Syllabus for M.Sc., Biotechnology

(From the Academic Year 2015-16 onwards)

Since 1919

Department of Biotechnology
National College
(Autonomous)
Tiruchirappalli – 620 001.

National College (Autonomous)

(Nationally Accredited at 'A' Level by NAAC)
Tiruchirappalli – 620 001.

M.Sc., Biotechnology Program Structure under CBCS

(For candidates admitted from the academic year 2015 – 16 onwards)

SEM	Subject Code	Course	Title of the Paper	Hrs / Week	Credit	Exam Hours	Marks		Total
							Int.	Ext.	Max. Mark
I		Core Course I	Biochemistry & Biophysics	6	5	3	25	75	100
		Core Course II	Cell and Molecular Biology	6	5	3	25	75	100
		Core Course III	Microbiology	6	5	3	25	75	100
		Core Course IV	Lab in Biochemistry, Cell and Molecular Biology, Microbiology and Immunology	6	5	6	25	75	100
		Elective Course I	Immunology and Immunotechnology	6	4	3	25	75	100
TOTAL				**30**	**24**	**-**	**125**	**375**	**500**
II		Core Course V	Molecular Genetics	6	5	3	25	75	100
		Core Course VI	Recombinant DNA Technology	6	5	3	25	75	100
		Core Course VII	Enzymology & Bioinstrumentation	6	5	3	25	75	100
		Core Course VIII	Lab in Molecular Genetics, rDNA Technology and Enzymology.	6	5	6	25	75	100
		Elective Course II	IPR, Biosafety & Bioethics	6	4	3	25	75	100
TOTAL				**30**	**24**	**-**	**125**	**375**	**500**
III		Core Course IX	Plant Biotechnology	6	5	3	25	75	100
		Core Course X	Animal Biotechnology	6	5	3	25	75	100
		Core Course XI	Lab in Plant Biotechnology, Animal Biotechnology, Bioprocess Technology & Bioinformatics	6	5	6	25	75	100
		Elective Course III	Bioprocess Technology	6	4	3	25	75	100
		Elective Course IV	Bioinformatics & Biostatistics	6	4	3	25	75	100
TOTAL				**30**	**23**	**-**	**125**	**375**	**500**
IV		Elective Course V	Research Methodology & Biotechnology Management	6	5	3	25	75	100
		Core Course XII	Project Work	24	14	-	75	225	300
Total				**30**	**19**	**-**	**100**	**300**	**400**
Grand Total				**120**	**90**	**-**	**475**	**1425**	**1900**

Semester I **Course Code -**

CORE I – BIOCHEMISTRY & BIOPHYSICS

Hours: 6 **Credits: 5**

Unit: 1 **Bioenergetics**: Molecular basis for evolution. Principles of thermodynamics - free energy functions - ATP as main career of free energy. Energy molecules. Biological oxidation - reduction reaction. Biomolecular Interactions - Structure and properties of H_2O. Solute – Solvent Interactions - Bonding; strong and weak interactions – hydrogen bonding – hydrophobic - hydrophilic interactions and ionic interactions.

Unit: 2 **Overview of Metabolic pathways:**Carbohydrate-Lipid-amino acid pathways. Biochemistry of monosaccharide – disaccharides – polysaccharides, Carbohydrate Metabolism - Glycolysis - citric acid cycle. Oxidative phorphorylation. Photophosphorylation Glyoxalate cycle - Carbohydrate biosynthesis - C_2 - C_3 - C_4 cycles. Lipid metabolism - chemical nature of fatty acids and acylglycerols - sources and storage of fatty acids - utilization fatty acids for energy production. Triacyglycerols - cholesterol - Phospholipids - sphingolipids.

Unit: 3 **Understanding structure of proteins**: primary – secondary - tertiary and quaternary. Globular and fibrous proteins. Protein stability - protein folding. Ramachandran plot. Amino acid metabolism – an over view: incorporation of nitrogen to amino acids - transport of nitrogen to liver and kidney - urea cycle - synthesis and oxidation of amino acids - de novo synthesis and salvage pathways in nucleotide metabolism.

Unit: 4 **Understanding structure of nucleic acids**: primary – secondary - tertiary and quaternary - structural components of nucleic acids- DNA supercoiling. RNA structures. DNA-protein interactions.

Unit: 5 **Structure of biological membranes**: Membrane proteins and transport - Ion – Channels - model membranes - liposomes. An overview of the Biochemistry of hormones: classification - mechanism of action - signal transduction. Hormonal integration of mammalian metabolism. Vitamins.

REFERENCE BOOKS:

1. Branden C and Tooze J. (1999). ntroduction to protein structure, Publishing Inc.
2. Lehninger A.L, Nelson D.L and Cox M.M. (2003). Principles of Biochemisty, Worth publishers, New York.
3. Mathew C. K, Van Holde and Ahern. (2008) Principles of Biochemistry. Pearson Publishers
4. Stryer L. (2002). Biochemistry, W.H. Freeman & Co.,New York.
5. Thomas Devlin (2002).Textbook of Biochemistry, John publishers.
6. Voet D and Voet J. (2005). Principles of Biochemistry. Wiley Publications

Semester I **Course Code -**

CORE II – CELL & MOLECULAR BIOLOGY

Hours: 6 **Credits: 5**

Unit – 1 **Cell Biology:** Cell Theory- Prokaryotic and Eukaryotic cell structure and Intracellular organelles. DNA & RNA - genetic material - structure and function. Prokaryotic and eukaryotic genome organization, Mitochondrial and Chloroplast DNA, cytoskeleton. Mitosis and meiosis.

Unit – 2 **Replication:** Enzymes in DNA replication - modes of replication. Prokaryotic and eukaryotic replication – events. Natural plasmids – types and replication.

Unit – 3 **Transcription:** Prokaryotic and Eukaryotic transcription - RNA polymerase - transcription factors - mechanism of transcription - Post Transcriptional modifications - Export of mRNA - Si RNA- SnRNA.

Unit – 4 **Translation:** Genetic code - Elucidation of Codons - mRNA- ribosomes - aminoacyl tRNA synthetase. Prokaryotic and eukaryotic translation. Regulatory elements in translation - post-translational modification. Regulation of gene expression - Operon concepts – Lac- Trp- Ara – positive and negative control.

Unit – 5 **DNA Repair & Protein Localization:** DNA repair and recombination-Chaperons and protein folding - nuclear localization signals for nucleus – mitochondria – chloroplast – Golgi - endoplasmic reticulum- membrane and secretory proteins and targeting.

REFERENCE BOOKS:

1. Griffiths A. J, Miller J. H, Suzuki D. T, Lewontin R. C and Gelbart W. M. (2000). An Introduction to Genetic Analysis, W. H. Freeman and company.
2. Levin B. (2004). Genes VII, Oxford University press.
3. Maloy S.R, Cronan J.E and Friefelder D. (1994). Microbial Genetics, Jones and Bartlett publishers.
4. Snustand D. P, Simmons M.J and Jenkins J.B. (1997). Principles of Genetics. John Wiley and sons.
5. Trun N and Trempy J. (2004). Fundamental Bacterial Genetics, Blackwell Science Ltd.
6. Watson J.D, Hopokins N.H,Roberts J.W, Steitz J.A and Weiner A.M. (2004). Molecular Biology of Gene, Benjamin / Cummings Publishing company.

Semester I **Course Code -**

CORE III – MICROBIOLOGY

Hours: 6 **Credits: 5**

Unit – 1 **Introduction to microbiology**: Scope and History. Classification of microorganisms. Morphology and fine structure of bacteria, fungi and virus - Bacteriophage. Light microscopy - Phase contrast – Interference - Fluorescence and Electron microscopy: SEM – TEM - principles - applications and limitations. Specimen preparation for Light and Electron Microscopy.

Unit – 2 **Isolation and cultivation of bacteria**: Microbial growth - culture media - isolation of pure culture. Growth curve: Diauxy - continuous culture – chemostat – turbidostat - synchronized growth. Measurement of microbial growth – Total cell count method - viable cell count method and biomass determination. Effect of environment on microbial growth: temperature – pH - osmotic pressure - hydrostatic pressure - surface tension - electromagnetic radiation - sound and microwaves.

Unit – 3 **Principles of sterilization and disinfection.** Physical and chemical methods of microbial control. Maintenance and preservation of microorganism- Antimicrobial chemotherapy – determination of levels of antimicrobial activity- mechanisms of action of antimicrobial agents - factors influencing. Principles of antimicrobial resistance. Bacterial spores.

Unit – 4 **Microbial Nutrition:** Nutritional requirements – C, H, O, N, P and S - growth factors and nutritional types of microorganisms. Uptake of nutrients: passive and facilitated diffusion - active transport - group translocation and membrane function. Cultivation of moulds and yeast.

Unit – 5 **Bioremediation & Bioenergy**: Concepts of bioremediation (insitu – exsitu) – Solid waste management – biotechnological approach. Waste water management – treatment schemes – dairy, textile industries. Bioenergy – microbes as food and feed, methane production, microbial fuel cells.

REFERENCE BOOKS

1. Davis B. D, Dulbecco R, Eisen H.N and Ginsberg H.S. (1980). Microbiology, Harper Intl. Edition.
2. Pelczar M.J, Jr. Chan E.C.S and Krieg N.R. (2001). Microbiology, Tata McGraw Hill Publishing Co.
3. Prescott L.M, Harley J.P and Klein D.A. (1996). Microbiology. Wm.C. Brown Publishers.
4. Tortora, Funke and Case. (1995). Microbiology – An Introduction, Benjamin-Cummings Publications.

Semester I **Course Code -**

CORE IV – Lab in Cell and Molecular Biology, Biochemistry, Microbiology and Immunology

Hours: 6 **Credit: 5**

1. Application of colorimeter- spectrophotometer- pH meter and buffers. Preparation of a few regularly used buffers in molecular biology.
2. Estimation of proteins- aminoacids- sugars.
3. Polyacrylamide gel electrophoresis. :
4. Thin layer chromatography- Paper chromatography- ion-exchange chromatography.
5. Demonstration of Ion- exchange, HPLC- GLC
6. Media preparation- Sterilization.
7. Culture transfer techniques- Isolation of pure cultures.
8. Bacterial staining (Simple- Negative- Gram's- Capsule- Acid fast- Spore)
9. Bacterial growth curve.
10. Antibiosis: Isolation of Antibiotic producing organisms form soil,
11. Antimicrobial Sensitivity test: Kirby Bauer Method.
12. Extracellular activities of micro organisms (Amylase, Lipases, Protease and gelatinase)
13. Preparation of Ag - Protocols of immunization- methods of bleeding- Routes of administration of antigen.
14. Blood group - typing. Peripheral mono nuclear cell separation- lymphocyte subset identification and enumeration.
15. Immunoelectrophoresis- immunodiffusion and rocket electrophoresis. ELISA Western blotting.
16. Cell division- mitosis (Onion root tip) and Meiosis (Tradescantia, Pollen Mother cell)
17. Observation of Cell structure and staining of Chloroplast and Nucleus.

REFERENCE BOOKS:

1. Cappuccino J.G and Sherman N. (2004). Microbiology. A laboratory manual, Pearson Education.
2. Ed. Murray R.G.F, Wood W.A and Krieg N.B. (1994). Methods for Genetics and Molecular Bacteriology. American society for Microbiology.
3. Jayaraman J. (1988). Laboratory Manual of Biochemistry, Wiley Eastern.
4. Kannan N. (2003). Handbook of Laboratory culture media- Reagents- Stains and Buffers, Panima Publishers, New Delhi.
5. Miller J.H. (1992). A short course in Bacterial Genetics, Cold Spring Harbor Laboratory.
6. Rodney Boyer. (2003). An Introduction to Practical Biochemistry, Pearson Education.
7. Sambrook J and Russell D. W. (2001). Molecular Cloning, Cold Spring Harbour Lab. Press.
8. Wilson and Walker. (1994). Practical Biochemistry, Cambridge University Press.

Semester I **Course Code -**

Elective Course I – IMMUNOLOGY & IMMUNOTECHNOLOGY

Hours: 6 **Credits: 4**

Unit – 1 **Immune System:** Introduction - Cells of the Immune system - Innate and Acquired immunity - Primary and secondary lymphoid organs – Nature of antigens - Chemical and molecular basis of antigenecity – Immunogenecity - Haptens - Adjuvants - Primary and Secondary Immune Responses - Theory of Clonal selection.

Unit – 2 **Humoral Immunity:** B-lymphocytes and their activation - Structure and function of Immunoglobulin - Isotypes of immunoglobulins - Antigen-Antibody interactions - Antibody affinity- avidity; Agglutination – Precipitation - Idiotypic antibodies - monoclonal antibodies - antibody engineering – Generation of antibody diversity - Major Histocompatibility Complex.

Unit – 3 **Cell Mediated Immunity:** Biology of T lymphocyte - Classification of T lymphocytes - Structure of T Cell Receptor (TCR) - TCR diversity and genetics - Antigen presenting cells (APC) – macrophages - dendritic cells - Origin and functions of APC - Antigen processing and presentation – Cytokines - Cell mediated cytotoxicity - mechanism of Tcell and NK cell mediated lysis - Complement- Hypersensitivity.

Unit - 4 **Immunity And Infection Mechanism:** Tissue injury and Inflammation – Immunosuppression - Immunological Tolerance - Immunity to infectious agents – Transplantation – Autoimmunity - Tumor Immunology, Immunodiagnostics. Immunodiffusion and Immunoelectrophoresis – Hemagglutination - production of polyclonal and monoclonal antibodies - Western Blotting – ELISA - Radio Immunoassay - FACS.

Unit – 5 **Vaccines**: Conventional - Molecular vaccines -Types of vaccines - Recent trends in Immunology of Infectious diseases. Active/passive immunization- whole organism vaccines-purified macromolecules as vaccines- recombinant vector vaccines- DNA vaccines- multivalent subunit vaccines strategies for Hepatitis B- Malaria- HIV and Cancer. Dendritic cells as therapeutic agents. Multi – valent vaccines.

REFERENCES

1. Elgert K.D. (1996). Immunology - Understanding Immune system, John Wiley and sons publications.
2. Kuby J, Cameron J, Todd C and Mitchell J. (2000). Immunology, W.H. Freeman and Co.
3. Roitt I,Brostoff and Male. (2001). Immunology, Mosby Publications.

Semester II **Course Code -**

CORE V – MOLECULAR GENETICS

Hours: 6 **Credits: 5**

Unit: 1 **Cross over and Recombination:** Genetics of Bacteria and virus: Overview of genetic exchange in bacteria. Conjugation – discovery- F^+ x F^- matings- Hfr conjugation- sexduction- Determining linkage from interrupted mating experiments. Determining gene order from the gradient of transfer. Transduction – Discovery- generalized transduction- specialized transduction- Transformation – the process- competency. Bacterial viruses- discovery- genetic fine structure. Phage cross- rII System- Selection in genetic crosses of bacteriophages.Elucidation of fine Structure of genes by Benzer's experiment- Cis-Trans complementation. Linkage mapping techniques in eukaryotes – Ordered and un-ordered Tetrad analysis in Neurospora crassa.

Unit: 2 **Mutation & DNA Repair & DNA Recombination:** Mutation – Genetic variability required for evolution. Mutation – basic features of the process – somatic- Germinal- spontaneous- induced random- non – adaptive- reversible nature of mutations. Molecular basis of mutation – chemical- Radiation- transposable genetic elements- organ of spontaneous mutations. Mutations – phenotypic effects – effect of mutation in human hemoglobin genes- blocks in metabolic pathways. Conditional lethal mutations and their uses. Ames Test. Suppression of mutation.

Unit : 3 **Gene regulation in eukaryotes:** spatial and temporal regulation of eukaryotic genes – tubulin genes in plants- globins genes in animals. Induction & transcriptional activity by environmental and biological factors – temperature- molecular control & Transcription in eukaryotes- enhancers- silencers. Eukaryotes transcription factors. Cytoplasmic control of mRNA stability. Chloroplast and Apicoplast DNA. Mitochondrial control DNA - gene expression- inter play between mitochondrial and nuclear gene products. Epigenetic regulation- RNA mediated regulation. DNA methylation.

Unit: 4 **Transposable genetic elements :** IS Elements- composite transposons- Tn3- Tn5- Tn 9- Tn10 elements- medical significance. Eukaryotes – Ac and Ds elements in maize- P elements in drosophila. Retro transposons. Genetic and evolutionary significance of transposable elements.

Unit: 5 **Cancer biology :** Cell cycle – genetic control of cell division – hematopoiesis as model system role of transcription factors and Growth factors. Genetic basis of cancer - benign- malignant- metastatic cancer. Oncogenes and tumour suppressor genes- Ras protein signaling and cancer. Apoptosis.

REFERENCE BOOKS:

1. Atherly A. G, Girton J. R and McDonald J. F. (1999). The Science of Genetics, Harcourt College Publishers.
2. Goldsby R. A, Kindt T. J, Osborne B. A and Kuby J. (2003). Immunology, W. H. Freeman and Company.
3. Griffiths A. J, Miller J. H, Suzuki D. T, Lewontin R. C and Gelbart W. M. (2000). An Introduction to Genetic Analysis, W. H. Freeman and company.
4. Levin B. (2003).Genes VII, Oxford university press.
5. Sinustad. (1997). Principles of Genetics, John Wiley publications.
6. Trun N and Trempy J. (2004). Fundamental Bacterial Genetics, Blackwell publishers.
7. Watson J.D, Hopokins N.H, Roberts J.W, Stettz J.A and Weiner A.M. (2004). Molecular Biology of Gene, The Benjamin/ Cummings Publishing company.

Semester II **Course Code -**

CORE VI - RECOMBINANT DNA TECHNOLOGY

Hours: 6 **Credits: 5**

Unit: 1 **Introduction to rDNA technology**: DNA modifying enzymes and their uses. Restriction enzymes-Discovery- types- use of type II restriction enzymes-Elucidation of restriction site- Restriction mapping. DNA polymerases -Klenow-DNA polymerase I- thermostable DNA polymerases used in PCR- T4 / T7 DNA Polynucleotide kinases and alkaline phosphatases. RNA polymerases- ligases-nucleases - DNAse I- SI Nuclease-Mung Bean Nuclease- RNAases- Exo III.

Unit: 2 **Cloning Vectors and their applications**: Vectors for gram positive and gram negative bacteria. Bacteriophage vectors - Lambda and Ml3 virus-based vectors-cosmids- phagmids. Yeast vectors. Expression vectors- vectors facilitating protein purification Shuttle vectors. Artificial chromosomes-BAC-YAC- HAC. Inteins (protein introns)- Exteins

Unit : 3 **DNA Cloning:** sticky ends- blunt ends- homopolymeric tailing- use of adaptors and linkers. PCR based cloning. Preparation of radiolabelled / fluorescent labeled DNA & RNA probes. Chemical synthesis of oligo-nucleotides. Blotting & hybridization techniques. Screening of recombinants- alpha complementation- Blue – white selection.

Unit : 4 **DNA sequencing:** - Maxxam-Gilbert- Sanger methods. Automated DNA sequencing. PCR technology - concept- types- primer design- analysis of products and applications. DNA-fmger printing. Chromosome jumping- chromosome walking. Site - directed mutagenesis.

Unit : 5 **cDNA arrays and Micro array technology**: Strategies for the production of recombinant proteins - insulin- human growth hormone- industrially important proteins. Construction of genomic library- cDNA library.

REFERENCE BOOKS:

1. Bernard R, Glick and Jack J. Pasternak. (2002). Molecular Biotechnology, Panima Publishing House, New Delhi.
2. Brown T. A. (2001). Gene Cloning, Blackwell Science Publishers.
3. Ernst L and Winnacker. (2003). Genes to Clones, Panima Publishing House, New Delhi.
4. Glover D.M and Hames B.D. (1995). DNA cloning I & II, IRL Press.
5. Innis M. A, Gelfand D.H and Sninskey D. J. J. (1995). PCR strategies, Acadmic Press.
6. Primrose S. B. (2001). Molecular Biotechnolgy, Panima Publishing House, New Delhi.
7. Watson J.D, Gilman M, Witkowski and Zoller M. (1992). Recombinant DNA, Scientific American books.

Semester II **Course Code -**

Core VII - ENZYMOLOGY AND BIOINSTRUMENTATION

Hours: 6 Credits: 5

Unit - 1 **Enzyme Classification and nomenclature**: General properties of enzymes like effect of pH- Temperature- Ions etc. Extraction- assay and purification of enzymes. Steady state kinetics. Michaelis – Menten- Lineweaver Burke- Eadie-Hofstee and Hanes – Woolf equation and y value. Different types of inhibitors. Pre-steady state kinetics. Fast kinetics to elucidate the intermediates and rate limiting steps (flow and relaxation techniques) Km and Kcat values.

Unit - 2 **Enzyme Kinetics and Mechanism**: Enzyme specificity. Evidences for enzyme substrate complex Nucleophilic and electrophilic attack. Role of metal ions and Co-Enzymes in enzyme catalysis. Mechanism of enzyme action eg.- Lysozyme-Chymotrypsin, DNA Polymerase-RNase etc. Zymogens and enzyme activation. Allosteric interactions and product inhibition. Complex kinetics and analysis. Membrane bound enzymes – extraction- assay. Clinical and Industrial applications of Enzymes. Immobilizations of Enzymes and their applications. Enzyme engineering. Biosensors - glucose oxidase, cholesterol oxidase, urease and antibodies as biosensors.

Unit – 3 **Tracer Techniques**: Radioactive isotope and half life & isotope; Assessing the metabolic pathways- Meselson and Stahl experiment- autoradiography. Counting techniques: Liquid scintillation counting- Photomultiplier tubes- Chemiluminescence and bioluminescence. Green fluorescent protein. Fluorescence activated cell sorting.

Unit: 4 **Separation Techniques**: Principles and application of gel exclusion chromatography- ion exchange chromatography- affinity chromatography- Gas and high performance liquid chromatography. Electrophoretic techniques (single & Two – Dimension, Pulse-field gel electrophoresis)- Centrifugation (Velocity and buoyant density) & Precipitation techniques for the separation of proteins and nucleic acids.

Unit: 5 **Spectroscopic techniques:** Theory, Principles, Instrumentations and Applications of UV-Visible and IR spectrophotometry, Fluorescence, NMR, Atomic absorption, Mass, Raman, CD, ORD and Flame spectrophotometry, Luminometry, ESR Spectrometry, Mossbauer Spectrophotometry, , Flowcytometry. Mass spectrometry-MALD1-TOF.

Reference Books

1. Alan Fersht (1995). Enzyme structure and Mechanisms, W.H.Freeman and Company New York.
2. Canter and Canter. (1996). Biophysical Chemistry.
3. Glick and Pasternack (1994). Molecular Biotechnology, ASM Press.
4. Puri and Sharma. Physical chemistry. S. Chand publications.
5. Soni P.L. Physical chemistry, S. Chand publications
6. Branden C and Tooze J. (1999). Introduction to protein structure, Publishing Inc.

7. Lehninger A.L, Nelson D.L and Cox M.M. (2003). Principles of Biochemisty, Worth publishers, New York.
8. Mathew C. K, Van Holde and Ahern. (2008) Principles of Biochemistry. Pearson Publishers
9. Stryer L. (2002). Biochemistry, W.H. Freeman & Co.,New York.
10. Thomas Devlin (2002).Textbook of Biochemistry, John publishers.
11. Voet D and Voet J. (2005). Principles of Biochemistry. Wiley Publications

Semester II **Course Code -**

CORE VIII – LAB IN MOLECULAR GENETICS - rDNA TECHNOLOGY AND ENZYMOLOGY.

Hours: 6 **Credits: 5**

1. Experiments with lac operon- induction and assay of beta-galactosidase.
2. Preparation of competent cells and transformation- Transduction- Conjugation
3. Isolation and quantification of Nucleic acids – Bacterial- fungal- animal- plant
4. Restriction digestion of DNA
5. Ligation of DNA fragments.
6. Demonstration of gene transfer techniques- Cloning a gene
7. Enzyme kinetics – salivary amylase- acid / alkaline phosphatase-
8. Enzyme Immobilization
9. Enzyme preparation and purification – acid phosphatase –Ammonium Sulphate precipitation
10. Agarose gel electrophoresis- resolution and purification of DNA fragments.
11. PCR amplifications- RFLP- RAPD.
12. Purification of protein (Enzyme) by ion exchange chromatography. [DEAE cellulose chromatography]
13. Identification and quantitation of activity of amylase/ cellulose/ amyloglucosidase/ invertase/ alkaline phosphatase (salivary/microbial/animal/plant source].
14. Determination of specific activity.
15. Determination of activity in presence of activators.
16. Determination of activity in presence of inhibitors.
17. Determination of optimum pH
18. Determination of optimum temperature
19. Determination of Km
20. Study of competitive, non-competitive inhibitors

REFERENCE BOOKS:

1. Glover D.M and Hames B.D. (1995). DNA cloning I & II, IRL Pres.
2. Grierson and Covey S.N. (1988). Plant Molecular Biology.
3. Ignacimuthu S. S. J. (1996). Applied Plant Biotechnology, McGraw Hill publications Co. Ltd., New Delhi.
4. Innis M.A, Gelfand D. H and Sninskey D. J.J. (1995). PCR strategies, AcadmiPress.
5. Miller J.H. (1992). A short course in Bacterial Genetics, Cold Spring Harbor Laboratory.
6. Molecular cloning. Volume I- Volume II and Volume III, Academic Press.

Semester IV **Course Code –**

Elective – II: IPR, BIOSAFTEY AND BIOETHICS

Hours: 6 Credits: 4

UNIT I **Biosafety:** Introduction – biosafety issues in biotechnology - historical background. Biological Safety Cabinets, Primary Containment for Biohazards. Biosafety Levels - Levels of Specific Microorganisms, Infectious Agents and Infected Animals.

UNIT II **Biosafety Guidelines**: Guidelines and regulations (National and International including Cartegana Protocol) – operation of biosafety guidelines and regulations of Government of India; Definition of GMOs & LMOs. Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture. Environmental release of =GMOs - Risk - Analysis, Assessment, management and communication.

UNIT III **Intellectual Property Rights:** Introduction to IPR, Types of IP - Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge and Geographical Indications. Importance of IPR – patentable and non patentables, patenting life, legal protection of Biotechnological inventions. Agreements and Treaties - History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments. IPR and WTO regime - Consumer protection and plant genetic resources.

UNIT IV **Patents And Patent Laws**: Objectives of the patent system - Basic, principles and general requirements of patent law. Biotechnological inventions and patent law - Legal development - Patentable subjects and protection in Biotechnology. Patent Filing Procedures - National & PCT filing procedure, Time frame and cost, Status of the patent applications, Precautions while patenting, disclosure/ nondisclosure, financial assistance for patenting, introduction to existing schemes. Patent licensing and agreement. Patent infringement - meaning, scope, litigation, case studies.

UNIT V **Bioethics:** Introduction to ethics and bioethics, framework for ethical decision making. Ethical, legal and socioeconomic aspects of gene therapy, germ line, somatic, embryonic and adult stem cell research. Ethical implications of GM crops, GMO's, human genome project, human cloning, designer babies, biopiracy and biowarfare. Eugenics and its possible approaches. Animal right activities - Blue cross in India- society for prevention of cruelty against animals. Ethical limits of Animal use. Green peace - Human Rights and Responsibilities.

REFERENCES:

1. Beier F.K, Crespi R.S and Straus T. Biotechnology and Patent protection, Oxford and IBH Publishing Co. New Delhi.
2. Jeffrey M. Gimble, Academia to Biotechnology, Elsevier Academic Press.
3. Rajmohan Joshi (Ed.). 2006. Biosafety and Bioethics. Isha Books, Delhi.
4. Sasson A, Biotechnologies and Development, UNESCO Publications.
5. Senthil Kumar Sadasivam and Mohammed Jaabir M. S. (2008). IPR, Biosafety and Biotechnology Management, Jasen Publications, India.

Semester III **Course Code –**

CORE IX – PLANT BIOTECHNOLOGY

Hours: 6 Credits: 5

UNIT I **Introduction to Tissue Culture:** Objectives, roles and landmarks in plant breeding; special breeding techniques: Mutational breeding and distant hybridization. History of plant cell, tissue and organ culture – laboratory organization – aseptic techniques – nutritional requirements and culture media. Micro propagation – Mass production of plantlets – hardening and mist chambers – transplantation to field – techniques for maintaining plantlets in the field. Types of cultures – Solid – Liquid – Stationary – agitated – batch cultures – Organogenesis – callus induction – Caulogenesis – Rhizogenesis – technique of hairy root production. – Somatic embryogenesis – induction of multiple shoots.

UNIT II ***In-Vitro*** **Propagation:** Production of virus free plants – production and exploitation of haploids and triploids – techniques of overcoming incompatibility barriers – embryo rescue – protoplast culture and parasexual hybridization – exploitation of Somaclonal and Gametoclonal variations. Mass Culture of Cells – Manipulation of cell line selection – immobilization of cells and its application – cryopreservation – germplasm conservation and establishment of gene banks – Synseed technology.

UNIT III **Gene Transfer Techniques:** Genetic Engineering in Plants - Molecular biology of Agrobacterium mediated DNA transfer- Ti plasmid Vectors- Binary and co-integrated vectors- Transformation strategies in plants – *Agrobacterium tumefaciens* & *Agrobacterium rhizogenes*. Plant viruses as vectors. Physical method of transfer-Biolistics –Electroporation. Transposons in transgenic plants – their uses – Terminator gene technology, RNAi, Metabolic Engineering.

UNIT IV **Molecular Markers:** Selectable Markers, reporter genes- Promoters used in Plant vectors genetic engineering for - heat, drought and saline tolerance (Osmogenes) - Virus resistance - Pest resistance – Bt genes, Non-Bt like protease inhibitors, alpha amylase inhibitors - Herbicide resistance - Herbicide tolerance - Delayed fruit ripening - Fungal and bacterial resistance - Secondary metabolite production . Production of therapeutic proteins - antibodies, vaccines - edible vaccines-hormones- Golden Rice. Marker free transgenic plants. Co-transformation-Transgenic silencing.

UNIT V **Plant Genome Mapping:** Physical and molecular maps, gene tagging –Seed production techniques, release of new varieties and plant breeders right: UPOV 369, 370, 372. Plant DNA finger printing: Hybridization and PCR based markers (RFLP, SSR's, RAPD, QTLs, SCARS, AFLP etc.,). Green House Technology - Molecular aspects of nitrogen fixation. Management aspect of plant Genetic Engineering. Transgene escape – Tagging - mapping and cloning of plant genes. Molecular biology of plant pathogen interactions.

REFERENCE:

1. Bernard R. Glick and Jack J. Pasternak. (2001). Molecular Biotechnology- Principles and applications of recombinant DNA technology. ASM Press,Washington DC.
2. Bhojwani S.S. and Razdan M.K. (2004). Plant Tissue culture: theory and practice, Elsevier science.
3. Chrispeels M.J and Sadava D.F. (1994). Plants, Genes and Agriculture. Jones and Bartlett Publishers.
4. Dixon R.A and Gonzales R.A. (2004).Plant cell culture, IRL press.
5. Erbisch F.H and Maredia K.M. (2000). Intellectual property in agricultural Biotechnology, University Press.
6. Glick and Paster Mark (2002). Molecular Biotechnology, Panima Publishers.
7. Hammond J, McGarvey P and Yusibov V. (Eds). (1999). Plant Biotechnology – New products and Applications, Springer Publication.
8. Kalyankumar De. (2007). An Introduction to Plant Tissue Culture Techniques. New Central Book Agency, Kolkata.
9. Lycett G.W. and Grierson D. (1990). Genetic Engineering of crop plants.

Semester III **Course Code –**

CORE – X ANIMAL BIOTECHNOLOGY

Hours: 6 Credits: 5

Unit : 1 **Gametogenesis**: Reproduction, Gametogenesis – male and female, Structure, chemistry, dynamics and regulation of sperm locomotion, capacitation and egg-surface targeting, Molecular biology, cytology and biochemistry of oogenesis: Synthesis Ovulation and hormonal control in mammals. Molecular and cellular biology of fertilization: Acrosome reaction and signal transduction, monospermy and species-specificity. Egg activation,

Unit: 2 **Developmental Biology:** Implantation and formation of the placenta in mammals. early cleavages and blastocyst formation in mammals and biochemical and cellular changes during the passage down the oviduct to the uterus. Gastrulation in mammals-formation of primitive streak, morphogenetic movements and neural induction. Organogenesis and foetal development. Drosophila as a model to understand the genetics of development - and storage of maternal transcripts, proteins and cell organelles in drosophila.Pattern forming genes and expression in Drosophila.

Unit : 3 **Animal cell and tissue culture:** – primary cell culture- transformed cell lines- cell culture media – components and their function- serum- and serum free media. Flask culture and passage of cells CO_2 incubator. Organ culture methods of introducing of DNA into cell lines – microinjection- calcium phosphate transfection-lipofection- electroporation. Reporter gene systems – luciferase and green fluorescent protein- CAT assay. Preservation of animal cells. American type culture collection.

Unit : 4 **In vitro fertilization and embryo transfer:** ART procedures – IVF, ICSI, Embryo transfer techniques, ART – Medical practice and research. Development and use of transgenic animals – retroviral method- embryonic stem cell method- micro – injection method. Generation of gene knockouts and insertional mutants in mice. Stem Cells – types- Gene therapy. Cloning of animals. Stem cell therapy – reproductive cloning. Biotechnology of silkworms and aquaculture.

Unit: 5 **Hybridoma technology and Diagnostics:** Monoclonal antibody production, biochemical principle, procedure, purification and applications. T cell cloning and applications – cytokine technology. **DNA diagnostics -** PCR based diagnostics; ligation chain reaction, southern blot diagnostics, array-based diagnostics, DNA sequencing, genetic profiling, single nucleotide polymorphism. Inborn errors of metabolism, Transgenesis-gene transfers, knock-outs.

Reference Books:

1. Bernard R. Glick and Jack J. Pasternak (2002). Molecular Biotechnology, Panima Publishing House, New Delhi.

2. Garrison C, Fathman F and Fitch W. (1982). Isolation- Characterization and utilization of T – Lymphocyte clones, Academic Press
3. Goldsby R. A. Kindt T.J, Osborne B. A and Kuby J. (2003). Immunology, W.H. Freeman and company.
4. Griffiths A. J, Miller J.H, Suzuki D.T, Lewontin R.C and Gelbart W.M. (2000). An introduction to Genetic analysis, W. H.Freeman and Company.
5. Masters J.R.W. (2000), Animal Cell culture, Oxford University Press.
6. Puher A. (1993). Genetic Engineering of animals (Ed.), VCH Publishers-Weinheim-FRG.
7. Ranga M.M. (2003). Animal Biotechnology.
8. Springer T. A. (1985), Hybridoma Technology in Biosciences and Medicine, Plenum Press, New York.
9. Watson J.D, Gilman M, Witknowski J and Zoller M. (1992). Recombinant DNA, Scientific American Books, New York.
10. Watson J.D, Hopkins N.H, Roberts J.W. Steitz J. A and Weiner A.M. (2002). Molecular Biology of gene, Benjamin / Cummings.

Semester III **Course Code –**

CORE XI - LAB IN PLANT BIOTECHNOLOGY, ANIMAL BIOTECHNOLOGY, BIOPROCESS TECHNOLOGY AND BIOINFORMATICS

Hours: 6 Credits: 5

1. Plant tissue culture- sterilization, media preparation, hormones.
2. Micropropagation, shoot induction, multiplication, root induction and hardening.
3. Callus induction, cell suspension cultures, regeneration, haploid culture, anther culture. Protoplast isolation,
4. Agrobacterium-mediated transformation, GUS expression, extraction of DNA from transformed plants.
5. Preparation of Ag - Protocols of immunization- methods of bleeding- Routes of administration of antigen.
6. Immunoelectrophoresis - immunodiffusion and rocket electrophoresis.
7. ELISA and Western blotting
8. Demonstration. Primary cell culture-fibroblasts from mouse & Chick embryo - Cell viability- MTT Assay.
9. Introduction to bioprocess technology parts and designs of bioreators; production of biomass; batch and continuous fed batch fermentation- recovery of products.
10. Laboratory scale fermentation of antibiotics- immobilization of cells and enzymes.
11. Computer basic knowledge; hardware, connection cables, typing, Windows 98/XP, Internet browsers, search engines.
12. LAN connections, setting up the IP address, network security.
13. Internet surfing and searching information, downloading and installing software (Acrobat Reader, etc).
14. Program to store a DNA sequence
15. Program to concatenate DNA fragments
16. Program to convert DNA to RNA
17. Program to read protein sequence data from a file
18. Program to find motif in a protein sequence
19. Program to count nucleotide in a sequence
20. Program to find the percentage of G and C in a DNA sequence
21. Program to find the percentage of type of amino acid in a sequence
22. Program to find is a DNA is stable or not.

REFERENCE BOOKS:

1. Abubel F.M. (1987). Current Protocols in Molecular Biology Vol. & II, John Wiley Publishers, New York.
2. Bhojwani S.S. and Razdan M.K. (2004). Plant Tissue culture: theory and practice, Elsevier science.
3. Dixon R.A and Gonzales R.A. (2004).Plant cell culture, IRL press.
4. Hammond J, McGarvey P and Yusibov V. (Eds). (1999). Plant Biotechnology – New products and Applications, Springer Publication.

5. Hudson L and Hay H.C. (1980). Practical Immunology, Blackwell Scientific Publications.
6. Kalyankumar De. (2007). An Introduction to Plant Tissue Culture Techniques. New Central Book Agency, Kolkata.
7. Lycett G.W. and Grierson D. (1990). Genetic Engineering of crop plants.
8. Muthukkaruppan V.R, Baskar S and Sinigaglia F. (1986). Hybridoma Techniques: A Laboratory Course, Macmillan India Limited.
9. Sambrook. (2001). Molecular Cloning: A laboratory manual Vol. I – III, Cold Spring Harbor Laboratory.
10. Weir D.M. (1986). Hand Book of Experimental Immunology Vol. I & II, Blackwell Scientific Publications.

Semester III **Course Code -**

ELECTIVE - III BIOPROCESS TECHNOLOGY

Hours: 6 Credits: 4

UNIT I **Introduction to White Biotechnology:** Isolation and screening of industrially important microbes. Strain improvement - mutation and recombination. Media/substrates for industrial fermentation/process - typical media, media formulation, water, energy and carbon sources, nitrogen sources, minerals, growth factors, buffers, precursors, inhibitors, inducers and antifoams. Media formulation/optimization. Preservation of industrially important microorganisms.

UNIT II **Fermentation and Fermentor/Bioreactor:** Concepts of basic modes of fermentation – Batch, Fed batch and Continuous fermentation. Fermentor/Bioreactor design and operations - basic function, design, components and body construction. Sterilization of Fermentor/Bioreactor - air and media sterilization. Bioprocess control and monitoring - control and monitoring of variables such as temperature - pH – aeration - agitation - pressure - online measurement - on / off control - PID control - computers in bioprocess control system.

UNIT III **Types of Fermentors / Bioreactors:** Mechanical - Stirred tank bioreactors, pneumatic - Airlift fermentors, Hydrodynamic - jet fermentors, enzymatic membrane reactors, photo bioreactors, solid state fermentors, anaerobic solid stage silage fermentors, bed fermentors, tower fermentors, rotating disc fermentor, bubble cap fermentor, animal cell culture reactors and plant cell culture reactors.

UNIT IV **Downstream Processing:** Objectives and criteria - foam separation - precipitation methods. Filtration - filtration devices and filter aids. Centrifugation - industrial scale centrifugation and cell disruption. Liquid - liquid extraction, solvent recovery. Chromatography - two-phase aqueous extraction, extraction, ultra filtration, membrane process, drying devices, crystallization and whole broth processing. Effluent treatment - disposal, treatment process and by - products.

UNIT V **Bioprocess Economics and Industrial Production:** Bioprocess economics. Production of enzymes-amylases and proteases. Acetone – Butanol - Ethanol (ABE) fermentation. Antibiotic production - penicillin, streptomycin and tetracycline. Amino acid - Lysine, proline and glutamic acid. Vitamin production - vitamin B12. Organic acid production – acetic and citric acid. Cell and enzyme immobilization.

REFERENCE BOOKS:

1. Arnold L. Demain and Julian E. Davis. (2004). Industrial Microbiology and Biotechnology, ASM Press.
2. Casida L.E. (1968). Industrial Microbiology, John Wiley & Sons.
3. Coulson J.M and Richardson J.F. (1984). Chemical Engineering, Pergamon Press.
4. Emt.el-Mansi and Bryce C.F.A. (2004). Fermentation Microbiology and Biotechnology, Taylor and Francis Ltd.
5. Flickinger M.C and Drew S.W. (1999). Encyclopedia of Bioprocess Technology – 5 Volumes, John Wiley & Sons.

6. Glazer A.N and Nikaldo H. (1995). Microbial Biotechnology, W H Freeman and company network.
7. Gungalus I.C and Stainer R.Y. (Eds.). The Bacteria, Vol. III, Academic press. New York.
8. Prescott L. M, Harley J. P and Klein D. A. (1999). Microbiology, 4th edition, Mc Graw Hill.
9. Sala Teh J.R. Bacterial physiology and metabolism, Academic press, New York.
10. Stainer R.Y, Ingrtham J.L, Wheels M.L and Painter P.R. (1987). General Microbiology, MacMillan.
11. Stanbury P.F, Whitaker A and Hall S.J. (1995). Principles of Fermentation Technology, Butterwoth Heinemann.
12. Stanbury P.F, Whitaker A and Hall S.J. (1997). Principles of fermentation technology, Oxford University Press.

Semester III **Course Code –**

ELECTIVE COURSE IV - BIOINFORMATICS & BIOSTATISTICS

Hours: 6 **Credits: 4**

Unit – 1 **Structural Biology:** Factors determining primary – secondary - tertiary and quaternary structures of Proteins and Nucleic acids. Algorithms to identify the patterns in the primary – secondary - tertiary and quaternary structures.

Unit – 2 **Databases:** Introduction to databases - Types of databases. Flat file database - Relational databases - Object oriented databases - Database software: Overview of Sequence Retrieval System – Oracle - MySQL. Database design: visualization of databases - data mining. Structural Bioinformatics**:** Models of protein structure – Structure function – relationship - Structural alignment – Classification of 3D structure. CATH and SCOP – Concepts in protein prediction. Micro array data and analysis: Tools and resources - Proteomic data analysis - Bioinformatics in drug discovery.

Unit – 3 **Phylogenetic analysis:** Internet sequences on the net - Sequencing DNA- RNA Proteins – Determination of Protein Structure – Gene and Protein expression data – Protein interaction data-File formats – Sequences databases – Genome and organism specific databases – Retrieval - Entrez – SRS - Similarity searches – Amino acid substitution matrices - FASTA- BLAST – various types of BLAST. Multiple sequence alignment: Protein families - Protein domain families. Building trees – Evolution of macromolecular sequences – Genome annotation.

Unit – 4 **Programming In C & Perl:** C-language-Introduction-Operators-expressions-variables- input output statements- control statements- function- arrays- pointers-structures- unions- file handling and case studies. Introduction to PERL- variables-strings and numbers- lists analysis- hashes- conditional loops- strings- pattern matching- applying PERL to bioinformatics.

Unit – 5 **Biostatistics:** measures of central Tendency - mean arithmetic's- harmonic and geometric median and mode - measures of dispersion -standard deviation and standard error; correlation coefficient- simple linear regress- Basic idea of significance test- hypothesis test. Level of significance - T test - 'Chi' square and goodness of fit - Graphics.

REFERENCES

1. Attwood T.K and Parry Smith D.J. (2001). Introduction to bioinformatics, Pearson Education Asia.
2. Balaguruswamy E. (1992). Programming in ANSI C, TataMcGraw Hill.
3. David W. Mount. (2001).Bioinformatics, Cold Spring Harbor Laboratory Press.
4. Gibas C and Jambeck P. (2001). Developing bioinformatics in computer skills, Oreilly & Associates Inc. Shroff Publishers.
5. Kutti. (1995). C and Unix programming: a conceptual perspective, Tata McGraw Hill.

Semester IV **Course Code –**

ELECTIVE V RESEARCH METHODOLOGY AND BIOTECHNOLOGY MANAGEMENT

Hours: 6 Credits: 5

UNIT I **Research Concepts and Data Collection**: Definition of Research, Qualities of Researcher, Components of Research Problem, Various Steps in Scientific Research, Types of Research; Hypotheses Research Purposes - Research Design - Survey Research - Case Study Research. Sources of Data: Primary Data, Secondary Data; Procedure Questionnaire - Sampling Merits and Demerits - Experiments - Kinds - Procedure; Control Observation - Merits - Demerits - Kinds - Procedure - Sampling Errors - Type-I Error - Type-II Error.

UNIT II **Research Reports**: Structure and Components of Research Report, Types of Reports, Styles of reporting, Steps in drafting reports, editing and evaluation of final draft, evaluating the final draft; Good Research Report, observation and research report. Pictures and Graphs; Research proposal/ Grant- definition, structure, budget allocation, specific aims, background and significance. Hierarchy of funding agencies in India and their operations.

UNIT III **Model Organisms in Biology:** definition of model organism and research resources – classification of model organisms. Non-human mammalian models – mouse *(Mus musculus)*; Guinea pigs *(Cavia porcellus).* Non-mammalian models – Bacteria (Escherichia *coli*), Viruses (T4 and Lambda Bacteriophage), Yeast (*Saccharomyces cerevisae*), Amoeba (*Dictyostelium discoideum*), Round worm (*Caenorhabditis elegans)*, Fruit fly *(Drosophila melanogaster)*, Zebra fish *(Danio rerio),* Mouse Ear cress (*Arabiddopsis thaliana)*, Maize (*Zea mays*) – rationale of model organism, comparative physiology, life cycle, scope and research preferences. Repositories- ATCC, NCCS, Pune. Culture collection and submission.

Unit - 4 **Biotechnology Management:** Introduction - Designing a manuscript- grant experimental protocols & experimental methods. Selection of a Biotechnology company. **Setting up of a Laboratory**: laboratory administration – collaborations - inventories and inspections – personnel – Recruitment hiring – mentoring - promoting and terminating

Unit – 5 **Good Manufacturing Practices Ensuring Biosafety:** Biosafety regulations - Good laboratory practices - Good manufacturing practices in industry. Storage and disposal of hazardous wastes: radioactive materials - pathogenic strains. GMO's and their release in environment. Experimental protocol approvals -Levels of containment - Environmental aspects of biotech applications.

REFERENCE BOOK

1. Beier F.K. and Crespi R.S. and Straus T. Biotechnology and Patent protection, Oxford and IBH Publishing Co. New Delhi.
2. Jeffrey M. Gimble, Academia to Biotechnology, Elsevier Academic Press.
3. Sasson A. Biotechnologies and Development, UNESCO Publications.

Semester IV **Course Code –**

COURSE CODE XII
PROJECT WORK
REPORT AND VIVA VOCE

Hours: 24 Credits: 14