COURSES OF STUDIES

M.Sc. in Biotechnology

(2021-2023)

FAKIR MOHAN UNIVERSITY

Vyasa Vihar, Balasore-756089, Odisha

Department of Bioscience and Biotechnology

M. Sc. Biotechnology

1st Semester		
BT-411	Cell Biology	4CH
BT-412	Microbiology	4CH
BT-413	Biomolecules & Enzymology	4CH
BT-414	Biostatistics & Bioinformatics	4CH
BT-415	Practical	8CH
2nd Semester		
BT- 421	Genetics & Molecular Biology	4CH
BT- 422	Immunology	4CH
BT- 423	Bioprocess Engineering & Technology	4CH
BT- 424	Bio techniques & Instrumentation	4CH
BT- 425	Practical	8CH
3rd Semester		
BT- 531	Animal Biotechnology	4CH
BT- 532	Genetic Engineering	4CH
BT- 533	Plant Biotechnology	4CH
BT- 534	Choice Base Credit Paper (Fundamentals of Biotechnology)	4CH
BT- 535	Pratical	8CH
	*Non credit course on Fakir Mohan Studies	
4th Semester		
BT- 541	Research Methodology and Scientific Communication Skills	4CH
BT- 542	Bioresources: Characterization, Conservation and Applications	4CH
BT- 543	Journal Paper Presentation	4CH
BT- 544	Project Dissertation, Presentation & Grand Viva	12CH

INSTRUCTIONS FOR STUDENTS

1. The course is of two years' duration comprising of four semesters of both theory and practical. The theory papers carrying 100 marks have external valuation of 80 marks and internal valuation of 20 marks. The theory paper carrying 80 marks will have examination of three hours and internal paper (20 marks) will have one-hour duration. Practical carrying 100 marks will have six hours' duration.

2. Practical papers will be examined by one internal examiner and one external examiner. If necessary, the practical examination may be extended to the next day.

3. All units of each paper are compulsory having equal weightage (4CH each). However, the Project Dissertation, Presentation & Grand Viva (BT-544) in the fourth semester will be of 12CH.

5. All students have to attend at least 75% classes each in theory and practical. Students having less than 75% attendance will not be eligible to fill up the forms for each semesterexamination.

6. For the session, 25% of the syllabus has been underlined which are to be self-studied by the students.

First Semester

BT-411 **CELL BIOLOGY** **4CH**

Course Objectives

The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules, the understanding of various biological processes becomes deeper and inclusive.

Unit-I: Dynamic organization of cell

Diversity of cell, sizes & shapes, Cell theory, Structure of prokaryotic and eukaryotic cells, internalorganization of the cell – Cell Wall, cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton; mitochondria, chloroplasts and Cellular energy transactions; nuclear compartment: nucleus, nucleolus and chromosomes, Cell motility – cilia, flagella of eukaryotes and prokaryotes.

Unit-II: Chromatin structure and dynamics

The structure of DNA and RNA, Organization of genes and chromosomes, Structure of eukaryotic and prokaryotic chromosome; Chromatin organization, heterochromatin, euchromatin Operon, unique and repetitive DNA, Cell cycle-molecular events and model systems, Cell cycle regulation, checkpoints in cell cycle; Mitosis & Meiosis and cytokinesis.

Unit-III: Genome instability and cell transformation

Proto-oncogenes**,** viral and cellular oncogenes, tumor suppressor genes: structure, function and mechanism of action of pRB; structure, function and mechanism of action of p53 protein; oncogenes as transcriptional activators. Apoptosis and Programmed Cell Death: Morphology of apoptotic cells, mechanism of apoptosis, Physiology of apoptotic cells, Inhibition of Apoptosis, Assays for Apoptosis.

Unit-IV: Cellular signalling, transport and trafficking

Transport of nutrients, ions and macromolecules across membranes, molecular mechanisms of membrane transport; transport across mitochondria and chloroplasts; nuclear transport; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior, intracellular protein trafficking, Protein localization, synthesis of secretory and membrane protein, receptor mediated endocytosis.

Unit-V: Cell differentiation & Development

Stem cells, their differentiation into different cell types and organization into specialized tissues; Cellular basis of differentiation and development– gametogenesis and fertilization, Development in Drosophila and Arabidopsis.

Books

1. Cell Biology by De-Robertis Saunders, Singapore.
2. Reproduction in eukaryotic cells, Prescott DM, Academic Press.
3. Developmental Biology, Gilbert SF, Sinauer Assoc. Inc.
4. Cell in Development and Inheritance, Wilson EB, McMillan, New York.
5. Molecular Biology of Cells, Alberts B et al.
6. Molecular Cell Biology, Lodisch et al.
7. Fertilisation, Longo FT, Chapman Hall, London
8. Cell by GM Cooper.

BT-412 **MICROBIOLOGY** **4 CH**

Course Objectives

The objectives of this course are to introduce field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition; methods for control of microbes and host- microbe interactions.

Unit-I: Microbial Diversity

Introductory Microbiology: History, Microbial evolution, modern approaches in taxonomy, ribotyping, ribosomal RNA sequencing; taxonomic nomenclature and Bergey's manual role of micro-organisms; classification of microorganisms, criteria for classification; Diversity of Microorganisms: Archea, Eukarya, algae, fungi, slime molds, protozoa and mycoplasma, extremophiles and unculturable microbes.

Unit-II: Microbial Characteristics

Principles of microbial nutrition; culture media for different microorganisms, culture collection and maintenance of cultures. Microbial growth: mathematical expression of growth, growth curve, factors affecting growth. Metabolic diversity among micro-organisms, photosynthesis in micro-organisms, fermentations, nitrogen metabolism and nitrogen fixation, Sterilization techniques; Chemotherapy/ Antibiotics: mode of action, resistance to antibiotics, antiviral and antifungal drugs.

Unit-III: Virology

Virus and bacteriophages, general properties of viruses, RNA phages, DNA viruses, RNA viruses, viral structure, taxonomy of virus, viral replication, retro-viruses, cultivation and identification of viruses; sub-viral particles – viroids and prions. Microbial Diseases caused viruses.

Unit-IV: Host-parasite relationship

Microflora of skin, oral cavity, gastrointestinal tract: entry of pathogens into the host and genesis. Microbial Diseases caused by bacteria and pathogenic fungi, Emerging and resurgent infectious diseases. Brief introduction to the life cycle and molecular biology of some important pathogens of AIDS, Malaria, Hepatitis and Tuberculosis. Microbial communication system: bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.

Unit-V: Microbial Genetics

Mutation and mutagenesis, Ames test; Recombination in Bacteria, Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, Genetic systems of yeast and Neurospora, Extrachromosomal inheritance.

Books

1. General Microbiology, Stainer, R.Y., Ingraham, J.L., Wheelis, M.L., and Painter, P.R. The McMillan Press Lte.
2. Brock Biology of Microorganisms, Madigan, M.T., Martinko, J.M. and Parker, J.Prentice-Hall.
3. Microbiology, Pelczar, M.J., Jr. Chan, E.C.S., and Kreig, N.R., Tata-McGraw-Hill.
4. Microbial Genetics, Maloy, S.R., Cronan, J.E.Jr., and Friefelder, D. Jones and Bartlett Publishers.
5. Microbiology, A Laboratory Manual, Cappuccion, J.G., and Sherman, N., Addison Wesley.
6. Microbiological Applications (A Laboratory Manual in General Microbiology), Benson, H.J., W.C.B., Wim C. Brown Publishers
7. Prescott's Microbiology

BT-413 BIOMOLECULES AND ENZYMOLOGY 4CH

Course Objectives

The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways. The course shall make the students aware of various disease pathologies within the context of each topic.

Unit-I: Biomolecules

Carbohydrate – Classification, structure, general properties and functions of polysaccharides and complex carbohydrates; amino sugars, proteoglycans and glycoproteins. Lipids – Classification, structure, properties and functions of fatty acids, essential fatty acids, fats, phospholipids, sphingolipids, cerebrocides, steroids, bile acids, prostaglandins, lipoamino acids, lipoproteins, proteolipids, phosphatidopeptides, lipopolysaccharides. Proteins – Peptide synthesis: chemical and Merrifield synthesis. Primary (peptide conformation, N- and C- terminal, peptide cleavage), Secondary (α-helix, sheet, random coil, Ramachandran plot), Tertiary and Quaternary structures of proteins. Nucleic acids – Nucleosides and nucleotides, Structure and function of nucleotides. Primary, secondary and tertiary structure of nucleic acids.

Unit-II: Bioenergetics

Chemical foundations of Biology: Water- chemical properties, function as medium of cellular reactions and activities. pH and buffers, Solution: Methods of expressing the concentration (Molality, Molarity, Normality etc.). Bioenergetics-basic principles; equilibria and concept of free energy; ATP as energy currency, oxidation of carbon fuels; glycolysis and gluconeogenesis; Citric acid cycle; Oxidative phosphorylation.

Unit-III: Role of vitamins, cofactors & secondary metabolites in metabolism

Vitamins and Coenzymes: Structure and functions of thiamine, riboflavin, nicotinic acid, Pentathenic acid, pyridoxine, lipoic acid, Biotin, Folic acid, Ascorbic acid and Vitamin A. General characteristics and function of Plant and Animal hormones; Heterocylic compounds and secondary metabolites in living systems- pigments and isoprenoids

Unit-IV: Enzyme Kinetics

Chemical nature, Nomenclature, Classification, Mechanism of enzyme catalysis, Activation energy, Enzyme specificity, Enzyme substrate interaction, factors affecting enzyme activity, Enzyme kinetics, Michaelis – Menton's Equation, Lineweaver – Burk plot, kinetics of multi-substrate reaction, Different types of enzyme inhibitions.

Unit-V: Enzyme regulation

Regulatory enzyme, covalent modulation and non-covalent modulation of regulatory enzyme, Aspartate transcarbmylase, glycogen phosphorylase, Models of enzyme catalysis, chymotrypsin, hexokinase, carbonic anhydrase, restriction enzyme, ribozymes, biochemistry of ribozyme; hammerhead, hairpin and other ribozymes, strategies for designing ribozymes, applications of ribozyme, isozymes.

Books

1. Essentials of Molecular Biology, David Friefilder, Jones and Bartlett Publications. Proteins – Structure and Molecular Properties, TE Creighton, WH Freeman and Company.
2. Genes VH, B. Lewin, Oxford University Press.
3. Introduction to Protein Structure, C. Branden and J. Tooze, Garland Publishing, New York.
4. Encyclopedia of Molecular Biology, J. Kendrew, Blackwell Scientific Publications, Oxford.
5. Physical Chemistry of Macromolecules, Tanford, C., John Wiley and Sons.
6. Introduction to Biophysical Chemistry, R.B. Martin, McGraw Hill, New York.
7. Biophysical Chemistry, Cantor, W.H. Freeman.
8. Protein Structure, Max Peruz.

BT- 414 BIOSTATISTICS AND BIOINFORMATICS 4CH

Course Objectives

The objectives of this course are to provide theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.

Unit-I: Basics of Biostatistics-I

Types of biological data (ordinal scale, nominal scale, continuous and discrete logical systems data), frequency distribution and graphical representations (bar graph, histogram, box plot and frequency polygon), cumulative frequency distribution, Measures of Arithmetic Mean, median, mode, range.

Unit-II: Basics of Biostatistics-II

Standard Deviation, Coefficient of Variation, Correlation, Covariance, calculation of covariance and correlation, General Concepts of regression, and Regression Coefficients, Standard error of estimate. Tests of significance (F, Z and t-test); chi-square tests, ANNOVA.

Unit-III: Computer Applications

MS-Word, MS- Excel, MS-Power Point: Creating presentations and adding effects; Web browsing for information search using Academic search Engines: PubMed, Science Direct, Google Scholar, E-journal and E-Library – Public Library of Science (PLOS), Directory of Open Access Journals, INFLIBNET.

Unit-IV: Introduction to Bio-informatics and different tools

World Wide Web, Introduction to data structures and database concepts, NCBI, PubMed, Entrez databases, UniProt, SwissProt, Data mining. Database sequence searching from Nucleotide and protein databases-Blast and different types of blast, submitting DNA sequences to databases. Fasta format for sequence alignment, Sequence analysis, pairwise alignment, Multiple sequence alignment, generating motifs and profiles, local and global alignment, Needleman and Wunsch algorithm, Smith Waterman algorithm

Unit-V: Application of Bioinformatics

Predicting phylogenetic relationships, protein structure prediction & engineering, Homology modelling and docking, Protein structure prediction. Internet tools for DNA sequence translation; Restriction enzyme mapping; primer designing, insilico PCR, Web tools for drawing plasmid map.

Books

1. Fundamentals of Biostatistics by Veer Bala Rastogi
2. Basic Biostatistics by G B N Chainy, P. K. Mohanty and G. Mishra
3. Fundamentals of Biostatistics by Bernard Roser
4. Misra, B.N. and M.K. Misra. 1983. Introductory Practical Biostatistics
5. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Andreas D. Baxevanis, B.F. Francis Ouellette (John Wiley and Sons)
6. Introduction to Bioinformatics by Arthur M. Lesk
7. Biostatistics: Basic concepts & methodology for Health Sciences, W.W.Daniel & C L Cross

BT-415 **Practical** **8CH**

1. Microscopy
2. Microtomy.
3. Mitosis and meiosis.
4. Preparation of liquid and solid media for the growth of micro-organisms.
5. Isolation and maintenance of organisms by plating, streaking, and serial dilution methods, slants and stab cultures, storage of microorganisms.
6. Isolation of pure cultures of bacteria from soil and water.
7. Cryopreservation and thawing.
8. Growth; growth curve, measurement of bacterial populations by turbidometry and serial dilution methods. Effects of temperature, pH, carbon and nitrogen sources on growth.
9. Measurement of doubling time.
10. Microscopic examination of bacteria, yeast and moulds and study of organisms by Gram stain, acid fast stain and staining for spores.
11. Assay of antibiotics and demonstration of antibiotic resistance.
12. Biochemical characterization of selected microbes.
13. Determination of absorption maxima of bromophenol blue, potassium dichromate solution.
14. Validation of Beer-Lambert Law.
15. Quantitative estimation of Protein, Sugars, Lipids by spectrophotometer.
16. Quantitative estimation of Amino acids.
17. Determination of activity of different enzymes.
18. Preparation of Buffers.
19. Karyotyping
20. Using NCBI and Introduction and use of various genome databases
21. Sequence information resource: using NCBI, EMBL, GenBank, Entrez, Swiss- Prot/TrEMBL, UniProt
22. Similarity search using tools like BLAST and interpretation of results
23. Multiple sequence alignment using ClustalX2
24. Phylogenetic analysis of protein and nucleotide sequences
25. Use of different protein structure prediction databases (PDB, SCOP, CATH)
26. Homology modelling of proteins
27. Demonstration of apoptosis of DNA laddering

Second Semester

BT- 421 GENETICS & MOLECULAR BIOLOGY 4CH

Course Objectives

The objectives of this course are to take students through basics of genetics and molecular biology covering prokaryotic and higher eukaryotic domains.

Unit-I: Introduction to Genetics

An overview on Mendelian & Non-Mendelian inheritance, Linkage & crossing over, sex linked inheritance, gene mapping (in *E.Coli* & *Drosophilae*), Mutation- types and significance, Structure & numerical variation in chromosomes, meiotic behaviour and genetic consequences in structural heterozygotes, Polygenic inheritance, multiple alleles, evidences of DNA as genetic material, Gene concept, and one gene-one polypeptide hypothesis.

Unit-II: Replication

DNA polymerases, Prokaryotic and Eukaryotic DNA replication; DNA repair, Recombinase enzyme, Recombination: Homologous Recombination: Holiday Model, RecA and other recombinases, Site specific recombination: FLP / FRT and Cre/Lox combination.

Unit-III: **Transcription**

Prokaryotic transcription, Eukaryotic transcription, RNA polymerases, General and specific transcription factors, mechanisms of transcription regulations, transcriptional and post-transcriptional modifications.

Unit-IV: **Translation**

Prokaryotic and Eukaryotic translation, the translation machinery, universal genetic codes, degeneracy of codons, Wobble hypothesis; mechanisms of initiation, elongation and termination, regulation of translation, co-and post- translational modifications of proteins.

Unit-IV: Cell Signaling

Signaling molecules and cell- surface receptors, G-protein coupled receptors, TGF-β and Smads, Cytokine receptors and JAK-STAT pathway, Receptor Tyrosine kinases and Ras, MAP kinase pathways, Toll and IMD pathway in innate immunity, Pathways that involve signal-induced protein cleavage, Phosphoinositides as signal transducers.

BOOKS

1. Molecular Biology LabFax, T.A. Brown (ed), Bios Scientific Publishers Ltd., Oxford, 1991.
2. Molecular Biology of the Gene (4th edition), J.D. Watson, N.H. Hopkins, J.W.Roberts, J.A. Steitz and A.M. Weiner, the Benjamin / Cummings Pub. Co. Inc., California, 1987.
3. Molecular Cell Biology (2nd Edition), J. Darnell, H. Lodish and D. Baltimore, Scientific American Books Inc USA 1994.
4. Molecular Biology of the Cell (2nd edition), B. Alberts, D. Bray, J. Lewis, M. Raff. K. Roberts, and J.D. Watson, Garland Publishing Inc., New York, 1994.
5. Gene VI (6th edition), Benjamin Lewin, Oxford University Press, U.K., 1988.
6. Molecular Biology and Biotechnology, A Comprehensive Desk Reference, R.A. Meyeres (ed.), VCH Publishers Inc., New York, 1995.
7. Genomes, T.S. Brown.

BT- 422 IMMUNOLOGY 4CH

Course Objectives

The objectives of this course are to learn about structural features of components of immune system as well as their function. The major emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection.

Unit-I: Fundamental concepts and overview of the immune system

Introduction, Phylogeny of immune system, Innate and acquired immunity, Clonal nature of immune response, Organization and structure of lymphoid organs, Cells of the immune system: Hematopoiesis and differentiation, B-lymphocytes, T-lymphocytes, macrophages, dendritic cells, natural killer and lymphokine activated killer cells, eosinophil, neutrophils and mast cells.

Unit-II: Antigen-antibody interactions

Nature and biology of antigens: immunogens, haptens and super antigens. Immunoglobulins: Basic structure and function, Hybridoma technology and monoclonal antibodies, Antigen-antibody interactions, Antigen processing and presentation

Unit-III: Immunogenetics

Major histocompatibility Complex, BCR and TCR generation of diversity. Regulation of immune response, generation of humoral and cell mediated immune responses, Activation of B and T – lymphocytes, T-cell regulation, MHC restriction, Immunological tolerance.

Unit-IV: Cell mediated Immune responses

Cytokines and their role in immune regulation, Complement System, Cell - mediated cytotoxicity: Mechanism of T cell and NK cell mediated lysis, antibody-dependent cell- mediated cytotoxicity, macrophage mediated cytotoxicity, lymphocyte trafficking, Hypersensitivity.

Unit-V: Clinical immunology

Immunity to infectious agents (intracellular parasites, helminthes and viruses), Tumour immunology, AIDS and other immune-deficiencies, Vaccines, Autoimmunity, Transplantation immunology.

BOOKS

1. Kuby Immunology, 4th edition, R.A. Goldsby, Thomas J. Kindt, Barbara A. Osborne (Freeman).
2. Immunology, A Short Course, 4th Edition, Eli Benjamin, Rcchard Coico, Geoffrey Sunshine (Wiley-Liss).
3. Fundamentals of Immunology, William Paul.
4. Immunology by Roitt and others.

BT- 423 BIOPROCESS ENGINEERING AND TECHNOLOGY 4CH

Course Objectives

The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

Unit-I: Bioreactor design and analysis

Introduction to bioprocess engineering, Bioreactors, Types of specialized bioreactors (CSTR, Bubble Column, Airlift, Tower, fluidized, Packed Bed, photobioreactors etc.), Measurement and control of bioprocess parameters, stability of microbial reactors, Media for industrial fermentation, Air and media sterilization, Isolation, preservation and maintenance of industrial microorganisms, analysis of mixed microbial populations, Kinetic of microbial growth and death.

Unit-II: Fermentation processes

Analysis of batch, fed-batch and continuous bioreactions, Solid State fermentation; biotransformation; Enzymatic Bioconversion; Enzyme and whole cell immobilization and their industrial applications; large scale animal and plant cell cultivation.

Unit-III: Downstream processing and product recovery

Downstream processing : Introduction removal of microbial cells and solid matter, foam separation, precipitation, filtration, centrifugation, cell disruptions, liquid-liquid extraction, chromatography, membrane process, drying and crystallization, effluent treatment: DOC and COD treatments and disposal of effluents.

Unit-IV: Industrial production of food & chemicals

Alcohol (ethanol), acids (citric, acetic and gluconic), solvents (glycerol, acetone, butanol), antibiotics (Penicillin, streptomycin, tetracycline), aminoacids (lysine, glutamic acid), single cell protein, Use of microbes in mineral beneficiation and oil recovery, Introduction of food technology, Elementary idea of canning and packing, Sterilization and pasteurization of food products, Technology of typical food/food products (bread, cheese, idli), Food preservation.

Unit-V: Metabolic Engineering

Microbes for production of industrial enzymes, Biofuel, Flavanoids, biodegradable plastics; Metabolic engineering of Plant Secondary metabolites (phenylpropanoid pathway, shikimate pathway); Metabolic engineering of Animal cells for production of therapeutic proteins, antibodies and vaccines.

BOOKS

1. Biochemical Engineering, Aiba, S., Humphrey, A.E. and Millis, N.F., University of Tokyo Press, Tokyo.
2. Biochemical Engineering Fundamentals, Baily, J.E. and Ollis, D.F., McGraw-Hill Book Co., New York.
3. Bioprocess Technology: Fundamentals and Applications, KTH, Stockholm.
4. Bioprocess Engineering : Basic Concepts, Shuler,M.L., and Kargi, F., Prentice Hall, Englewood Cliffs.
5. Principles of Fermentation Technology, Stanbury, P.F., Whitaker, A., Pergamon Press, Oxford.
6. Bioreaction Engineering Principles, Nielson, J. and Villadsen, J., Plenum Press.
7. Biochemical Engineering, Lee, J.M., Prentice Hall Inc.
8. Modern Industrial Microbiology and Biotechnology, Okafor, N, Science Publishers, New Hampshire 03748, USA.
9. Metabolic Engineering: Principles and Methodologies, Stephanopoulos, G.N; Aristidou, A.A and Nielsen,N., Academic Press.

BT-424 BIOTECHNIQUES & INSTUMENTATION 4CH

Course Objectives

This course is broad-based in nature encompassing several new technologies that current experimental researchers are employing to probe complex system biology questions in life-sciences. The objectives of this course are to teach basics of the new principles to students so as to appreciate current-day research tool-kit better.

Unit-I: Basic instrumentation

pH measurements by method of pH indicators and potentiometric methods, Centrifugation Techniques: Principle and application of High speed centrifuges, Continuous flow centrifuge, Density gradient centrifuge, Analytical ultracentrifugation, Bomb Calorimetry: Principle, experimental arrangement and its application.

Unit-II: Microscopy

Light Microscope, lenses and microscopes, Phase Contrast, fluorescence microscopy, Confocal microscope, SEM, TEM, fluorescent in situ hybridization (FISH), biosensors, flow cytometry.

Unit-III: Spectroscopy

The principle, instrumentation and application of the ultraviolet and visible spectrometry, Fluorescence Photometry, Infra-red-spectroscopy. Atomic Absorption Spectroscopy (AAS): The principle, differences, instrumentation and application of Flame emission spectroscopy and Absorption spectroscopy, Mass spectrometry for proteins & peptide analysis. MS data with specific protein sequences.

Unit-IV: Chromatography Techniques

The principle, experimental techniques, qualitative and quantitative analysis, applications of Adsorption Chromatography, Ion exchange chromatography, Paper chromatography, Thin layer chromatography (TLC), Gas liquid chromatography (GLC), High performance liquid chromatography (HPLC), Affinity chromatography.

Unit-V: Electrophoresis & Radiology

Principle, methods of measurement and applications of paper and cellulose Acetate electrophoresis, Thin layer Electrophoresis, Polyacrylamide Gel Electrophoresis (PAGE), Two dimensional gel electrophoresis for separation of total cellular proteins, and Agarose Gel Electrophoresis; Blotting Techniques; Radioactivity and instruments for measurement of radiation such as Geiger–Müller counter & Liquid Scintillating counter.

BOOKS

1. Instrumental methods of analysis by Willard *et al*.
2. Practical Biochemistry: Principles and Techniques by Wilson and Walker
3. Principles and Techniques of Biochemistry and Molecular Biology By Wilson and Walker
4. Laboratory Manual of Biotechnology by S. K. Bhatnagar and Deepika Abrol, S. Chand & Co.

BT- 425 **Practical** **8CH**

1. Electrophoresis (Agarose & SDS)
2. Chromatography (Paper & TLC)
3. Isolation of genomic DNA
4. Preparation of metaphage chromosomes from cultured cells.
5. Isolation of RNA
6. Metabolic labeling of proteins and immunoprecipitation
7. Blood film preparation and identification of cells.
8. Lymphoid organs and their microscopic organization.
9. Immunization and collection of serum.
10. Double diffusion and immuno-electrophoresis.
11. Radial immuno diffusion
12. Purification of IgG from serum.
13. Separation of mononuclear cells by Ficoll-Hypaque.
14. Western-blotting
15. ELISA
16. Hapten conjugation and quantization.
17. Immunodiagnostics (demonstration using commercial kits).
18. Isolation of industrially important microbes
19. Scale up from frozen vial to agar plate to shake flask culture.
20. Estmation of Specific growth rate (μ) from growth curve
21. Measurement of residual substrates.
22. Estimation of BOD
23. Isolation of Industrial enzyme from microbes and plants.

Third Semester

BT-531 ANIMAL BIOTECHNOLOGY 4CH

Course Objectives

The objectives of this course are to introduce students to the principles, practices and application of animal biotechnology and animal genomics, genetic transformation and molecular breeding of animals.

Unit-I: Basics of Animal cell culture

Equipment and materials for animal cell culture technology, Primary and established cell line cultures, Introduction to the balanced salt solutions and simple growth medium, A brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium, Role of carbon dioxide, Role of serum and supplements, Serum and protein-free defined media and their applications, Measurement of viability and cytotoxicity, Biology and characterization of cultured cells, measuring parameters of growth.

Unit-II: Basic techniques of mammalian cell culture

Disaggregation of tissue and primary culture; maintenance of cell culture; cell separation, Scaling-up of animal cell culture, Cell synchronization, Cell cloning and micromanipulation, Cell transformation.

Unit-III: Application of animal cell culture

Stem cell cultures, embryonic stem cells and their applications, Somatic cell genetics, Origin and maintenance of cancer stem cells; Stem cell therapies; Organ and histotypic cultures, Three dimensional culture and tissue engineering

Unit-IV: Animal Reproductive Biotechnology

Structure of sperm and ovum; cryopreservation of sperms and ova of livestock, artificial insemination, super ovulation, embryo recovery and in vitro fertilization. Culture of embryos, cryopreservation of embryos, embryo transfer technology, transgenic manipulation of animal embryos, applications of transgenic animal technology.

Unit-V: Vaccinology

History of development of vaccines, introduction to the concept of vaccines, Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine. conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines. Vaccination and immune response.

BOOKS

1. Culture of Animals Cells 3rd Edition, R. Ian Freshney, Wiley-Liss.
2. Animal Cell Culture – Practical approach, ed., John, R.W. Masters, Oxford.
3. Cell growth and Division : A Practical Approach, ed., R. Basega, IRL, Press.
4. Cell Culture Lab Fax, eds., M. Butler and M. Dawson, Bios Scientific Publications Ltd., Oxford.
5. Animal Cell Culture Techniques, eds, Martin Clynes, Springer.
6. Methods in Cell Biology, Vol.57, Animal Cell Culture Methods, eds., Jenni P. Mather and David Barnes, Academic Press.

BT – 532 GENETIC ENGINEERING 4CH

Unit- I: Introduction and tools for genetic engineering

Scope of Genetic Engineering, Basic techniques in gene analysis: nucleic acid purification and yield analysis, nucleic acid blotting; Restriction enzymes, modification enzymes, DNA Ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers and adaptors; Gene-cloning vectors: Plasmids, bacteriophages, phagemids, cosmids and Preparation of ordered cosmid libraries, artificial chromosomes (YAC & BAC).

Unit-II: PCR Methods & Generation of Libraries

Polymerase chain reaction: Primer designing, thermostable polymerases, PCR product purification and cloning (TA and T-blunt vector), variants of PCR, RT-PCR, Real-time PCR, Applications of PCR. Cloning a gene: Genomic libraries, cDNA libraries, directional cDNA cloning, PCR-based libraries, subtraction libraries, Alternative strategies of gene cloning: Cloning interaction genes one– two – and –three hybrid systems, screening for the clones by nucleic acid hybridization, Immunoscreening and function based screening, phage display.

Unit-III: Gene manipulation and expression of Recombinant Genes

Creating mutations: Primer-extension mutagenesis, strand selection methods, cassette mutagenesis, PCR-based mutagenesis, creating random mutations in specific genes, protein engineering. Expression strategies for heterologous genes: Expression vector design, codon optimization, host engineering, *in vitro* transcription and translation, expression in *E. coli*, expression in yeast, expression in insect cells, expression in higher-eukaryotic cells, Processing of recombinant proteins: Purification and refolding, characterization of recombinant proteins, stabilization of proteins.

Unit-IV: Genome Analysis

Genome sequencing projects: Genomic mapping, genetic mapping, physical mapping, nucleotide sequencing (manual, automated, NGS including sequencing by synthesis and pyrosequencing), human genome project; Global changes in gene expression: Differential display, Microarrays, Protein arrays, ChIPs with everything), genome-wide two hybrid screens. Molecular markers in genome analysis: RFLP, RAPD, AFLP analysis, SSR, CAPS, SCAR, STS, SNP.

Unit-V: Transgenic technologies & GMO

Targeted gene replacement, chromosome engineering, antisense and RNA interference, knock-out analysis; Gene therapy: Vector engineering, Strategies of gene delivery, gene replacement / augmentation, gene correction, genome editing by CRISPER-CAS.

Biosafety regulations: Definition of GMOs and LMOs, role of institutional biosafety Committee, RCGM, GEAC for GMO application in food and agriculture, environmental release of GMOs, risk analysis and assessment, international agreements and national regulation relating to GMO Intellectual Property Rights

BOOKS

1. Molecular Cloning: A Laboratory Manual, J. Sambrook, E.F., Fritsch and T. Maniatis. Cold Spring Harbor Laboratory Press, New York, 2000.
2. DNA Cloning: A Practical Approach, D.M. Glover and B.D. Hames, IRL Press, Oxford, 1995.

3. Molecular and Cellular Methods in Biology and Medicine, P.B. Kaufman, W.Wu.D. Kim and L.J. Cseke, CRC Press, Florida, 1995.

4. Methods in Enzymology, Guide to Molecular Cloning Techniques, Vol.152, S.L. Berger and A.R. Kimmel, Academic Press Inc., San Diego, 1996.

5. Methods in Enzymology, Vol.185.

6. Gene Expression Technology. D.V. Goeddel, Academic Press Inc. San Diego, 1990.

7. DNA Science : A First Course in Recombinant Technology, D.A. Mickloss and G.A. Freyer, Cold Spring Harbor Laboratory Pres, New York, 1990.

8. Molecular Biotechnology, 2nd edition, S.B. Primrose, Blackwell Scientific Publishers, Oxford, 1994.

9. Milestones in Biotechnology, Classic Papers on Genetic Engineering, J.A. Davies and W.S. Reznikoff, Butterworth-Heinemann, Boston, 1992.

10. Route Maps in Gene Technology, M.R. Walker and R. Rapley, Blackwell Science Ltd., Oxford, 1997.

11. Genetic Engineering : An Introduction to Gene Analysis and Exploitation in Eukaryotes, S.M. Kingsman and A.J. Kingsman, Blackwell Scientific Publications, Oxford, 1998.

12. Molecular Biotechnology-Click.

BT-533 PLANT BIOTECHNOLOGY 4CH

Unit I: Plant Tissue culture

Introduction to cell and tissue culture, tissue culture as a technique to produce novel plants and hybrids, Tissue culture media (composition and preparation), Initiation and maintenance of callus and suspension culture; single cell clones, Cryopreservation, slow growth and DNA banking for germ plasm conservation.

Unit-II: Micropropagation

Organogenesis; somatic embryogenesis; transfer and establishment of whole plants in soil, Shoot-tip culture; Rapid clonal propagation and production of virus-free plants, Embyro culture and embryo rescue, Protoplast isolation, culture and fusion; selection of hybrid cells and regeneration of hybrid plants; symmetric and asymmetric hybrids, hybrids Biotransformation, Anther, pollen and ovary culture for production of haploid plants and homozygous lines,

Unit-III: Plant Transformation technology

The basis of tumor formation, hairy root, features of T1 and R1 plasmids, mechanisms of DNA transfer, role of virulence genes, use of T1 and R1 as vectors, binary vectors, use of 35S and other promoters, genetic markers, use of reporter genes, reporter gene with introns, use of scaffold attachment regions, methods of nuclear transformation, viral vector and their applications, multiple gene transfer, vector less or direct DNA transfer, In planta transformation. chloroplast transformation: Advantages, vectors, success with tobacco and potato.

Unit-IV: Application of plant transformation for productivity and performance

Herbicide resistance, phosphoinothricin, glyphosate, sufonyl urea, atrazine, insect resistance, Bt. Genes, non-Bt like protease inhibitors, alpha amylase inhibitor, virus resistance, coat protein mediated, nucleocapsid gene, disease resistance, chitinase, 1-3 beta glucanase, RIP antifungal proteins, thionines, PR proteins, nematode 17esistance abiotic stress post-harvest losses, long shelf life of fruits and flowers, use of ACC synthase, poly-galactrunase, ACC oxidase; promoter trapping, activation tagging; Transgene stability and gene silencing; terminator gene technology; male sterile lines, bar and barnase systems, carbohydrate composition and storage, ADP glucose pyrophosphatase.

Unit-V: Molecular Breeding and Application

Introduction to conventional plant breeding, Molecular marker-aided breeding and marker-assisted selection; QTL mapping: Choice of mapping population (Traits, phenotyping, Genetic diversity, population structure), Types of QTL mapping (Bi- parental and GWAS), linkage analysis and map construction; Fine mapping of QTLs; map-based cloning of QTLs; Application of mapped QTLs in marker-aided breeding programs. Arid and semi-arid plant biotechnology, Green house technology.

BOOKS

1. J. Hammound, P. McGarvey and V. Yusibov, eds, Plant Biotechnology; Springer Verlag, 2000.
2. T-J Fu, G. Singh, and W.R. Curtis, eds., Plant Cell and Tissue Culture for the Production of Food Ingredients, Kluwer Academic/Plenum Press, 1999.
3. H.S. Chawla, Biotechnology in Crop Improvement, International Book Distributing Company, 1998.
4. R.J. Henry, Practical Application of Plant Molecular Biology, Chanman and Hall, 1997.
5. P.K. Gupta, Elements of Biotechnology, Rastogi and Co., Meerut, 1996.

BT-534 CBCS (FUNDAMENTAL OF BIOTECHNOLOGY) 4CH

UNIT-I: Concept of Biology
Origin of life, cell (Prokaryotic and eukaryotic, unicellular and multi cellular) Cellular organization, tissue, organ and organ system

UNIT-II: Genetics and Molecular Biology
Gene, Chromosome, DNA, RNA, Central Dogma, Molecules of life (Protein, Carbohydrate and lipids), Genetics-heredity, Mendel and Mendelian principles chromosomal aberration, common hereditary diseases.

UNIT-III: Applied Microbiology
Culture & Maintenance of microbes, Microbial diseases of Plants and Animals, Antibiotics and Chemotherapy, Virus-Types, structure and life cycle, Antiviral drugs

UNIT-IV: Immunology
Immune system (Innate and Adaptive). Cells of immune system, Antigen and Antibody, autoimmune diseases, HIV, Vaccines.

UNIT-V: Recent Advancement in Biosciences and Biotechnology: Genetic engineering, Application of Biotechnology in health and agriculture, Bt. Cotton, stem cells, gene therapy, GMO, synthetic cells, IPR, Bioethics.

BT-535 **PRACTICAL** **8CH**

1. Preparation of tissue culture medium and membrane filtration,
2. Surface sterilization,
3. Organ culture
4. Callus propagation, organogenesis, transfer of plants to soil.
5. Protoplast isolation and culture.
6. Anther culture, production of haploids.
7. Cytological examination of regenerated plants.
8. Agrobacterium culture, selection of transformants, reporter gene (GUS) assays.
9. Cell fusion with PEG
10. Bacterial culture and antibiotic selection media.
11. Preparation of competent cells and Bacterial transformation.
12. Isolation of plasmid DNA.
13. Quantization of nucleic acids.
14. Agarose gel electrophoresis and restriction mapping of DNA.
15. Construction of restriction map of plasmic DNA.
16. PCR
17. Cloning in plasmid vectors.
18. Gene expression of *E. coli* and analysis of gene product.
19. Reporter gene assay (Gus/CAT/□-GAL)
20. Isolation of industrially important microorganisms for microbial processes.

Fourth Semester

BT-541 Research Methodology and Scientific Communication Skills 4CH

Course Objectives

The objectives of this course are to give background on history of science, emphasizing methodologies used to do research, use framework of these methodologies for understanding effective lab practices and scientific communication and appreciate scientific ethics.

Unit I: Introduction to Research methodology

Research: Definition, Importance of research, Characteristics of research, Types of research (basic, applied, qualitative, quantitative, analytical, etc); Features of translational research – Concept of laboratory to market (bench to public) – Industrial R&D.

Research process – Observation – Axiom – Theory –Experimentation; Selection and formulation of research problem, Research questions, Research design – Formulation of Hypothesis, Review of Literature, Framing Research objective.

Unit II: Preparation for research

Choosing a mentor, lab and research question; maintaining a lab notebook; Good lab practices; method of storing chemicals, solvents and glassware, procedures for maintenance of stock, handling of instruments; handling and storage of biological material, laboratory waste management and disposal; lab safety and management of personnel, facilities, buildings and equipment.

Unit III: Process and skill of communication

Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication-interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences.

Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

Unit IV: Scientific communication

Types of research report: Dissertation and Thesis, editorial, research paper, review article, short communication, conference presentation etc.; Scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts;

Publishing scientific papers - Assessment of Quality of Journals, peer review process and problems, recent developments such as open access and non- blind review; plagiarism, software for plagiarism; ethical issues; scientific misconduct.

Suggested Readings:

1) Leedy, P. D., & Ormrod, J. E. (2015). *Practical research: Planning and design*. Pearson.
2) Pruzan, P. (2016). *Research methodology: the aims, practices and ethics of science*. Springer.
3) Booth, W. C., Booth, W. C., Colomb, G. G., Williams, J. M., Colomb, G. G., & Williams, J. M. (2003). The craft of research. University of Chicago press.
4) Thomas, C. G. (2021). Research methodology and scientific writing. Springer Nature.
5) Illingworth, S., & Allen, G. (2020). Effective science communication. IOP Publishing Limited.
6) Aines, R. D., & Aines, A. L. (2019). Championing science. University of California Press.
7) Resnik, D. B. (2005). The ethics of science: An introduction. Routledge.
8) C.R. Kothari: Research Methodology- Methods and Techniques (New Age International Publishers)

BT-542 Bioresources: Characterization, Conservation and Applications 4CH

Course Objectives

Bioresources are being overexploited to meet market demand, threatening their existence. The present course aims at introducing students to approaches for documentation of biodiversity, nature and magnitude of threat to bioresources and imparting knowledge about their conservation.

Unit I: Survey and Documentation of biodiversity and bioresources

Biodiversity and bioresources: concept and scope; evolution of biodiversity, factors promoting biodiversity; levels of biodiversity - genetic, species and ecosystem diversity; measuring organismal diversity: species richness index, species evenness index, Shannon-Wiener Index and Simpson Index; measurement of biodiversity at spatial level: alpha, beta and gamma diversity.

Estimate of biodiversity loss; Means of biodiversity loss; Causes of biodiversity loss; Species threat status: IUCN threat categories and criteria; Red Data Book; Biodiversity hotspots; effect of climate change on biodiversity; Biopiracy: factors and reasons, steps to check biopiracy, applicability of modern technologies in checking biopiracy.

Unit II: Conservation of bioresources

Why conserve bioresources; global measures for conserving bioresources: international conservation organizations (IUCN, WWF, UNEP, Biodiversity International, WCMC); multilateral treaties (Ramsar Convention, WHC, CITES, CBD). Biological Diversity Act, 2002 and Biological Diversity Rules, 2004, Wild Life (protection) Act,1972 including amendments in 1991, Forest (conservation) Act, 1980, Bioresource Development Board, Indian Bioresource Information Network; National Biodiversity Authority, National Biodiversity Action Plan, 2008, State Biodiversity Boards; TRIPS Agreement, PVPFRA, Plant Breeder's rights, Farmer's rights, Tribunal rights, Traditional Resource rights, Variety registration.

Unit III: Conservation Strategies

In situ conservation sites: Protected areas - Biosphere Reserves, National Parks, Wildlife Sanctuaries; Reserve Forests; Community conserved areas - Sacred groves and community forests; *In situ* conservation of aquatic ecosystems: lakes, wetlands, mangroves, coral reefs, and ponds. *Ex situ* conservation sites: Botanical Gardens and Arboreta, Field gene banks, Seed banks, Zoological parks, zoos and aquaria, *In vitro* conservation; cryopreservation and cryobanks; conservation in permofrost conditions. Gene banks: IBPGR, Indian gene banks for plant, animal, fish, microbial and insect genetic resources; NBPGR, National Genetic Resource Advisory Council.

Unit IV: Molecular Characterization of bioresources

Biotechnology and its role in biodiversity conservation; Applications of molecular markers like RAPD, SSR, ISSR, SSAP and AFLP, Expressed Sequence Tags in molecular characterization of different bioresources. Proteins, isozymes and allozymes as markers, their significance in characterization; methods of isozyme and allozyme analysis. Softwares for molecular characterization and diversity analysis; Genetic and Genomic characterization of plant and animal resources for conservation and exploitation.

Unit V: Bioremediation

Introduction to environment; pollution and its control; pollution indicators; Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals, radionuclides, organic pollutants, technological aspects of bioremediation (*in situ, ex situ*). Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration phytostabilization); Bioinsecticides; Biofungicides; Plant growth promoting rhizobacteria (PGPR)

Suggested Readings:

1) David, H. (2005). Handbook of biodiversity methods: survey, evaluation and monitoring. Cambridge University Press.

2) Krishnamurthy, K. V. (2003). *Textbook of biodiversity*. Science Publishers.

3) Singh, M. P., Singh, B., & Dey, S. (2004). *Conservation of biodiversity and natural resources*. Daya Books.

4) Dey, S. (2004). *Bioresources and Genepool Conservation*. Daya Books.

BT-543	**Journal Paper Presentation**	**4CH**
BT-544	**Project Dissertation and Grand Viva**	**12CH**