

**NOTIFICATION**

Sub: Revised syllabus of M.Sc. in Biotechnology Programme.

Ref: Academic Council approval vide agenda No.: ಎಸಿಸಿ:ಶೈ.ಮ.ಸಾ.ಸ.1:1  
(2025-26) dtd 18.07.2025.

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The revised syllabus of M.Sc. in Biotechnology programme which has been approved by the Academic Council at its meeting held on 18.07.2025 is hereby notified for implementation with effect from the academic year 2025-26 and onwards.

Copy of the Syllabus shall be downloaded from the University Website  
([www.mangaloreuniversity.ac.in](http://www.mangaloreuniversity.ac.in))

  
**REGISTRAR**

To,

1. The Registrar (Evaluation), Mangalore University.
2. The Chairman, UG and PG Combined Board of Studies in Bio-technology, Dept. of Applied Zoology, Mangalore University.
3. The Co-ordinator, Bio-technology Programme, Dept. of Biosciences, Mangalore University.
4. The Asst. Registrar (ACC), O/o the Registrar, Mangalore University.
5. The Director, DUIMS, Mangalore University – with a request to publish in the website.
6. Guard File.

**MANGALORE UNIVERSITY**  
**DEPARTMENT OF BIOSCIENCES**  
**M.Sc. BIOTECHNOLOGY**

**Scheme and Syllabus for two-year (four semester) M.Sc. in Biotechnology with effect from 2025-26**

**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 Mangalore University regulations for the two-year (four semester) M.Sc. Degree Programmes.

**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 through 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

**MANGALORE UNIVERSITY**  
**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							
BTH 411	Molecular Cell Biology	4	3	30	70	100	4
BTH 414	Microbiology	4	3	30	70	100	4
BTH 415	Biochemistry	4	3	30	70	100	4
SOFT CORE COURSES –THEORY (CHOOSE ANY ONE)							
BTS 416	Inheritance Biotechnology	3	3	30	70	100	3
BTS 417	Enzyme Technology						
PRACTICALS							
BTP 406	Biochemistry	4	3	15	35	50	2
BTP 408	Microbiology	4	3	15	35	50	2
BTP 413	Molecular Cell Biology	4	3	15	35	50	2
BTP 418	Inheritance Biotechnology	4	3	15	35	50	2
BTP 419	Enzyme Technology						
Total						600	23

**SECOND SEMESTER**

Paper Code	COURSE TITLE	Teaching Hrs/week	Exam Hrs.	Marks		Total	Credits
				IA*	Exam		
HARD CORE COURSES -THEORY							
BTH 464	rDNA technology	4	3	30	70	100	4
BTH 468	Molecular Biology	4	3	30	70	100	4
SOFT CORE COURSES -THEORY (CHOOSE ANY TWO)							
BTS 470	Immunotechnology	3	3	30	70	100	3
BTS 455	Radiation Biology	3	3	30	70	100	3
BTS 471	Marine Biotechnology						
PRACTICALS							
BTP 466	rDNA technology	4	3	15	35	50	2
BTP 469	Molecular Biology	4	3	15	35	50	2
BTP 467	Immunotechnology	4	3	15	35	50	2
BTP 472	Radiation Biology	4	3	15	35	50	2
BTP 473	Marine Biotechnology						
OPEN ELECTIVES (CHOOSE ANY ONE)							
BTE 462	Biotechnology in daily life	3	3	30	70	100	3
BTE 463	Food Security						
Total						700	25

### **THIRD SEMESTER**

Paper Code	COURSE TITLE	Teaching Hrs/week	Exam Hrs.	Marks		Total	Credits
				IA*	Exam		
HARD CORE COURSES -THEORY							
BTH 516	Industrial Biotechnology	4	3	30	70	100	4
BTH 517	Agribiotechnology	4	3	30	70	100	4
BTH 520	Research Methodology and Bioinformatics	4	3	30	70	100	4
SOFT CORE COURSES -THEORY (CHOOSE ANY ONE)							
BTS 513	Nanobiotechnology	3	3	30	70	100	3
BTS 521	Bioanalytical Techniques						
PRACTICALS							
BTP 518	Industrial Biotechnology	4	3	15	35	50	2
BTP 519	Agribiotechnology	4	3	15	35	50	2
BTP 514	Research Methodology and Bioinformatics	4	3	15	35	50	2
OPEN ELECTIVES (CHOOSE ANY ONE)							
BTE 511	Environmental Management	3	3	30	70	100	3
BTE 512	Advances in Medicine						
Total						650	24

### **FOURTH SEMESTER**

Paper Code	COURSE TITLE	Teaching Hrs/week	Exam Hrs.	Marks		Total	Credits
				IA*	Exam		
HARD CORE COURSES –THEORY							
BTH 560	Biomedical Engineering	4	3	30	70	100	4
BTH 552	Environmental Biotechnology	4	3	30	70	100	4
SOFT CORE COURSES -THEORY (CHOOSE ANY ONE)							
BTS 561 BTS 562	Biotherapeutics Quality Control in Biotechnology	3	3	30	70	100	3
PRACTICALS							
BTP 561	Animal Biotechnology	4	3	15	35	50	2
BTP 557	Environmental Biotechnology	4	3	15	35	50	2
MOOC*		-	-	-	-	-	2
PROJECT WORK							
BTP 558	Project Work with Dissertation and Viva	4	4	30	70	100	4
Total						500	21
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

\*MOOC course may be taken up during any of the semesters with credits accruing to the 4<sup>th</sup> semester.

### Scheme of M.Sc. Biotechnology Programme

SEM	HARD CORE COURSES			SOFT CORE COURSES			OPEN ELECTIVES	PROJECT	MOOCs	TOTAL
	No of Courses	Credits	Total Credits	No of Courses	Credits	Total Credits	Total Credits			
I	3Th+3Pr	4+2	18	1Th+1Pr	3+2	5				23
II	2Th+2Pr	4+2	12	2Th+2Pr	3+2	10	3			25
III	3Th+3Pr	4+2	18	1Th	3	3	3			24
IV	2Th+2Pr	4+2	12					4	2	18
Total			60			18	6	4	2	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, 05 marks for Class record and 05 marks for Viva. 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-2x2.5=10 marks), 05 marks for Viva 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

### 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)

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. 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 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:  $\alpha$ -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)

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,  $\alpha$ ,  $\beta$  &  $\omega$  types. Energetics of  $\beta$  oxidation. Biological functions of fat-soluble vitamins: A, D, E and K. Water soluble vitamins: coenzymes.

#### UNIT IV (13 hrs)

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. Allosteric enzymes and metabolic regulation, sigmoid kinetics, 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, Ribozymes,

Abzymes. Enzyme engineering (Protein engineering), Immobilization of enzyme, kinetics of immobilized enzymes and their applications

### 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 Intl. Publ. New Delhi, 1998
- 7) Enzyme Biochemistry, Biotechnology and Clinical Chemistry. Palmer T., Harwood Pub., 2001
- 8) Fundamentals of Enzymology. Price, N.C. & Stevens, L., Oxford Pub., 1999
- 9) Immobilized Enzymes and Cells. A. Rosevear et al., IOP Pub., 1987
- 10) Industrial Enzymes and their Applications. Uhlig H. John Wiley and sons, 1998
- 11) Thermostability of Enzymes. Gupta M.N., Narosa Pub., 1993

## CELL AND MOLECULAR BIOLOGY

**Hours: 52**

### Course outcomes:

*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)

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. Integrating cells into tissues: Cell adhesion, Cell junctions; Extracellular matrix, extracellular matrix receptors and signaling.

### Unit II (13 hrs)

Subcellular Organization: Ultrastructural organization and functions of Golgi complex, endoplasmic reticulum, mitochondria, chloroplast, peroxisomes, lysosomes, ribosomes, nucleus and nucleolus. 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.

### Unit III (13hrs)

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: 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).

#### **Unit IV (13hrs)**

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 -  $\text{Ca}^{2+}$ ,  $\text{IP}_3$ , DAG, cAMP & cGMP. Signalling pathways during development.

#### **References**

1. Molecular Biology of the Cell. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D., Garland Publishing Inc., 2002
2. The Cell. A Molecular Approach. Cooper, G.M. Sunderland: Sinauer Associates, Inc., 2000
3. Cell and Molecular Biology. De Robertis, E.D.P. & 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

## **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)**

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. Microbial metabolism: Microbial respiration, aerobic and anaerobic respiration, fermentation, Bacterial photosynthesis. General account of symbiosis, mutualism, antagonism, parasitism and commensalism in microorganisms.



## UNIT II (13 hrs)

Principle and applications of Light, Phase contrast, differential interference contrast, fluorescence, Confocal and Electron Microscopy. Stains and staining- Principles of staining, simple staining, negative staining, differential staining, Gram and acid fast staining, flagella staining, capsule and endospore staining. Growth kinetics, factors affecting growth and death; Culture media, methods of isolation, enumeration, cultivation and preservation of microorganisms. Culture collection centres (ATCC, IMTECH, NCCS-MCC etc.). Control of microbes- Sterilisation, disinfection, antiseptic, tyndallisation, pasteurization: Physical- dry heat, moist heat, UV light, ionizing radiation, filtration, HEPA filter, Chemical-phenol and phenolic compounds, (halogen aliphatic alcohol, formaldehyde, ethylene oxide, heavy metals) anionic and cationic detergents.

## 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. Risk levels and Biosafety laboratories. Biological warfare and Bioterrorism

## UNIT IV (13 hrs)

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

## ENZYME TECHNOLOGY

**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, proximity and orientation, factors affecting enzyme activity, temperature, pH, time substrate concentration. Isozymes, co-enzymes, metalloenzymes, multifunctional and multienzyme complexes -PDC. Multiple substrate reaction types with specific examples (bisubstrate).

### **UNIT II (13 hrs)**

Theories of enzyme catalysis (Collision theory and Activation energy theory) 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, Dixon plot. Fast kinetics to elucidate the intermediates and rate limiting steps. 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. Ribozymes, Abzymes. Clinical and industrial application of enzymes, enzymes and inborn errors of metabolism, 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

## **INHERITANCE BIOTECHNOLOGY**

Hours: 40

### **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. Understand the genetics behind genetic diseases and syndromes

CO 3. Understand population genetics, and about genotype and allelotype frequency calculation.

### **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). Study of model systems: Drosophila, Arabidopsis, *C.elegans*.

### **UNIT II (13 hrs)**

Chromosome analysis, karyotyping, cytogenetic mapping, 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. Mutation studies in Drosophila.

### **UNIT III (14 hrs)**

Population and evolutionary genetics: Genetic variation, Gene pool, allele frequencies, Hardy-Weinberg equilibrium, inbreeding, outbreeding and changes in allelic frequency. Natural selection, Genetic drift, gene flow, Speciation: allopatric and sympatric; Convergent evolution; Sexual selection; Co-evolution., proteins and DNA Sequence polymorphism, Molecular basis of evolution in human.

### **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

## **PRACTICALS**

### **BIOCHEMISTRY**

#### **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

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

## **MOLECULAR 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  
Isolation and staining of salivary gland chromosomes in *Drosophila*  
Demonstration of Barr bodies in buccal cells

## **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

## **INHERITANCE BIOTECHNOLOGY**

### **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*  
Mutants of *Drosophila*  
Micronucleus test in mice  
Banding techniques and karyotyping  
Study of human blood groups  
Chromatographic separation of eye pigments in *Drosophila*  
Problems on quantitative inheritance  
Problems on gene frequencies in population

## **ENZYME TECHNOLOGY**

### **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  
Mechanism of action of lysozyme  
Mechanism of action of chymotrypsin  
Mechanism of action of polymerases  
Immobilization of enzymes and their applications

**II SEMESTER**  
**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. Identification of DNA as genetic material, experiments of Griffith, Avery MacLeod and McCarthy. DNA Replication: Semiconservative mechanism, prokaryotic and eukaryotic DNA replication, Okazaki fragments; enzymology and control of DNA replication; inhibitors of replication; Replication in  $\phi$ x 174, M-13, T-phages and Lambda phages. Molecular mutation (mechanisms of missense, nonsense, transition, transversion and frame-shift mutation, lethal mutation, origin of spontaneous mutation and control). DNA damage – mechanical and chemical; types of DNA repair, photo-reactivation, base excision, recombination, mismatch, SOS.

**Unit II (13 hrs)**

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

**Unit III (13 hrs)**

Translation in Prokaryotes and Eukaryotes: Genetic code, initiation of translation, chain elongation, Termination, post-translational modification and structure determination and involvement of different translational factors at different stages of the process. Folding of polypeptides; involvement of molecular 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 IV (13 hrs)**

C-value paradox, co-linearity of genes, split genes, gene families. Transposable elements, Discovery, types and their significance in bacteria and Eukaryotes. Epigenetics, functional

perturbation, knockdown (interference RNA, small interference RNA), knockout technology, micro RNA.

### 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

## rDNA TECHNOLOGY

**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), Next Gen Sequencing.

### 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, Fluorescent In-situ Hybridization (FISH) Technique, Comparative genomic 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, 2D-electrophoresis. Manipulating gene expression: Transcriptional fusions, translational fusions, *In-vitro* mutagenesis: Oligonucleotide directed mutagenesis, deletions, Insertional mutagenesis, direct single base mutagenesis. General guidelines for recombinant DNA research activity. Containment facilities and biosafety practices; Rules for import and export of biological materials.

#### 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

## IMMUNOTECHNOLOGY

**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 (10 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; Cells involved in immune response-T-cells – T helper cells, T cytotoxic cells, B-cells, NK cells, Macrophages. Clonal selection theory. Lymphocyte activation, clonal proliferation, differentiation.

### **UNIT II (10 hrs)**

Antigens and haptens, determinants; B-cell epitopes; TI antigens. Types of immunoglobulins: structure, distribution and function. Antigen-antibody reactions – Antigen equilibrium, dialysis, precipitation reactions, immunodiffusion. Affinity and Avidity. Antibody diversity - V, D, J, gene segments and DNA rearrangements, molecular biology of antibody synthesis. Production, purification and characterization of monoclonal antibodies. Polyclonal antibodies versus monoclonal antibodies. ELISA, RIA, Fluorescent techniques, Fluorescent activated cell sorter (FACS).

### **UNIT III (10hrs)**

Effector mechanisms in immunity-macrophage activation. Lymphokines – Interleukins and their role in immune regulation. Toxin and Toxin resistance. Complement system. Human and mouse MHC, Transplantation immunology. HLA in human health and disease; HLA tissue typing. Immune-suppression in transplantation. Immunization and antibody response.

### **UNIT IV (10hrs)**

Hypersensitivity reactions, treatment approaches. Immunological tolerance. Autoimmune diseases. Thyrotoxicosis, Systemic Lupus Erythematosus, Antinuclear antibodies. Tumor immunology immuno-surveillance, immunological escape – tumor specific and associated antigens. Immune deficiency diseases – primary, secondary immune deficiencies; X-linked gammaglobulinemia, AIDS. Concepts in vaccine development. Types of vaccines. Immunotherapeutic approaches to disease treatment-immunotoxins, Lymphokine-activated killer cells. T-cell cloning and their applications.

### **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 al., W.H. Freeman & Co. 2007
5. Immunology. Riott, I.M., Brostoff, J., 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

## **RADIATION TECHNOLOGY**

**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  $^{32}\text{P}$ ,  $^{35}\text{S}$ ,  $^{14}\text{C}$ ,  $^3\text{H}$ ,  $^{125}\text{I}$ . 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

## **MARINE BIOTECHNOLOGY**

**Hours:40**

### **Course outcomes:**

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

- CO 1. Comprehend the uses of marine organisms,
- CO 2. Understand significances, interactions, impacts
- CO 3. Use management technologies to come up with solutions

### **Unit 1 (13 hrs)**

Introduction to marine environment; marine flora – phytoplankton, seaweeds, sea grasses and mangroves. Applications of Marine Organisms: Marine viruses and Giruses Giant bacteria and their significance Unculturable bacteria: occurrence ,characteristics and exploitation Barophilic organisms & their applications Seaweeds for removal of metal pollutants GFP, RFP characteristics and their applications Green mussel adhesive protein Chitosan: products

and applications. Biomimetics

### **Unit II (13 hrs)**

Marine organism management Marine pollution Biofouling and corrosion Ballast water Red tides Bacterial & viral pathogens in aquaculture Aquaculture diseases in finfish and shellfish

### **Unit III (14 hrs)**

Marine technology: Samplers: water samplers, dredges , grabs, snappers. Sampling (Field trips) and identification: Phytoplankton & Zooplankton Nekton Benthos Estimations: Chlorophyll Nutrients: nitrates/nitrites, phosphates/silicates Dissolved oxygen Salinity, pH & alkalinity

### **References**

1. Le Gal, Y., Ulber, R., & Antranikian, G. (2005). Marine Biotechnology (Vol. 96).
2. Munn, C. (2011). Marine microbiology: Ecology & applications.
3. Osborn, M. (2005). Molecular microbial ecology.
4. Rainey, F., Oren, A. (2006). Extremophiles, Volume 35, 1st Edition.
5. Nabti, E. (2017). Biotechnological Applications of Seaweeds.
6. Day, R., Davidson, M. (2014). The Fluorescent Protein Revolution.
7. Hicks, B. (2002). Green Fluorescent Protein.
8. Ahmed, S., Ikram, S. (2017). Chitosan.
9. Bar-Cohen, Y. (2006). Biomimetics.
10. Naik, M., Dubey, S. (2017). Marine pollution and microbial bioremediation.
11. Flemming, H.-C., Murthy, P.S., Venkatesan, R., Cooksey, K.E. (2009). Marine and Industrial Biofouling.
12. Liengen, T., Basséguy, R., Féron, D., Beech, I.B. (2015). Understanding Biocorrosion.
13. Okaichi, T. (2003). Red Tides.
14. Pillay, T. V. R. (2001). Aquaculture.
15. Swain (2006). Fish and Shellfish Immunology.
16. Farch, D. (2015). Diseases of fish.
17. Evans et al. (2000). Environmental Biotechnology- Theory and Application.
18. Evams, G et al. (2003). Environmental Biotechnology.

### **PRACTICALS (HARD CORE COURSES)**

#### **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. grasshoppers)

Chick and *Drosophila* developmental stages

Histological identification of germ layers of developing embryos

Induced breeding in fishes

## **rDNA TECHNOLOGY**

### **Course outcomes:**

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

- CO 1. Use the tools and techniques used in rDNA technology
- 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 rDNA technology

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

## **IMMUNOTECHNOLOGY**

### **Course outcomes:**

*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

## **MARINE BIOTECHNOLOGY**

### **Course outcomes:**

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

- CO 1. Comprehend the uses of marine organisms
- CO 2. Calculate productivity
- CO 3. Conduct water sample analysis
- CO 4. Evolve solutions from the sea

Samplers: water samplers, dredges , grabs, snappers.  
Sampling (Field trips) and identification - Phytoplankton & Zooplankton, Nekton and Benthos  
Estimations - Chlorophyll; Nutrients: nitrates/nitrites, phosphates/silicates; DO; Salinity, pH & alkalinity  
Seaweeds for removal of metal pollutants  
GFP, RFP applications  
Drugs from the sea  
Green mussel adhesive protein  
Chitosan : products and applications  
Biomimetics

## **RADIATION TECHNOLOGY**

### **Course outcomes:**

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

- CO 1. Understand the advantages of radiation
- CO 2. Use techniques in radiation biology,
- CO 3. Apply radiation technology in medicine etc
- CO 4. Follow safety protocols while working in 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

## **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

## 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

#### INDUSTRIAL BIOTECHNOLOGY (HARD CORE COURSE)

Hours: 52

##### 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 and its regulation
- 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.
- CO 5. Understand basic principles of primary and secondary metabolite production by the microorganisms, and acquire knowledge of their production
- CO 6. Know use of microorganisms as probiotics and the role of nutraceuticals in human health, waste utilization to generate biofuels and biogas.

##### UNIT I (13 hrs)

Fermentation- 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 a 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. Types of fermentation processes: submerged fermentation, surface or solid substrate fermentation, Modes of fermentation – batch, continuous, fed batch - kinetics of fermentation processes.

##### UNIT II (13hrs)

Downstream processing of biological molecules: Separation of cells, foam separation, flocculation, filtration, 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. Process flow sheeting – block diagrams, pictorial representation. Online acquisition: Bioprocess control and monitoring of variables such as temperature, agitation, pressure, pH, PID control.

##### UNIT III (13hrs)

Application of cells in bioprocess (LAB, PAB, yeast, mixed cultures, plant and animal cells) Production of primary and secondary metabolites: Primary Metabolites- Production of commercially important primary metabolites like organic acids (Lactic acid, citric acid, acetic acid, amino acids (Glutamic acid and Lysine). Secondary Metabolites- Production processes for various classes of secondary metabolites: Antibiotics (Penicillin, streptomycin) Vitamins (Vitamin B12, and Vitamin A), peptide antibiotics (Lantibiotics) and Steroids.

##### UNIT IV (13 hrs)



Production of enzymes and other bioproducts: Production, purification and applications of Industrial Enzymes (amylase, invertase pectinase). Biopreservatives, Biopolymers, Biodiesel, Bioconversion, Biofuels and waste Utilization of biofuels. Microbial exopolysaccharides - applications (Pharmaceuticals and Food industries): Alginate, Cellulose, Hyaluronic acid, Xanthan,  $\gamma$  polysaccharides of lactic acid bacteria; Chitin, chitosan and chitin derivatives. Microbial beverages: Production of wine, beer, and vinegar. Microbial foods: Oriental foods, sauerkraut, Cheese, SCP, SCO (PUFA), & Mushroom cultivation, Baker's yeast, Probiotics.

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

## AGRIBIOTECHNOLOGY

**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.
- CO 5. Learn protection and registration of new plant varieties and plant germplasm conservation, General agreement on trade and tariff, use of traditional knowledge digital library i.e ayurvedic and unani medicinal plants, Farmers rights and plant breeders rights

### 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. Biological oxidation: Electron transport chain, chemiosmotic hypothesis, ATP synthesis, oxidative phosphorylation, substrate level phosphorylation, uncouplers and inhibitors of respiration. Photosynthesis, regulation, Calvin cycle, C<sub>3</sub>-C<sub>4</sub> 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, Various in vitro techniques: callus cultures, meristem cultures, anther culture, embryo culture, micropropagation, protoplast culture, somaclonal variation, synthetic seeds; cryopreservation. 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 III (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. Plant microbe interactions: Rhizosphere, mycorrhizas, rhizobia, diazotrophs and endophytes. Plant pathogen interactions. Biopesticides- *Bacillus thuringiensis*, *Bacillus popilliae*, *Trichoderma*, Baculoviruses., Biofertilizers - *Rhizobium*, *Azotobacter*, *Azospirillum*, Cyanobacteria, *Mycorrhiza*, phosphate solubilizers, *Frankia*., Plant Growth Promoting Rhizobacter. Molecular diagnosis of plant diseases and biological control.

## UNIT IV (13 hrs)

CBD, GAAT, TRIPs, Plant variety protection, International Union for the Protection of new Varieties of Plants (UPOV), plant protection act, registration of new varieties, rights and obligations, farmer's rights; traditional ecological knowledge. Traditional knowledge digital library (TKDL). Plant germplasm conservation, characterization and documentation. Seed certification (laws, regulations and standards), seed patent law, Patent-related litigations and controversies (neem, basmathi rice, turmeric).

## 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

## RESEARCH METHODOLOGY AND BIOINFORMATICS

**Hours: 52**

### 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.

### **UNIT II (13 hrs)**

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 III (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 IV (13hrs)**

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. Scheffler, W. C., Addison Wesley Pub., 1979
10. Biostatistical Analysis. Zar, J. H. Prentice Hall, 2010
11. Biostatistics. Lewis, A. E.. Prentice Hall, 2010

## NANOBIOTECHNOLOGY

**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 in health-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, WorldScientific, 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

## BIOANALYTICAL TECHNIQUES

**Hours: 40**

### Course outcome

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

- CO 1. Apply the principle, instrumentation of bioanalytical 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, FTIR, fluorescence, CD, NMR, ESR, Atomic absorption, Plasma emission, X-ray diffraction, Mass spectrometry (modes of ionization and detection).

### **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

## **PRACTICALS**

### **INDUSTRIAL 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)

## **AGRIBIOTECHNOLOGY**

### **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

## **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

## **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<sub>2</sub> and NO<sub>x</sub>); 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

## **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 al., W.H. Freeman & Co. 2007



**IV SEMESTER**  
**BIOMEDICAL ENGINEERING (HARD CORE)**

**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). Guidelines for use of small laboratory animals in experimentation and pre-clinical research, maintenance and regulations.

**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. Prenatal diagnosis (amniocentesis and chorionic villus sampling). Genetic counseling.

## 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

## ENVIRONMENTAL BIOTECHNOLOGY (HARD CORE)

52 hrs

### 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)

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<sub>2</sub> and NO<sub>x</sub>); Pollution indicator organisms (plants, animals and microbes) (e.g. lichens, algae, Chironomids, coliforms, *Salmonella*, *Shigella*, *Vibrio*, Hepatitis A). Sampling of air and water pollutants. Biological treatment of liquid wastes – aerobic and anaerobic treatments, sewage and effluent treatments.

### UNIT II (13 hrs)

Microbial degradation of toxic chemicals (pesticides, plastics), degradation of organic compounds (cellulose, lignin, hydrocarbons: aliphatic, aromatic, alicyclic hydrocarbons). microbial mining (uranium, gold, iron), microbial influenced corrosion and remedies, Principles of microbial bioremediation, in situ and ex situ bioremediation, phytoremediation, bioaugmentation, biostimulation. Microbiological treatment of solid wastes – composting, land farming, bioreactors. Biogas production as non-conventional energy sources.

### UNIT III (14hrs)

Bioaccumulation, biomagnification. Case studies on major industrial disasters (nuclear/gas leaks, Minamata, endosulfan). Carbon footprint – possible methods to reduce. Major signs of climate change, impact on the marine world (decline in population, temperature-dependent sex determination) on the human health (extreme weather events, droughts, wildfires, floods and storm, vector borne disease – malaria, dengue, food insecurity. Microbiological treatment of solid wastes – composting, land farming, bioreactors. 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 (14hrs)**

Environmental issues of aquaculture; biofouling (microfouling and macrofouling); biofilms; biomolecules from the sea; scope of marine biotechnology. Pollution control measures, international and national pollution regulatory acts; Permissible limits and indices for pollutants. Hazardous wastes: microbial processing and disposal (radioactive wastes, pharmaceuticals, refinery). 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
- 9) Pollution Control in Process Industries. Mahajan S.P., Tata McGraw-Hill, 1990
- 10) Environmental Pollution Control Engineering. Rao C.S., Wiley Easter, 1992

#### **PRACTICALS**

##### **BIOMEDICAL ENGINEERING**

##### **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

##### **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)

## BIOTHERAPEUTICS

Hours:40

### Course outcomes:

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

CO 1. Learn elements of pharmacology, pharmacokinetics and pharmacodynamics

CO 2. Understand various facets of drug

CO 3. Comprehend principles and levels of toxicity, detection and safety

CO4. Understand concepts of clinical trials and related regulations

### Unit 1 (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- Preclinical research (dose-response curve, maximum tolerated dose); CPCSEA guidelines, commonly used species of experimental animals. Basic principles of bioassays.

### Unit II (13 hrs)

Mode of action and adverse effects of drugs (Paracetamol, Metformin, Cetirizine, Carboplatin). Pharmacodynamic / pharmacokinetic correlation. Toxicology studies (NOEL, NOAEL). Drug toxicity tests: OECD guidelines, determination of LD50, acute, sub-acute and chronic toxicity studies. 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 and EPA. Quality standards: ISO. Organic medicinal product research and development Drugs and cosmetics regulation, drug price control order.

### References

1. Human Physiology, Guyton
2. Essentials of Medical Pharmacology Tripathi. K. D., Jaypee Bros Med Publ, New Delhi
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

## **QUALITY CONTROL IN BIOTECHNOLOGY**

Hours:40

### **Course outcomes:**

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

- CO 1. Employ various aspects of quality control and quality assurance aspects of various biotechnological industries.
- CO 2. Be familiar with aspects like cGMP, QC tests, documentation, quality certifications, GLP and regulatory affairs.

### **Unit I (13 hrs)**

Quality Assurance, Quality Control, Role of Quality Assurance, QA testing, Role of Quality Control, Test for quality control, Quality assurance – Quality control – Practice of cGMP- Overview of ICH Guidelines – QSEM, with special emphasis on Q-series guidelines. Good Laboratory Practices: Scope of GLP, Definitions, Quality assurance unit, protocol for conduct of non clinical testing, control on animal house, scope of quality certifications – responsibilities of QA & QC departments, Analysis of raw materials, finished products, packaging materials, in process quality control (IPQC), Developing specification (ICH Q6 and Q3).

### **Unit II (13 hrs)**

Quality assurance and quality control in clinical trials - Audit criteria, Audit process, Responsibilities of stakeholders in audit process, Audit follow-up and documentation, Audit resolution and Preparing for FDA inspections, Fraud and misconduct management – Clinical Trial Data Management- Standard Operating Procedures, Data management plan, CRF & Data base design considerations, Study set-up, Data entry, CRF tracking and corrections, Central lab, IVRS, source data. Data cleaning, managing laboratory and ADR data, Data transfer and database lock, Quality Control and Quality Assurance in CDM, Data mining and warehousing

### **Unit III (14 hrs)**

Quality in food, nutraceuticals, biological and cosmetic products - WHO guidelines on nutrition. NSF International: Its Role in the Dietary Supplements and Nutraceuticals Industries, NSF Certification, NSF Standards for Food And Dietary Supplements. Good Manufacturing Practices for Nutraceuticals, Quality, safety and legislation for herbal products in India, USA and European Union, Analysis of Cosmetics, Toxicity screening and test methods: Quality control and toxicity studies as per Drug and Cosmetics Act, Analysis of Food additives- milk constituents and milk products- Pesticide analysis

### **References**

1. Good Clinical Practices for Clinical Research in India, Central Drugs Standard Control Organization, Ministry of Health and Family Welfare, Govt. of India, 2013
2. Current Good Manufacturing Practices: Pharmaceutical, Biologics, and Medical Device Regulations and Guidance Documents, Allport-Settle MJ, 2009
3. The CMP Handbook: A guide to quality and compliance, Cooper B., 2017
4. cGMP starter guide: principles in good manufacturing practices for beginners, Tobin EP, 2016

## **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  
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