in vitro* and *in vivo*.

CO 2. Learn the various techniques utilized for the introduction of recombinant DNA molecules in bacteria, yeast and mammalian cells.

CO 3. Elucidate the steps involved in the genetic engineering from amplification of DNA molecules to cloning of molecules, and screening strategies for clone identification.

CO 4. Understand the importance of high capacity vectors, plasmids and the various steps involved in genomic library preparation to understand complex genomes.

CO 5. Differentiate between different gene mapping methods, analysis of gene expression by various methods, and techniques used for introduction of mutations

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 IV (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

BTS 453 BIOPROCESS TECHNOLOGY (SOFT CORE COURSE) Hours: 40

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand basic principles of bioprocess technology and advantages of bioprocess over chemical process.

CO 2. Learn various aspects of up- and down-streaming processes in pilot scale study and application to larger scale in industry

CO 3. Have firm knowledge about industrial application of various fermenters and regulation of the fermentation process.

CO 4. Gain knowledge on recovery of products, techniques used for separation of cells, physical and chemical methods of cell lysis, filtration, centrifugation and large-scale separation techniques.

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: 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.

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, 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 III (14hrs)

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. StanburyP.F. et al Pergamon Press, 1984

BTS 454 BIOANALYTICAL TECHNIQUES (SOFT CORE COURSE) Hours: 40

Course outcome

After successful completion of the course, students will be able to:

CO 1. Apply the principle, instrumentation of bio analytical techniques such as chromatography and electrophoresis for the separation of different biomolecules

CO 2. Learn the principle and application of different spectroscopic methods for the structural analysis of biomolecules.

CO 3. Demonstrate the application of radioisotope techniques for the quantification of biomolecules based on isotope labelling.

CO 4. Understand the types and properties of different nanostructures and nanoparticles for the future application of nanotechnology in different fields of science.

UNIT I (13 hrs)

Principle, instrumentation and applications of separation techniques for different biomolecules and applications: Chromatography classification – Planar and columnar, Classification based on scale – analytical, semi preparative and preparative. Chromatography – paper, TLC, Gel filtration, ion exchange, affinity, HPLC and GC. Electrophoresis - gel, agarose-gel, PAGE, SDS-PAGE, Iso-electric focusing.

UNIT II (13 hrs)

Physical techniques in structural analysis of biomolecules and applications: Spectroscopy: Interaction of different electromagnetic radiations with matter, 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 (14hrs)

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

BTS 455 RADIATION BIOLOGY (SOFT CORE COURSE) Hours 40

Course outcome

After successful completion of the course, students will be able to:

CO 1. Understand the types, sources and measures of radiation
CO 2. Acquire training in laboratory practices in radiobiology laboratory
CO 3. Understand use of radioisotopes and radiotechniques
CO 4. Link living cells/tissues with radiation including radiation-related damage and use in therapeutics
CO 5. Know about research tools and techniques using radiation and radioactive isotopes

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 (14hrs)

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

BTS 456 SIGNAL TRANSDUCTION (SOFT CORE COURSE) Hours 40

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand the basics and advances of cell signalling
CO 2. Learn about signalling molecules in plants and animals.
CO 3. Learn about receptor family, signal transduction and second messenger pathways
CO 4. Get a glimpse of cell signalling during development and in unique cells based on external stimuli.

Unit I (13 hrs)

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 (13 hrs)

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 (14hrs)

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)

BTP 457 MOLECULAR BIOLOGY

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Acquire basic technical knowledge in molecular biology
CO 2. Understand development of models for cancer biology
CO 3. Learn techniques of histology of different tissues
CO 4. Learn tools and techniques used in developmental biology using suitable examples

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

BTP 458 GENETIC ENGINEERING

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Use the tools and techniques used in Genetic engineering
CO 2. Acquire expertise to use plasmids, vectors
CO 3. Learn to use different RNA, DNA based enzymes
CO 4. Acquire skills in recent techniques in 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)

BTP 459 BIOPROCESS TECHNOLOGY

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Know about the instrumentation used in industrial biotechnology
CO 2. Develop skills in techniques used in processing

CO 3. Culture microorganisms of industrial importance in pilot scale
CO 4. Develop skills in scaling up and industrial biotechnology

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

BTP 460 RADIATION BIOLOGY

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Know about the advantages of radiation
CO 2. Perform the techniques used in radiation biology,
CO 3. Understand applications in medicine etc
CO 4. Practice safety protocols while working in a radioactive facility

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

BTP 461 SIGNAL TRANSDUCTION

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Have hands on exposure to skills in handling cells and tissues
CO 2. Perform advanced techniques in cell biology
CO 3. Evolve experiments to understand cross talk between cells
CO 4. Unravel the cell cycle using suitable examples

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

BTE 462 BIOTECHNOLOGY IN DAILY LIFE (OPEN ELECTIVE)
Hours: 40

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand microbial diversity and microflora associated with humans and animals, interaction between microbes, plants and animals and design procedures for the production of various industrially important compounds.

CO 2. Comprehend genetic manipulation of plants for the production of elite plants with superior traits such as insect resistance, improved nutrient content etc. and apply plant tissue culture methods for the propagation of plants

CO 3. Compare the interaction of microbes with plants based on benefits and harmful effects, and application of microflora in the improvement of environment.

CO 4. Differentiate the techniques involved in the animal biotechnology for production of superior livestock, uses of assisted reproductive techniques for preservation and propagation of superior germplasm, genetically modified organisms, uses in therapy, cloning etc.

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 (14hrs)

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

BTE 463 FOOD SECURITY (OPEN ELECTIVE)
Hours 40

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand the composition of food and its applications in the body
CO 2. Learn about food spoilage and application of biotechnology in food processing.
CO 3. Learn about food preservation by various methods
CO 4. Understand food processing for preparation of various products, food safety standards, laws and regulations

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 (14hrs)

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 DekkerInc., 1996
3. Food microbiology - Frazier WC andWesthoff 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

III SEMESTER

BTH 501 MICROBIAL BIOTECHNOLOGY Hours: 52

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand basic principles of primary and secondary metabolite production by the microorganisms,

CO 2. Understand regulation of fermentation processes and upstreaming and downstreaming

CO 3. Acquire knowledge of production of secondary metabolites like penicillin, streptomycin, and tetracycline, amino acids, vitamins, hormones, organic acids, microbial beverages like beer, and wine

CO 4. Know usee of microorganisms as probiotics and the role of nutraceuticals in human health, waste utilization to generate biofuels and biogas.

UNIT I (13 hrs)

Microbial products: Microbial Biomass, Primary metabolites, secondary metabolites microbial enzymes, transformed products. Gene cloning in microorganisms other than *E. coli* (*Salmonella, Rhizobium, Agrobacterium, Bacillus subtilis, Streptomycetes, Aspergillus niger*). Microbial primary and secondary metabolites: Aminoacids (Glutamic acid, L-lysine), Vitamins and hormones (vitamin B12, vitamin A, riboflavin, gibberellins). Organic acids and other industrial chemicals (Lactic acid, citric acid, alcohol, acetic acid, glycerol, acetone). Antibiotics (Penicillin, streptomycin, tetracycline), peptide antibiotics (lantibiotics)

UNIT II (13 hrs)

Microbial Enzymes: Microbial production of enzymes (Protease, amylase, invertase, pectinase, xylanase) substrate, production, purification of enzymes, immobilization, their application in food and other industries.Microbial exopolysaccharides (EPS), classification and applications (health, industrial, pharmaceutical and food): Alginate, Cellulose, Hyaluronic acid, Xanthan, Dextran, Gellan, Pullulan, Curdlan, polysaccharides of lactic acid bacteria; Chitin, chitosan and chitin derivatives.

UNIT III (13hrs)

Microbial beverages and food: Production of wine, beer, and vinegar. Microbial food: Oriental foods, Baker's yeast, cheese, SCP, SCO (PUFA), mushroom cultivation, sauerkraut, silage, probiotics. Nutraceuticals. Bioconversion, biofuels, biogas. Waste utilization to generate biofuels.

UNIT IV (13 hrs)

Biofertilizers: *Rhizobium, Azotobacter, Azospirillum,* Cyanobacteria, *Mycorrhiza*, phosphate solubilizers, *Frankia*. Biopesticides: *Bacillus thuringiensis, Bacillus popillae, Trichoderma*, Baculoviruses. Plant growth promoting Rhizobacteria (PGPR)

References

1. Comprehensive Biotechnology. Vol. 1, 2, 3 & 4. Moo-Young, M., Pergamon Press, 2011
2. Fundamentals of Biotechnology. Prave,P.et al., Wiley-Blackwell Pub., 1987
3. Industrial Microbiology. Cassida, L.E., John Wiley & Sons, 1968
4. Industrial Biotechnology. Crueger, W.&Crueger,A., Sinauer Associates Inc., 1990
5. Industrial Biotechnology. Demain, A.L., American Society for Microbiology, 1986
6. Microbial Biotechnology. Glazer, A.G., WH Freeman and Company, 1994
7. Microbial Technology. Peppler, H.J., Vol. 1 & 2. Academic Press, 1979

BTH 502 PLANT BIOTECHNOLOGY Hours: 52

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Compare the plant genome with chloroplast and mitochondrial genomes, to demonstrate the application of plant breeding methods, to differentiate the mechanism involved in different biological process.

CO 2. Demonstrate different techniques involved in the plant tissue culture for the propagation of plants and germplasm preservation.

CO 3. Utilise plant tissue culture methods for the production of commercially important secondary metabolites.

CO 4. Demonstrate the genetic manipulation of plants for the production of elite plants with superior traits such as insect resistance, improved nutrient content etc.

UNIT I (13 hrs)

Plant genome structure, gene families in plants, organization of chloroplast genome, mitochondrial genome and their interaction with nuclear genome, RNA editing in plant mitochondria. Mitochondrial DNA and Cytoplasmic male sterility. Plant breeding mechanism: types and applications**.** Plant genomics, molecular markers aided plant breeding, RFLP, RAPD, AFLP markers, QTL, SSR, STS markers, Proteomics, drug discovery Biological oxidation: Electron transport chain, chemiosmotic hypothesis, ATP synthesis, oxidative phosphorylation, substrate level phosphorylation, uncouplers and inhibiters of respiration. Photosynthesis, regulation, Calvin cycle, C_3-C_4 plants

UNIT II (13 hrs)

Regulation of gene expression in plant development: Germination, apical meristem, floral development, leaf development, seed development and seed storage proteins. Plant hormones (auxins, cytokinins and gibberellins, IBA, NAA, 2-4-D, TDZ). Plant tissue culture, history, laboratory design, aseptic conditions, methodology, media, techniques of callus cultures, meristem cultures, anther culture, embryo culture, micropropagation, protoplast culture, somaclonal variation, synthetic seeds; Germplasm conservation and cryopreservation

UNIT III (13 hrs)

Cell suspension cultures and bioreactor technology, plant biosynthesis and production, regulation, commercial importance of secondary metabolites by tissue culture. Plant-derived vaccines, plantibodies and pharmacognosy. Gene rearrangement. Tissue culture in Industrial Biotechnology including gene transfer methods

UNIT IV (13 hrs)

Development of transgenic plants for virus, bacteria, fungi, insect resistance. Transgenic crops for improved quality (Bt cotton, Bt brinjal, golden rice), herbicide tolerant, stress resistant plants, RNAi and antisense RNA technology, delay of softening and ripening of fleshy fruits by antisense RNA, ACC gene synthesis in tomato, banana and watermelon, terminator seed technology, GM foods and human health. Molecular diagnosis of plant diseases and biological control.

References

1. Biotechnology in Agriculture and Forestry. Bajaj, Y.P.S., Springer, 2007.
2. Biotechnology of Higher Plants. Russell, G.E. Intercept Pub., 1988
3. Plant Cell and Tissue Culture. A Lab manual. Reinert, J.& Yeoman, M.M., Springer, 1982
4. Plant Biotechnology. Mantell,S.H. & Smith, H. Cambridge University Press, 1983
5. Introduction to Plant Biotechnology. Chawla, H.S. Science Publ. Inc., 2002

BTS 503 IMMUNOTECHNOLOGY (SOFT CORE COURSE) Hours: 40

Course outcome

After successful completion of the course, students will be able to:

CO 1. Understand the structure, components and functioning of the immune system, including toxins and toxin resistance

CO 2. Understand the molecules related to immune system such as immunoglobulins, antigens and the genes associated with diversity and specificity, tissue histocompatibility

CO 3. Differentiate reactions and concepts and various techniques associated with immunoglobulins such as in diagnostics and research, vaccine development etc.

CO 4. Use the knowledge regarding advances in the field for application in therapeutics

UNIT I (13 hrs)

History and scope of immunology. Types of immunity – humoral and cell-mediated. Innate and adaptive immunity. Specificity and memory. Primary and secondary lymphoid organs; immunization. Cells involved in immune response-T-cells, B-cells. Clonal selection theory. Lymphocyte activation, clonal proliferation, differentiation. Effector mechanisms in immunity-macrophage activation. Lymphokines – Interleukins and their role in immune regulation. Toxin and Toxin resistance.

UNIT II (13 hrs)

Antigens and haptens, determinants; types of immunoglobulins: structure, distribution and function. Antigen-antibody reactions – Antigen equilibrium, dialysis, precipitation reactions, immunodiffusion. Affinity and Avidity. Immunization and antibody response. Antibody diversity - V, D, J, gene segments and DNA rearrangements, molecular biology of antibody synthesis. Complement system. Human and mouse, MHC, Transplantation immunology. HLA in human health and disease HLA tissue typing. Immune-suppression in transplantation.

UNIT III (14hrs)

Hypersensitivity reaction, treatment approaches. Immunological tolerance. Autoimmune diseases. Thyrotoxicosis, Systemic Lupus Erythematosus, Antinuclear antibodies. Tumor immunology – tumor antigens, immuno-surveillance, immunological escape. Immune deficiency diseases – AIDS; Immunological tolerance. Production, purification and characterization of monoclonal antibodies. Polyclonal antibodies versus monoclonal antibodies. T-cell cloning and their applications. ELISA, RIA, Western blotting, Fluorescent techniques, Fluorescent activated cell sorter (FACS). Concepts in vaccine development. Types of vaccines. Immunotherapeutic approaches to disease treatment-immunotoxins, Lymphokine- activated killer cells.

References

1. Cellular and Molecular Immunology. Abbas, A.K. et al., Elsevier Saunders Co., 2015
2. Essential Immunology. Riott, I.M., Blackwell Scientific Publications, 1994
3. Handbook of Experiments in Immunology, Vol. 1 & 2, Weir D.M., Wiley, 1997
4. Kuby Immunology. Kindt T.J. et at., W.H. Freeman & Co. 2007
5. Immunology. Riott, I.M., BrostoffJ., Male, D. Mosby Pub., 2001
6. Immunobiology. Janeway C.A. and Travers, P. Churchill Livingstone Pub., 1996
7. Practical Immunology. Hudson L. and Hay F.C., Blackwell Scientific Pub., 1989

BTS 504 RESEARCH METHOLOGY AND BIOINFORMATICS
(SOFT CORE COURSE) Hours: 40

Course outcome

After successful completion of the course, students will be able to:

CO 1. Acquire knowledge about basic concepts of research, scientific writing and paper publications

CO 2. Use statistical measures such as dispersion, normal, binominal and poisson distribution, student's t-test, ANOVA, chi-square test etc.

CO 3. Use databases, sequence alignment programs, BLAST and FASTA along with algorithms and applications.

CO 4. Construct a phylogenetic tree and carry out protein structure analysis, protein prediction tools

CO 5. Perform Computer Aided Drug Design (CADD) and apply it to design new drugs.

UNIT I (13 hrs)

Empirical science, scientific method, literature review, research gaps, questions, objectives, design, lab notebook. Search engines. Sampling - Experiments and controls. Data collection, quantitative and qualitative analysis. Determining outcomes and results. Ethics in research, scientific misconduct. Plagiarism. Technical writing skills, scientific papers. Referencing. Statistics – Definition, application of statistics in Biosciences, Classification and tabulation, Graphical representation of data, Histogram, frequency polygon, frequency curve. Measures of central tendency, Measures of dispersion. Normal distribution, Binomial, Poisson, Probability, non-parametric statistics, Correlation and regression; Sign test, Rank sum test, Rank correlation. Testing of hypothesis: Significance of t-test and ANOVA, Multiple range test, Chi-square test. Experimental designs. Diversity measures and evenness (e.g. Simpson and Shannon-Wiener). Statistical packages.

UNIT II (13 hrs)

Introduction to Bioinformatics. Basics of UNIX OS and PERL Programming. Biological databases: Nucleotide and protein sequence and structure (primary and secondary) databases, File formats, Molecular visualization softwares. Sequence analysis. Sequence Alignment: Gap penalties, scoring matrices, Alignment algorithms - Global and Local alignments, Dynamic programming and Heuristic methods (BLAST, FASTA). Multiple Sequence Alignment: Tree alignment, Star alignment, Progressive alignment methods and tools. Stand alone packages for sequence alignment: GCG Wisconsin and EMBOSS package.

UNIT III (14hrs)

Phylogenetics. Representation of phylogeny. Methods of phylogeny: Maximum Parsimony, Maximum Likelihood, Distance method, UPGMA. Softwares for phylogenetic analysis: PHYLIP, CLUSTAL, Tree viewing and editing softwares. Nucleotide sequence and structure prediction methods and tools: Promoter Scan, Gen Scan, CENSOR, Repeat Masker. Whole genome analysis. Genome sequencing strategies, Restriction mapping, Primer designing. Gene Expression analysis - microarray techniques. Protein sequence and structure prediction, Molecular modeling softwares and servers, Protein folding, Threading. Computer-aided Drug Designing: Molecular Docking. Distributed computing approach: Genome@home, Folding@home.

References

1. Research Methodology Methods and Techniques. Kothari, C.R., New Age Publishers, New Delhi 2004

2. Beginning Perl for Bioinformatics. Tisdall, J.D., San Val Pub., 2001
3. Bioinformatics: Sequence and Genome Analysis. Mount, D.W., CSHL Press, 2004
4. Bioinformatics: Methods and protocols. Misener, S., &Krawetz,S. A., Humana Press, 2000
5. Fundamental Concepts of Bioinformatics. Krane, D.E.& Raymer, M.L., Pearson Ed., 2002
6. Introduction to Protein Structure. Branden,C.-I. & Tooze,J., Garland Pub., 1999
7. Introduction to Bioinformatics. Attwood, T.& Parry-Smith, D., Prentice Hall Pub., 1999
8. Introductory Statistics for Biology. Parker, R.E., Hodder Arnold Pub., 1979
9. Statistics for Biological Sciences. Schefler,W. C., Addison Wesley Pub., 1979
10. Biostatistical Analysis. Zar, J. H. Prentice Hall, 2010
11. Biostatistics. Lewis,A. E.. Prentice Hall, 2010

BTS 505 MEDICAL BIOTECHNOLOGY Hours: 40

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Have an overview of the immune system with particular reference to diagnostics, therapy and transplantation.

CO 2. Understand and use the genetics behind genetic diseases and syndromes and techniques associated with diagnosis and gene therapy

CO 3. Develop knowledge in cancer biology with particular reference to carcinogenic agents, basis of cancer, treatment strategies and approaches, stem cells and applications

UNIT I (13 hrs)

Immunology: Overview: concept of self and non-self, antigens, antibodies; immune response, evolution of immune response, immunological tolerance, hypersensitivity, humoral and cell-mediated immunity, active and passive immunization, antigen processing and MHC. Immunobiology: blood groups and transplantation antigens, HLA. Immune deficiencies and disorders – AIDS. Allergy. Diagnostic tools: Antigen-antibody reaction, agglutination, immunoelectrophoresis, immunofluorescence, enzyme-linked immunosorbant assay (ELISA), radioimmunoassay (RIA). Immunization and vaccines – new types of vaccines, edible vaccines. Organ transplantation.

UNIT II (13 hrs)

Genetics: Structure, organization and types of eukaryotic chromosomes, Heterochromatin, euchromatin, telomeres, types of chromosomes. Cell division. Molecular and cellular biology of fertilization*in-vitro* fertilization, assisted reproductive techniques, cloning. Karyotyping - heritable diseases and syndromes. Prenatal diagnosis (amniocentesis and chorionic villus sampling), Diagnosis of genetic diseases,Gene therapy, PCR.

UNIT III (14hrs)

Cancer biology: Cell cycle and its regulation. Apoptosis. 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. Recent advances in therapeutic approaches to disease treatment: Stem cells - types and applications. Cancer therapy – immunotoxins and gene therapy.

References

1. The Cell. A Molecular Approach. Cooper, G.M. Sunderland: Sinauer Associates, Inc., 2000
2. Basic Genetics. Hartl D.L. & Jones E.W. Jones & Bartlett Pub., 1998
3. Kuby Immunology. Kindt T.J. et at., W.H. Freeman & Co. 2007

PRACTICALS (HARD CORE COURSES)

BTP 506 MICROBIAL BIOTECHNOLOGY

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Develop hands-on and practical skills in fermentation
CO 2. Perform microbial assays,
CO 3. Develop pilot scale production of beverages
CO 4. Analyse microbial uses in agriculture

Submerged and solid state fermentation
Estimation of microbial biomass
Estimation of microbial enzymes, mycotoxins, organic acids and antibiotics
Microbiological assays (antibiotics, amino acids and vitamins)
Properties of microbial exopolysaccharides (e.g. cell immobilization)
Uses of Chitin and its derivatives
Pilot scale production of alcoholic beverages
Microbial interactions with plants (rhizobia, mycorrhizas) and plant production
Assessment of nitrogen fixation (acetylene reduction test)
Phosphate solubilization in bacteria, fungi and actinomycetes
Qualities of biofuels (e.g. biodiesel, biogas)

BTP 507 PLANT BIOTECHNOLOGY

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Set-up a plant tissue culture lab
CO 2. Develop hand-on practical skills in plant tissue culture methods
CO 3. Differentiate and use different media, hormones etc,
CO 4. Develop skills in *in-vitro* development of plants, protoplast culture etc.

Estimation of plant hormones (e.g. auxins, gibberellins)
Plant tissue culture methods
Callus culture (compact and friable)
Ovule and anther culture
Cell suspension cultures
Embryogenesis
Synthetic seeds
Protoplast preparation
Protoplast fusion techniques
Plant cell immobilization
Methods of inducing resistance through tissue culture

PRACTICALS (SOFT CORE COURSES)

BTP 508 IMMUNOTECHNOLOGY

After successful completion of the course, students will be able to:

CO 1. Demonstrate immune system structure and function
CO 2. Carry out experiments to quantify immune cells
CO 3. Get hands-on training in various immunological assays of medical and diagnostic importance
CO 4. Develop skills in immunotechnology

Study of immune system in rats
Blood film preparation and study of immune cells
Histology of organs of immune system
Study of insect hemocytes
Production of antiserum
Isolation of lymphocytes
Antigen-antigen reactions (*in vitro*)
Phagocytosis (*in vitro*)
Immunodot technique
Immunodiffusion technique
Immunological diagnosis of pregnancy and infection
Demonstration of ELISA technique

BTP 509 RESEARCH METHODOLOGY AND BIOINFORMATICS

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Use biological databases
CO 2. Retrieve sequences for analysis
CO 3. Carry out analysis including phylogenetic tree construction and molecular modelling
CO 4. Get hands-on training in research methodology and biostatistics

Biological databases - BLAST, FASTA
Restriction mapping
Mean SEM, Histogram
Student's t-test
ANOVA

BTP 510 MEDICAL BIOTECHNOLOGY

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Perform various medical tests
CO 2. Develop skills in diagnostic testing
CO 3. Appropriate techniques required in clinical laboratories for diagnosis
CO 4. Diagnose genetic disorders based on various abnormalities

Hemagglutination test
Antibiotic sensitivity
Karyotype preparation
Chromosomal staining techniques
Avidin-biotin technique in immunohistochemical staining
Immunoblot

BTE 511 **ENVIRONMENTAL MANAGEMENT**
(OPEN ELECTIVE) **Hours: 40**

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Know about transfer of nutrients through biogeochemical cycles, toxicity induced by pollutants and their mobility in trophic levels.

CO 2. Acquire knowledge on microbial diversity, pollution indicator organisms, bioremediation, bioconversion, biomagnification etc.

CO 3. Understand *in-situ* and *ex-situ* bioremediation processes, industrial pollution and waste management

CO 4. Understand sustainable development

UNIT I (13 hrs)

Biogeochemical Cycles: Carbon, nitrogen, oxygen, phosphorous, sulphur, iron and calcium. Environmental pollution: Soil (ecotoxicology of pollutants; fate of insecticides, fungicides and pesticides in soil; physicochemical and microbiological analysis), water and air pollution monitoring (e.g. SO_2 and NO_x); Pollution indicator organisms (plants, animals and microbes) (e.g. algae, Chironomids, coliforms, *Salmonella*, *Shigella*, *Vibrio*, Hepatitis A).

UNIT II (13 hrs)

Microbial degradation of toxic chemicals (pesticides, detergents, plastics). Degradation of organic compounds (cellulose, lignin, hydrocarbons: aliphatic, aromatic, alicyclic hydrocarbons). Microbial deterioration of textiles, paper, leather, wood. Biomaterials, microbial mining (uranium, copper, gold, iron), microbial influenced corrosion and remedies, bioaccumulation, biomagnification, biogas production as non-conventional energy sources.

UNIT III (14hrs)

Principles of microbial bioremediation, *in situ* and *ex situ* bioremediation, microbiological treatment of solid wastes – composting, land farming, bioreactors. Biological treatment of liquid wastes – aerobic and anaerobic treatments sewage and effluent treatments. Hazardous wastes: microbial processing and disposal (radioactive wastes, sewage, pharmaceuticals, refinery and leather). Waste management and utilization (plantation crop wastes, aquatic weeds, kitchen/garden waste, poultry waste). GMOs, Environmental release and monitoring of GMOs, Ethical issues.

References

1) Ecology. Odum
2) Environmental biotechnology. Jogdand SN., Himalaya Pub. House., 2012
3) Environmental and biochemistry. Kudesia VP and Jetley UK., Pragathi Prakashan Pub., 1991
4) Microbial ecology: fundamental and applications. Atlas RA. and Bartha R., Benjamin/Cummings, 1997
5) Microbial biotechnology. Glazer AN., WH Freeman and Co., 1995
6) Sewage and Industrial Effluent Treatment: A practical guide. Arundel J., Blackwell Science Pub. 1995
7) Soil Microbiology. Subba Rao N.S., Oxford & IBH Pub.
8) Waste Water Engineering. Metcalf & Eddy Inc. McGraw-Hill International

BTE 512 **ADVANCES IN MEDICINE**
(OPEN ELECTIVE) **Hours: 40**

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Have an overview of the immune system with particular reference to malfunctioning in disease

CO 2. Understand the genetics behind genetic diseases and syndromes and understand cell division and assisted reproductive techniques

CO 3. Know about cancer biology with particular reference to carcinogenic agents, basis of cancer, treatment strategies and approaches, stem cells and applications

CO 4. Comprehend altered disease states and its physiological implications

UNIT I (13 hrs)

Immunology: Overview: concept of self and nonself, antigens, antibodies; immune response, evolution of immune response, immunological tolerance, hypersensitivity, humoral and cell-mediated immunity, active and passive immunization, antigen processing and MHC. Immunobiology: blood groups and transplantation antigens, HLA. Immune deficiencies and disorders – AIDS. Allergy.Immunization and vaccines. Organ transplantation.

UNIT II (13 hrs)

Genetics: Structure, organization and types of eukaryotic chromosomes, Heterochromatin, euchromatin, telomeres, types of chromosomes. Cell division. Molecular and cellular biology of fertilization*in-vitro* fertilization, assisted reproductive techniques, cloning. Karyotyping - heritable diseases and syndromes. Prenatal diagnosis (amniocentesis and chorionic villus sampling). Diagnosis of genetic diseases and gene therapy.

UNIT III (14hrs)

Cancer biology: 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. Cell cycle and its regulation. Apoptosis. Recent advances in therapeutic approaches to disease treatment: Stem cells - types and applications. Cancer therapy – immunotoxins.

References

1. The Cell. A Molecular Approach. Cooper, G.M. Sunderland: Sinauer Associates, Inc., 2000
2. Basic Genetics. Hartl D.L. & Jones E.W.Jones&Bartlett Pub., 1998
3. Kuby Immunology. Kindt T.J. et at., W.H. Freeman & Co. 2007

IV SEMESTER

BTH 551 **ANIMAL BIOTECHNOLOGY** **Hours: 52**

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand Basics and dynamics of animal cell culture, organ culture, stem cells and tissue engineering, techniques used in counting of cells, cell viability/toxicity assays

CO 2. Differentiate methods for gene transfer in animal cells, tissue-specific promoters, gene therapy

CO 3. Comprehend transgenic technology and use of animals as bioreactors

CO 4. Elucidate Assisted reproductive techniques including cloning

Unit I (13 hrs)

Animal tissue culture, history, laboratory design, aseptic conditions, methodology and types of media. Role of carbon dioxide, serum and supplements. Equipments and materials for animal cell culture technology. Basic techniques of mammalian cell culture *in vitro*; desegregation of tissue and primary culture; maintenance of cell culture; Cell lines-characteristics and routine maintenance. Biology and characterization of the cultured cells, measuring parameters of growth. Measurement of viability and cytotoxicity.

Unit II (13 hrs)

Cell synchronization, Cell separation techniques. Somatic cell fusion, Cell cloning. Organ and histotypic cultures. Three-dimensional culture - Tissue engineering. Application of animal cell culture - Stem cell cultures, embryonic stem cells, mesenchymal stem cells, induced pluripotent stem cells and their applications. Culture of fish, molluscan and crustacean cells and their applications: Culture of secretory/ glandular cells to produce hormones, Pearl oyster mantle cells to produce pearls.

Unit III (13 hrs)

In vitro fertilization (IVF) and embryo transfer (ET), Sex determination or sex specific markers, sexing of sperm and embryos, Assisted reproductive technology (ART). *In vitro* gamete maturation, Intracytoplasmic sperm injection, Cryopreservation of gametes and embryo, Animal cloning-reproductive cloning, therapeutic cloning, xenotransplantation. Improvements of animals using transgenic approach with specific examples. Animals as bioreactors. Applications of biotechnology in sericulture. Production of Transgenic fishes. General steps to make and analyze transgenic fish and Genetically Improved Farmed Tilapia (GIFT).

Unit IV (13 hrs)

Animal genes and their regulation, some specific promoters for tissue specific expression. Gene manipulation in animals-cloning vectors and expression vectors for gene transfer to animal cells. Gene transfer methods in animal cells, Animal cells as cloning hosts. Gene expression in cell culture. Genetic engineering for production of regulatory proteins, blood products, vaccines and hormones. Applications of recombinant DNA in humans: mapping and cloning human disease genes, DNA based diagnosis of genetic diseases, gene therapy, types of gene therapy, somatic versus germline gene therapy, mechanism of gene therapy, Immunotherapy, gene knockout.

References

1. Animal Transgenesis and Cloning. Houdebine, L.-M., John Wiley & Sons, 2003

2. Animal Cell Culture and Technology. Butler, M., BIOS Scientific Publishers, 2004
3. Animal Cloning: The Science of Nuclear Transfer. Panno, J., Facts on File Inc., 2005
4. At the Bench: A Laboratory Navigator. Barker, K. CSHL Press, 2005
5. Basic Cell Culture: A Practical Approach. Davis, J.M. Oxford University Press, 2002
6. Culture of Animal Cells: A Manual of Basic Technique., Freshney R.I. Wiley-Blackwell. 2010
7. Gene VII. Lewin,B., Oxford University Press, New York, 2000
8. Gene Biotechnology. Wu, W. et al., CRC Press, 2004
9. Molecular Biotechnology, Glick, B.R. & Pasternak,J.J.ASM Press, Washington, 2010
10. Principles of Gene Manipulation. Primrose, S.B. et al., Blackwell Publishers, 2006
11. Principles of Cloning. Cibelli, J.B. et al. Academic Press, 2008
12. Recombinant DNA. Scientific Americans Books/W.H.Freeman& Co., 1992
13. Fish Biotechnology. Ranga M.M. & Q.J. Shammi Agrobios, New Delhi, 2010

BTH 552 ENVIRONMENTAL BIOTECHNOLOGY (HARD CORE)

Hours: 52

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand transfer of nutrients through biogeochemical cycles
CO 2. Comprehend the toxicity induced by pollutants and their mobility in trophic levels.
CO 3. Acquired knowledge on microbial diversity, pollution indicator organisms, bioremediation, bioconversion, biomagnification etc.
CO 4. Differentiate *in-situ* and *ex-situ* bioremediation processes, industrial pollution and waste management

UNIT I (13 hrs)

Biogeochemical Cycles: Carbon, nitrogen, oxygen, phosphorous, sulphur, iron and calcium; cycling of toxic metals (Cd, Hg, Pb). Environmental pollution: Soil (ecotoxicology of pollutants; fate of insecticides, fungicides and pesticides in soil; physicochemical and microbiological analysis), water and air pollution monitoring (e.g. SO_2 and NO_x); Pollution indicator organisms (plants, animals and microbes) (e.g. algae, Chironomids, coliforms, *Salmonella*, *Shigella*, *Vibrio*, Hepatitis A).

UNIT II (13 hrs)

Microbial degradation of toxic chemicals (pesticides, detergents, plastics). Degradation of organic compounds (cellulose, lignin, hydrocarbons: aliphatic, aromatic, alicyclic hydrocarbons). Microbial deterioration of textiles, paper, leather, wood. Biomaterials, microbial mining (uranium, copper, gold, iron), microbial influenced corrosion and remedies, bioaccumulation, biomagnification, biogas production as non-conventional energy sources

UNIT III (13 hrs)

Principles of microbial bioremediation, *in situ* and *ex situ* bioremediation, microbiological treatment of solid wastes – composting, land farming, bioreactors. Biological treatment of liquid wastes – aerobic and anaerobic treatments sewage and effluent treatments. Pollution control measures, international and national pollution regulatory acts; Permissible limits and indices for pollutants; Hazardous wastes: microbial processing and disposal (radioactive wastes, sewage, pharmaceuticals, refinery and leather). Waste management and utilization (plantation crop wastes, aquatic weeds, kitchen/garden waste, poultry waste).

UNIT IV (13 hrs)

Natural products (wood, rubber, coir and gums). Food processing (dairy, bakery, beverages, vegetable and cashew). Coastal regulatory zone (CRZ) and environmental issues of aquaculture; biofouling (microfouling and macrofouling); biofilms; biomolecules from the sea; scope of marine biotechnology. GMOs, Environmental release and monitoring of GMOs, Ethical issues

References

1) Ecology. Odum
2) Environmental biotechnology. Jogdand SN., Himalaya Pub. House., 2012
3) Environmental and biochemistry. Kudesia VP and Jetley UK., Pragathi Prakashan Pub., 1991
4) Microbial ecology: fundamental and applications. Atlas RA. and Bartha R., Benjamin/Cummings, 1997
5) Microbial biotechnology. Glazer AN., WH Freeman and Co., 1995
6) Sewage and Industrial Effluent Treatment: A practical guide. Arundel J., Blackwell Science Pub. 1995
7) Soil Microbiology. Subba Rao N.S., Oxford & IBH Pub.
8) Waste Water Engineering. Metcalf & Eddy Inc. McGraw-Hill International

BTS 553 BIOTECHNOLOGY ENTREPRENEURSHIP
(SOFT CORE COURSE) Hours:40

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Obtain basic knowledge of principle concepts in economics, finance and various other aspects of business management and entrepreneurship in Biotechnology
CO 2. Understand strategic options to manage and market technological innovations in Biotechnology
CO 3. Acquire basic skills in project planning and management in Biotechnology
CO 4. Analyse relevant real-world cases and examples in Biotechnology
CO 5. Developing a Start-up plan and evaluate its feasibility in the field Biotechnology
CO 6. Understand general guidelines and bio safety practices and rDNA research
CO 7. Comprehend protection and registration of new plant varieties, plant germplasm conservation, Farmers rights and plant breeder's rights.
CO 8. Elucidate general agreements on trade and tariff, use of traditional knowledge digital library i.e ayurvedic and unani medicinal plants

UNIT I (13 hrs)

Entrepreneurship and Innovation: Categories of innovation, The Start-up Process, Market segmentation, Elements of Marketing Mix, Case studies of commercialization of novel concepts in biotechnology. Intellectual property rights (IPR) (meaning, classification and forms), importance of IPR in Science and Technology. Patents, patentability criteria, patenting procedures, patent applications. Salient features of Patent Law in India, US and Europe. Biopiracy, patent-related litigations and controversies (neem, basmathi rice, turmeric). Traditional ecological knowledge. Traditional knowledge digital library (TKDL). PTE in pharma.

UNIT II (13 hrs)

Outline of Macro- and Micro-economics, Opportunity cost, Willingness to pay, Pricing, Simple and Compound interest, Time value of money, Inflation, Break-even analysis**,** IPO, Shares, Dividend. Project Management: Types of projects, Steps in a project, Project Life-cycle, Magic triangle concept, Project specifications, SWOT analysis, Feasibility study, Types of risks and management, Gantt chart, Outline of a business plan. TRIPs, WTO, WIPO. Plant variety protection, International union for the protection of new varieties of plants (UPOV). Case studies of small scale biotech companies.

UNIT III (14hrs)

Biosafety and research: General guidelines for recombinant DNA research activity. Containment facilities and biosafety practices; Rules for import and export of biological materials. Guidelines for use of small laboratory animals in experimentation and pre-clinical research, maintenance and regulations. Biological warfare and Bioterrorism. CBD, plant protection act in India, registration of new varieties, rights and obligations, farmer's rights; Plant germplasm conservation, characterization and documentation. Seed certification (laws, regulations and standards), seed patent law.

References

1. Biotechnology, Biosafety and Biodiversity. Shantharam, S. & J.F. Montegomery. Science Pub., 1999
2. Biotechnology. Rehm H.-G.& G. Reed, Wiley Blackwell Pub., 1983

3. Biotechnology and the Law: IPR Vol.1 & 2. Cooper, I.P. Clark Boardman Co., 1989
4. Ethical guidelines for Biomedical Research on Human participants, Indian Council for Medical Research, Govt. of India, New Delhi, 2006
5. Good Clinical Practices for Clinical Research in India, Central Drugs Standard Control Organization, Ministry of Health and Family Welfare, Govt. of India, 2013
6. Brealey, R.A., Myers, S.C. and Marcus, A.J., Fundamentals of Corporate Finance. McGraw-Hill, 2012
7. Davila, T., Epstein, M. and Shelton, R. Making innovation work: how to manage it, measure it and profit from it. Upper Saddle River: Wharton School Publishing, 2006
8. Trompenaars, F. and Hampden-Turner, C. Managing people across cultures. Capstone Publishing Ltd., 2004
9. Mankiw, G. Principles of Economics. Cengage Learning, 2015
10. A Guide to the Project Management Body of Knowledge. PMBOK® Guide – Sixth Edition, 2017

BTS 554 NANOBIOTECHNOLOGY (SOFT CORE COURSE) Hours: 40

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Compare the types and properties of different nanostructures
CO 2. Understand structure and use of nanoparticles
CO 3. Demonstrate the synthesis of nanoparticles.
CO 4. Apply nanotechnology in different fields of science.

Unit I (13 hrs)

Principles of nanotechnology - Nanostructures, nanoparticles and their properties. Carbon Nano Structures: Introduction; Carbon buckyballs, fullerenes, nanostructures; quantum dots, nanotubes, magnetic nanoparticles, noble metal nanoparticles. Nanoscale properties and applications.

Unit II (13hrs)

Characterization of nanomaterials: UV-Vis Spectroscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy. Making nanostructures: Top-down and bottom-up approaches. Biological methods of synthesis of nanoparticles: Use of bacteria, fungi, Actinomycetes, Magnetotactic bacteria and plants.

Unit III (14hrs)

Applications in diverse fields: medicine, dentistry, environment, agriculture etc. Toxic effects of nanoparticles on the environment. Toxicity detection. Nanocomposite biomaterials; teeth and bone substitution, Food packaging - materials and properties. Applications of nanoparticle-based products inhealth-care and hygiene. Hybrid systems: Bioelectronic systems based on nanoparticle-enzyme hybrids; nanoparticle-based bioelectronics biorecognition events. DNA-based nanomechanical devices. Biosensors and biochips. Pharmaceutically important nanomaterials, drug nanoparticles, nanoparticles for crossing biological membranes. Fundamentals of nanosized targeted drug delivery systems.

References

1. Nanostructures and nanomaterials: Synthesis, properties and applications, Cao, G and Wang Y. 2011, World Scientific, Imperial College Press
2. Plenty of Room for Biology at the Bottom, An introduction to Bionanotechnology: Ehud Gazit, Imperial College Press,
3. Nanotechnology Booker R and Boysen E., Wiley Dreamtech Publ. New Delhi
4. Nanotechnology: A gentle introduction to the next big idea. Ratner M and Tatner D. Pearson Edition New Delhi

BTS 555 PHARMACOLOGY AND DRUG DEVELOPMENT
(SOFT CORE COURSE) Hours: 40

Course outcomes:
After successful completion of the course, students will be able to:
CO 1. Differentiate elements of pharmacology, pharmacokinetics and pharmacodynamics
CO 2. Understand various facets of drug development
CO 3. Comprehend principles and levels of toxicity, detection and safety
CO 4. Understand concepts of clinical trials and related regulations

Unit I (13 hrs)
Definition and scope of pharmacology. General principles of pharmacology - pharmacokinetics - membrane transport, absorption and distribution of drugs. Lipinski's rule for drug like molecule. Metabolism and excretion of drugs, kinetics of elimination, pharmacodynamics – mechanism of drug action, drug interactions, adverse drug interactions. Preclinical pharmacology; pre-clinical research (dose-response curve, maximum tolerated dose); CPCSEA guidelines, commonly used species of experimental animals. Basic principles of bioassays.

Unit II (13 hrs)
Drug development: Methods involved in the development of new drugs. Assay development. Receptor-drug interactions. High throughput screening (*in-vitro* and *in-vivo*) for pre-clinical pharmacokinetic and pharmacodynamic studies. Compartment models used in pharmacokinetics (oral and intravenous). Comparative fitting (once comp and two comp). Pharmacodynamic / pharmacokinetic correlation. Toxicology studies (NOEL, NOAEL). Drug toxicity tests: OECD guidelines, determination of LD50, acute, sub-acute and chronic toxicity studies. Irwin profile. Toxic risk assessment: Methods, monitoring, important and surveillance of risk assessment. Safety standards: Safety measure, safety regulation, protective practices and devices.

Unit III (13 hrs)
Clinical Trials – Introduction to good clinical practices, phases of Clinical Trials I-IV. Clinical Trial development: Study designs, protocol design and development; case report from design to development, Principles of data management, clinical trial management, pharmacovigilance. Regulatory authorities – FDA, EPA, EMEA, JPMA, TGA, DCGI. Quality standards: ISO. Organic medicinal product research and development. Drugs and cosmetics act, drug price control order, Application for new investigational new drug (IND), Application for new drug discovery (NDD) according to Indian control Authority and US FDA guidelines. Conducting bio-equivalence studies.

References

1. Human Physiology, Guyton
2. Essentials of Medical Pharmacology, Tripathi, K.D., Jaypee Bros Med Publ, New Delhi 2013
3. Pharmacology, Rang H.P., Dale, M.M., Ritter, J.M. et al, Elsevier Pub, 2012
4. Principles of Pharmacology, Munson, P.L., Breese, G.R., Mueller, R.A., Taylor & Francis, 1998
5. Modern Toxicology, Vol. I-III, Gupki P.K., Salunke, D. K. 1985, Metropolitan Publ, Delhi
6. Concepts of Toxicology, Omkar, 1995, Chand and Co., Jallandar

7. Ethical guidelines for Biomedical Research on Human participants, ICMR, Govt. of India, New Delhi 2006
8. Good Clinical Practices for Clinical Research in India, Central Drugs Standard Control Organization, Ministry of Health and Family Welfare, Govt. of India, 2013

PRACTICALS (HARD CORE COURSES)

BTP 556 ANIMAL BIOTECHNOLOGY

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Set up a typical cell culture laboratory
CO 2. Acquire sterilization techniques
CO 3. Use and analyse different media
CO 4. Acquire techniques used in animal cell culture.

Cleaning and sterilization methods for tissue culture
Preparation of media, buffers
Maintenance of cultures (normal and tumor cell lines)
Separation of peripheral blood mononuclear cells
Cell counting (hemocytometer)
Lymphocyte culture technique
In vitro macrophage culture from mouse
Preparation of human metaphase chromosomes
Cell viability tests
Cell proliferation assay
Growth kinetics of cells in culture
In vitro fertilization and embryo transfer techniques
Cryopreservation techniques
Cytotoxicity tests

BTP 557 ENVIRONMENTAL BIOTECHNOLOGY

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Acquire skills and techniques used in waste management
CO 2. Learn mechanisms of waste treatment
CO 3. Become skilled in vermicomposting and mushroom cultivation
CO 4. Understand biogas production

Production of compost (methods)
Vermicompost and its analysis
Cultivation of mushrooms
Biogas (biofuels) production
Wastewater treatment methods
Solid waste treatment methods
Experiments on biofouling and biofilms
Experiments on industrial waste treatment methods (e.g. distillery, whey)

BTP 558 PROJECT WORK

Course outcomes:

After successful completion of the course, students will be able to:

CO 1. Work independently on a research project
CO 2. Gather background information and synthesise relevant information
CO 3. Create a hypothesis and objectives
CO 4. Learn to communicate scientific facts and present the same
CO 5. Analyse data and interpret the same
CO 6. Publish the results

M.Sc. Biotechnology (CBCS)

Model question paper

BIOTECHNOLOGY
PAPER NUMBER AND TITLE

Time: 3 Hours Max. Marks: 70

Part A

Write short notes on **any TEN** of the following (not exceeding 1 page each): 10×2=20

Question No. 1: a-l

Part B

Write explanatory notes on **any FIVE** of the following (not exceeding 3 pages): 5×6=30

Questions No. 2 to 8

Part C

Write long answers on **any TWO** of the following (not exceeding 7 pages): 2×10=20

Question No. 9 to 12