COURSES OF STUDIES
M. Tech. Biotechnology (Self Financing)
(2018-2020)

DEPARTMENT OF BIOTECHNOLOGY AND BIOINFORMATICS
SAMBALPUR UNIVERSITY
JYOTI VIHAR-768 019, SAMBALPUR, ODISHA

OUTLINE OF COURSE STRUCTURE

COURSE	COURSE TITLE	CREDIT HOURS	MARKS
FIRST SEMESTER			
MBT -111	INSTRUMENTATION TECHNIQUES	4 CH	100
MBT -112	IMMUNOTECHNOLOGY	4 CH	100
MBT -113	MEDICAL MICROBIOLOGY	4 CH	100
MBT -114	BIOPROCESS TECHNOLOGY	4 CH	100
MBT -115	PRACTCAL RELATED TO IMMUNO-TECHNOLOGY AND MEDICAL MICROBIOLOGY	3 CH	50
MBT -116	PRACTICALS RELATED TO INSTRUMENTATION AND TECHNIQUES	3 CH	50
SECOND SEMESTER			
MBT -121	CELL AND TISSUE CULTURE TECHNIQUES	4 CH	100
MBT -122	INDUSTRIAL MICROBIOLOGY	4 CH	100
MBT -123	COMPUTATIONAL BIOLOGY	4 CH	100
MBT -124	RATIONAL DRUG DESIGN AND EVALUATION	4 CH	100
MBT -125	PRACTICALS RELATED TO CELL AND TISSUE CULTURE TECHNIQUES	3 CH	50
MBT -126	PRACTICALS RELATED TO COMPUTATIONAL BIOLOGY AND DRUG DESIGN	3 CH	50
THIRD SEMESTER			
MBT -231	RESEARCH METHODOLOGY	4 CH	100
MBT -232	PLANT GENOME MAPPING AND GENOMICS	4 CH	100
MBT -233	GENOMICS PROTEOMICS AND METABOLOMICS	4 CH	100
MBT -234	PHARMACEUTICAL BIOTECHNOLOGY	4 CH	100
MBT -235	PRACTICALS RELATED TO PHARMACEUTICAL BIOTECHNOLOGY	3 CH	50
MBT -236	SEMINAR	3 CH	50
FOURTH SEMESTER			
MBT -241	IPR, BIOSAFETY AND BIOETHICS IN BIOTECHNOLOGY	4 CH	100
MBT -242	REVIEW PAPER AND PRESENTATION	(2+2) CH	(50+50)
MBT -243	PROJECT WORK	16 CH	300
	TOTAL COURSE CREDIT	**90 CH**	**2000**

FIRST SEMESTER

MBT-111	INSTRUMENTATION TECHNIQUES	4 CH	100 marks

Objective: To educate the students on principle of operation and application of various instruments used for qualitative and quantitative analysis of chemical and biological samples.

Learning outcome: After studying this subject the students can be eligible to become a application specialist or technician in operating an instrument.

Unit-I

Principle, instrumentation and applications of microscopy (light, phase contrast, fluorescence); electron microscope (TEM and SEM); AFM; FACS; principle, instrumentation and application of scintillation counter, Geiger-Muller counter; radiolabeling for the measurement of metabolic activity; autoradiography.

Unit- II

Principle, instrumentation and applications of spectrophotometer (UV-VIS, Fluorescence, IR spectroscopy); mass spectroscopy: tandem MS, MALDI-TOF. characterization of nucleic acid and protein using MALDI-TOF and MS-MS.

Unit-III

Principle, instrumentation and applications of chromatography (size exclusion, ion-exchange, affinity, GLC, HPLC and FPLC); characterization of molecular structure using circular dichorism (CD), Optical Rotary Dichorism (ORD), NMR, ESR, X-ray crystallography.

Unit-IV

Principle, instrumentation and applications of Electrophoresis (Agarose, PAGE, IEF, 2-DE, DGGE); Principle, operation and application of Polymerase chain reaction (PCR), Variants of PCR; Blotting techniques (Southern blotting, Northern blotting, Western blotting); Nucleic acid sequencing.

Suggested readings:

1. Biochemical Techniques Theory and Practice by R. White (2009)

2. A Biologist Guide to Principle and Techniques by K. Willson and K.H. Gounding (2009)

3. An Introduction to Practical Biochemistry by D.T. Plummer (2008)

4. Analytical Chemistry by G.D. Christion (2000)

5. Principle and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker, Seventh Edition

MBT-112	IMMUNOTECHNOLOGY	4 CH	100 marks

Objective: To educate the students on cells, organs and their mechanism of action in protecting our body from any pathogenic organisms or substances. In addition, the subject educates student regarding the use of immune molecules (like antibodies and cytokines) for therapeutic and diagnostic purposes.

Learning outcome: After studying this subject the students can be able to answer how immune system of our body functions and what is the effect if they are suppressed or overactive. The students can also be expert in diagnostic techniques used in research and diagnostic labs

Unit-I

Cell and organs of immune system, soluble molecules and membrane associated receptors of innate immune system, toll-like receptors, antigens and antibodies, cytokines, complement system, major histocompatibility complex and antigen presentation, B-cell receptors, T-cell receptors.

Unit-II

Pathophysiology of important diseases of immune system; current approaches to diagnosis and treatment: hypersensitivity reaction, tolerance and autoimmunity, influenza, diphthereia, tuberculosis, malaria, SARS, AIDS, cancer and immunotherapy.

Unit-III

Application of immunological assays: antigen-antibody interaction, radioimmunoassay, ELISA, ELISPOT assay, western blotting, immunoprecepitation, immuno-fluorescence, alternatives to antigen-antibody reaction, immunoelectron microscopy, surface plasmon resonance, biosensor assays for assessing ligand-receptor interaction, CMI techniques (lymphoproliferation assay, mixed lymphocyte reaction).

Unit-IV

Tools and techniques in immunology: experimental animal models, cell culture, two-photon microscopy for *in vivo* imaging, use of bioinformatics tools in immunological research. Application of immunological concepts in drug development, vaccines and diagnostics: development of antibodies, antibodies as drugs, designing vaccines for active and passive immunization.; hybridoma technology and application of Mabs. Biotechnology produced Mabs.

Suggested readings:

1. Immunology (2007) by J. Kuby
2. Kenneth Murphy (Charles A Janeway, Paul Travers, Mark Walport) 8th Edition: Immunobiology
3. Abbas AK, Lichtman AH and Pillai S (2001) Cellular and Molecular Immunology; Elsevier, USA, 7th Ed.
4. Kindt, T.J., Goldsby, R.A. and Osborne, B.A. (2007). Kuby Immunology .W.H. Freeman and Co., New York, 7th Ed.
5. Roit, I. (2012). Essential Immunology. Blackwell Scientific Publications, Oxford, 12th Ed.
6. Primrose SB, Twyman RM and Old RW (2002) Principle of gene manipulation. Wiley-Blackwell, UK, 6th Ed.

MBT-113	MEDICAL MICROBIOLOGY	4 CH	100 marks

Objective: To educate the students on host-pathogen interactions, basics of microbial infection, diagnostic techniques used for detection of microbial infection and preventive measures taken to avoid microbial infections.

Learning outcome: After studying this subject the students can be able to answer how microbes exploit different ways to survive and grow inside the host and how host tries to check microbial growth. Besides students will learn the techniques used in microbiology labs for detection of infections and way to prevent or get cure from microbial infections.

Unit-I

Microbial pathogenesis: pathogrenicity: predisposing factors, PAI (characteristics, origin, virulence factors, evolution, pai prediction, barcoding of PAI, PAI regulation). Pathogenesis of viral infections, pathogenesis of fungal infections.

Unit-II

Basics of microbial infections: nosocomial infections (types of HAI, sources and reservoirs of HAI, microorganisms causing nosocomial infections), bacterial infections (MRSA, VRE, ESBL producing bacilli, carbapenem resistant enterobacteriaceae, CPE), viral infectious diseases (SARS, Avian influenza, H1N1 influenza), fungal infections (dermatomycoses: *Trichophyton* sp. *Epidermophyton* sp.), systemic infections (Coccidiodomycetes, Candidiasis, Cryptococcosis), opportunistic fungal infections.

Unit-III

Microbial diagnostics: bacteriology: staining procedures in clinical microbiology, typing methods: biotyping, antibiogram typing, bacteriocin typing, biofilm typing, bacteriophage typing, phage typing. nucleic acid based typing: PCR typings, ribotyping, plasmid profile based typing, optical map typing, WGS typing.
Mycology: signs and symptoms of fungal infection, culture methods: specimen collection, direct microscopy, culture of filamentous and yeast like fungi, laboratory diagnostic tools, non culture methods: PCR based identification of DNA from body fluids, detection of glucan in blood, galactomannan Ag testing.
Virology: sampling, cell culture, seropyting, diagnostics, assays, cytopathic effect test, genome sequencing, isolation and identification of structural and non-structural proteins.

Unit-IV

Prevention and control of diseases: principles and measures taken for infectious diseases, Biotechnologically produced vaccines, Mabs, antibiotics, anti-metabolites, genome knock out programmes using CRISPER/Cas 9.

Suggested readings:

1. Microbiology (2^{nd} Edn) by Talaro (2005)
2. Biology of Microorganism (9^{th} Edn) by Broak (2005)
3. Principal of Microbiology by Atlas (2009)
4. Microbiology (6^{th} Edn) by Fred Alcamo (2006)
5. General Microbiology by Stanier (2006)
6. Microbiology by Pelczar & Krieg (2009)

MBT-114	BIOPROCESS ENGINEERING & TECHNOLOGY	4 CH	100 marks

Objective: To educate pupils on tools and techniques used in growing microbes and monitoring their growth for producing useful products in industrial scale through various downstream processes.

Learning outcome: The students become aware about principle and instrumentation of methods and instruments used in the industries for commercial production. They also become eligible to join food and pharmaceutical industries.

Unit-I

Design and operation of conventional fermenter (probes, sterilization, agitation, aeration, heat and mass transfer, control parameters). Submerged vs solid substrate fermentation. Bioreactor design and application: batch, fed-batch, CSTR, tubular flow, plug flow, fluidized bed, membrane reactor), fermentation economics.

Unit-II

Cell kinetics: models of microbial growth; Substrate inhibition kinetics, product inhibition kinetics, ideal and non-ideal reactors; residence time distribution in bioreactor (E-curve, C-curve and F-curve), determination of average conversion in Batch reactor and CSTR. scaling up operation in bioreactor and its advantages.

Unit-III

Enzyme kinetics: michaelis-menten equation, briggs and haldane quasi steady-state approximation, enzyme inhibition (competitive, non-competitive, uncompetitive) and inhibitory kinetics, turnover number and kcat. Bi-substrate reaction kinetics, ordered and random kinetics, ping-pong catalysis (Delziel's form) and mathematical modeling.

Unit-IV

Downstream processing. Enzyme immobilization- types and methods; application of enzyme immobilization in bioreactors. Biosensors: enzyme biosensors, bio-electrodes, optrodes and immunochemical sensors.

Bioreactor design for animal cell culture (integrated suspension culture, immobilized cell cultivation); strategies of maximizing the productivity of amino acid and SCP production (case study).

Suggested readings:

1. Bioprocess Engineering Principles-Pauline M. Doran
2. Bioprocess Engineering-Basic Concepts-M.L Shuler & F. Kargi
3. Fermentation Microbiology and Biotechnology-El-Mansi and Bryce
4. Biotechnology- A text book of Industrial Biotechnology- Crueger & Cruger

MBT-115	PRACTCAL RELATED TO IMMUNO-TECHNOLOGY AND MEDICAL MICROBIOLOGY	3 CH	50 marks

MBT-116	PRACTICALS RELATED TO INSTRUMENTATION AND TECHNIQUES	3 CH	50 marks

SECOND SEMESTER

MBT-121	CELL AND TISSUE CULTURE TECHNIQUES	4 CH	100 marks

Objective: To educate pupils regarding materials and methods used for growing plant tissues and animal cells inside laboratory and use them for conservation, pharmaceutical product formation or for direct use in medicinal purpose.

Learning outcome: After studying the paper students can be able to grow exotic endangered plants in lab and can be able to culture and use animal cells.

Unit-I

Plant tissue culture concepts and methods: concept of totipotency and plasticity, tissue culture media and its composition, plant growth regulators; initiation and establishment of culture: explant preparation, callus culture, single cell culture, suspension culture, microspore culture, embryo rescue; micropropagation: organogenesis, somatic embryogenesis, artificial seed; protoplast technology: isolation and culture of protoplast, somatic hybridization, screening and selection of somatic hybrid.

Unit-II

Animal cell culture: equipments and safety parameters, aseptic techniques, cell culture reagents, media (defined and undefined media, complete-incomplete media), culture condition, maintenance of cell culture: culturing, sub-culturing, primary and continuous culture; in vitro transformation of animal cells; anchorage-dependent, monolayer and suspension culture; cryopreservation and cell revival; cell line banking; contamination check and prevention; biological characterization of cultured cell; measuring parameter of growth; cytotoxicity assay; cell viability measurement.

Unit-III

Induction of superovulation, embryo collection and evaluation, embryo splitting, embryo sexing, embryo transfer, advantages of embryo transfer in farm animals, in vitro fertilization, embryo cloning, nuclear transplantation, production of transgenic animals and gene farming, identification and transfer of gene influencing production and disease resistance.

Manipulation of plant product quality and quantity: photosynthesis, nitrogen fixation, solute uptake, nutritional quality; manipulation of reproductive biology and development: pollen production, pollen-stigma interactions, seed development, seed germination and mobilization of food reserves; phytochrome; regulation of flower development.

Unit-IV

Embryonic stem cells and adult stem cell; differences between stem cells and differentiated cells; isolation and culture of stem cells; use of embryonic stem cells and adult stem cells for health care; tissue engineering; three-dimensional culture: multi-cellular tumour spheroids mcts)- mono and co-cultures, re-aggregate organ cultures; drug testing in-vitro.

Suggested readings:

1. Michael Butler, "Animal Cell Culture and Technology", BIOS Scientific Publishers
2. John R.W. Masters, " Animal Cell Culture-A Practical Approach", Oxford University Press
3. R. Ian Freshney, "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications".
4. Introduction to Plant biotechnology H S Chawala
5. Plant tissue culture: theory and Practice S.S.Bhojwani and M K Razadan
6. Plant tissue culture S.S.Bhojwani and M K Razadan
7. Elements of Biotechnology P K Gupta
8. Plant cell and tissue culture Narayan Swamy Immunobiology
9. Abbas AK, Lichtman AH and Pillai S (2001) Cellular and Molecular Immunology; Elsevier, USA, 7th Ed.

MBT-122	INDUSTRIAL MICROBIOLOGY	4 CH	100 marks

Objective: To educate the students regarding taming of microbes for commercial production of drugs and important daily needed chemicals and how to make our food safe from the unwanted microbial growth.

Learning outcome: After studying this subject the students can be eligible to utilize microbes for human welfare and also be aware of techniques to safeguard the quality of human-consumed food material.

Unit-I

Introduction to industrial biotechnology: history and scope, commercial strain development-induced mutation, over producing decontrolled mutants, genetically engineered strain; industrial production of enzymes, fuels and industrial chemicals (alkanes, butanol, ethanol, electricity, amino acids, organic acids, exo-polysaccharides). Antibiotic, alkaloids, steroids, therapeutic peptides and proteins.

Unit-II

Fermentation technology, microbial technology for alcoholic beverages production (beer, wine & cider), vinegar production, dairy fermentation (butter & cheese), single cell protein and microbial leaching of metals, industrial biotechnology in chemical, pharmaceutical, food and allied sectors.

Unit-III

Principle of food preservation, method of food preservation (thermal processing, cold preservation, pascalisation, irradiation, chemical and natural food preservatives). Operational units in food industry, preservation by fermentation. Food safety and standards (adulteration, contamination, food laws, HACCP: a state of art for food safety, ISO 9000 series and other standards).

Unit-IV

Secondary Metabolic products produced by in vitro culturing of plant cells, selection of plant cells/tissues for the production of a specific product, Molecular Pharming. Culture system in secondary plant product biosynthesis, batch / continuous culture and immobilized plant cells.
Biotransformation of precursors by cell culturing. Extraction and analytical methods for the metabolites. Industries involved in the production of plant secondary metabolites, Potential and future prospect of the secondary metabolities production by plant cells culture techniques.

Suggested readings:

1. Bioprocess Engineering Principles, Pauline M. Doran, 2nd Ed., Academic Press (2012), ISBN-13: 9780122208515.
2. Bioprocess Engineering-Basic Concepts, Michael L Shuler, Fikret Kargi, Pearson Education Limited (2015). ISBN-13: 9789332549371.
3. Fermentation Microbiology and Biotechnology, C F A Bryce, E M T El Mansi, 2nd Ed., anebooks - T & F / Routledge (2006), ISBN-13: 9780849353345.
4. Biotechnology- A text book of Industrial Biotechnology, Wulf Crueger, Anneliese Crueger, Kr Aneja, Medtec (2017). ISBN-13: 9789385998638.

MBT-123	COMPUTATIONAL BIOLOGY	4 CH	100 marks

Objective: To provide training to the students on using computational tools for in silico analysis of bioactive compounds

Learning outcome: After studying this subject the students can be eligible to address problems regarding acquiring, storing, retrieving and analysis of bio-information.

Unit-I

Sequence databases and their uses; dynamic programming methods; database searching - Heuristic methods, Markov chain and Hidden Markov model. pairwise alignment using HMM; multiple sequence alignment methods; genome annotation - gene finding algorithms.

Unit-II

Basic concept of molecular evolution and phylogeny; ultrametric trees and distances, data preparation; phylogenetic inference algorithms: distance-based methods, character-based methods; assessment of tree reliability; software packages.

Unit-III

Building molecules: basic chemistry, steric and other constrains, analysis of PDB structure; structure and topology: protein structure, prediction of protein structure, fold, topology (algorithm and implementation). DNA structure and topology; interactions: force fields (classical & quantum), electrostatics, surface area; mapping of binding sites and interaction with small molecules; energy minimization, molecular simulation; molecular dynamics, Monte Carlo simulation (algorithm and implementation).

Unit-IV

Introduction to systems biology; classification of enzymes and metabolic pathways, genetic and biochemical networks: deterministic and stochastic descriptions, pathway databases, pathway inference, visualization tools (DAVID), pathway miner and similar software. Applications in chemical kinetics and metabolic pathway analysis. software packages: SBML, and open source programs eCell, virtual cell, StochSim, BioNets.

Suggested readings:

1. Bioinformatics: D.W. Mount

2. Introduction to Bioinformatics by Arthur Lesk

3. Bioinformatics Methods and applications by Mendiratta and Rastogi

4. BLAST, Ian Korf, Mark & Josaph; O'Reily Pub

5. Bioinformatics and Functional Genomics; J. Pevsner

MBT-124	RATIONAL DRUG DESIGN AND EVALUATION	4 CH	100 marks

Objective: To impart knowledge to students on drug discovery cycle, use of bioinformatic tools for prediction, structure determination and analysis of new drugs, clinical trials and toxicological evaluation of new drug candidates.

Learning outcome: After studying this subject the students can be eligible to pharmaceutical industries where researches on new drug discovery are carried out.

Unit-I

Drug discovery cycle, rational drug design techniques and types, 2D structures (atom lookup and connection tables; SMILES; SD files), 3D structures (pdb file format), conformational flexibility, structure minimization, 2D and 3D molecular descriptors, QSAR in drug design: QSAR methodology, QSAR applications in drug design, QSAR model selection and validation, pharmacophore and drug discovery, Lupinski rule of five, structure based drug design and virtual screening (CombiChem library development, molecular docking, MM-GBSA, MM-PBSA, LIE-SGB).

Unit-II

High-throughput chemistry: mix and split synthesis, solid-phase synthesis, solution-phase synthesis, combinatorial biosynthesis, library design, high-throughput screening of synthetic library, ADME/Tox of drug, toxicological evaluation of drug (OECD guideline, types of toxicity evaluation), *In vitro* assay and *in vivo* assay (case study).

Unit-III

Clinical trials of drug: pre-clinical vs clinical trials, objectives and principles, phases of clinical trial: Phase I (assess safety), Phase II (test for effectiveness), Phase III (large-scale testing), study design and trial consideration - study population, classifications of epidemiological research, randomization process, blinding, sample size, recruitment, ethics in clinical research, quality control in clinical trials, clinical trial registries, participant adherence, survival analysis, multicentric trials.

Unit-IV

Toxicology of drugs: pharmacokinetic and pharmacodyanamic drug-drug interactions, receptors involved in toxicology of drug **(**dopamine receptor, serotonergic receptor, GABA receptor, opioid receptor); metabolism of toxicants: phase-i reactions, phase-ii reactions, human cytochrome p450 isozymes and selected substrates, hepatotoxicity, nephrotoxicity, neurotoxicity, immunotoxicity, drug dependent and drug abuse.

Suggested readings:

1. Bioinformatics: D.W. Mount
2. Introduction to Bioinformatics by Arthur Lesk
3. Bioinformatics Methods and applications by Mendiratta and Rastogi
4. BLAST, Ian Korf, Mark & Josaph; O'Reily Pub
5. Bioinformatics and Functional Genomics; J. Pevsner
1. Robbins Pathological Basis of disease – 8th Edition
2. General Pathology by J.R.Walter and Israel – 7th edition
3. Andersons Pathology - LINDER – 10th Edition
4. Systemic Pathology . W St C Symmers

MBT-125	**PRACTICALS RELATED TO CELL AND TISSUE CULTURE TECHNIQUES**	**3 CH**	**50 marks**

MBT-126	**PRACTICALS RELATED TO COMPUTATIONAL BIOLOGY AND DRUG DESIGN**	**3 CH**	**50 marks**

THIRD SEMESTER

MBT-231	RESEARCH METHODOLOGY	4 CH	100 marks

Objective: To impart knowledge to students on meaning, objective, criteria of research. Students also learn how to define research problems, design experiments and way of acquiring, analyzing and representing biological data in statistically valid manner and testing their statistical significance.

Learning outcome: After studying this subject the students can be eligible not only to define research problems but also to design experiment and analyze statistical significance and represent the biological data in statistical manner.

Unit-I

Introduction to research methodology: meaning of research, objectives of research, research and scientific methods, research process, criteria of research, defining research problems, research design, basic principles of experimental design, developing research plan, sample design and its types, characteristics of sampling procedure.

Unit II

Methods of data collection, processing and analysis; frequency distribution, diagrammatic representation, probability distribution, binomial distribution, poisson distribution, distribution of data: normal, skewness and kurtosis; measure of central tendency (arithmetic mean, median, mode, geometrical and harmonic mean), measure of dispersion (range, mean deviation, variance, standard deviation, coefficient of variation), normal distribution: its importance and properties, tabulating areas under standard normal distribution, central limit theorem, skewness and kurtosis.

Unit- III

Tests of hypothesis**:** one-tailed versus two-tailed tests, p-value, type-i and type-ii errors, hypothesis tests, student t-test, paired t-test; categorical data and chi-square test: chi-square distribution and table, 2x2 contingency table, goodness of fit test; correlation and linear regression: relationships between two variables, uses of correlation and regression, scatter diagram, pearson's correlation coefficient, regression analysis, multiple regression; analysis of variance: one-way analysis of variance, two-analysis of variance, F distribution and application, non-parametric methods: advantages and disadvantages, Wilcoxon rank-sum test, Wilcoxon signed-rank test.

Unit- IV

Basics of computer: hardware and software, generation of computers, information storage devices, ROM and RAM, methods of computing (workstation, server, grid computing, parallel computing, cloud computing), application of computer softwares in biostatistics and data management.

Suggested readings:

1. Introductory Biostatistics for the Health Sciences, Michael R. Chernick and Robert H. Frills, Wiley-Interscience Publications
2. Pal Nabendu, Sarkar Sahadeb. Statistics: Concepts and Applications. PHI Learning Pvt. Ltd., 2005. ISBN: 8120326792.
3. Gentle, James E., Härdle, Wolfgang K. Mori, Yuichi (Eds.). Handbook of Computational Statistics Concepts and Methods. Springer 2004. ISBN:354040464.
4. Murray R. Spiegel, Larry J. Stephens Schaum's Outline of Statistics 3rd edition, McGraw-Hill New Delhi 3rd edition 2000. ISBN:0070435103.
5. Schaum's Outline of Introduction to Probability and Statistics. McGraw-Hill, 1999.

MBT-232	PLANT GENOME MAPPING AND GENOMICS	4 CH	100 marks

Objective: The objective of the course is to familiarize the students with the basic concepts in Genetic Engineering. The detailed biology of different Cloning Vehicles, methodologies in construction of genomic libraries; strategies used in gene cloning; DNA transfer in bacteria, plant, mammalian cell, fungal cell, etc. Analysis and expression of the cloned genes in host cell. Practical applications of rDNA and to familiarize with the Ethical issues and Biosafety regulations related to genetic engineering.

Learning outcome: At the end of the course the student will have thorough understanding of the techniques and applications of recombinant DNA technology from a academic and industrial perspective. The students should be capable of pursuing a career in an industry such as in a pharmaceutical industry, diagnostics company, Agricultural Biotechnology, etc.

Unit-I

Molecular markers: concept of molecular markers; molecular markers (RFLP, RAPD, AFLP, SSR, SCAR, STS, EST, SNP) and their development for molecular dissection of plant genome. concept of minimal cell genome, molecular marker based inference.

Unit-II

Genome mapping: molecular mapping of plant genome- mapping population, constructing molecular maps; molecular tagging and mapping of oligogenes and QTL; marker assisted selection of qualitative and quantitative traits; physical mapping of gene; map based cloning of gene and QTL; association mapping; comparative mapping and synteny map.

Unit-III

Plant genome sequencing and structural genomics: rationale of genome sequencing, genome sequencing: principles, methodology and strategies; genome sequencing projects in plants; curation draft sequence of genome; Recognition of coding and non-coding sequences and gene annotation; Tools of gene cataloguing and gene structure prediction; High throughput cloning of ORFs.

Unit-IV

Functional genomics: identification of candidate genes using positional cloning, microarray analysis, transcriptome analysis (EST, SAGE), proteome comparison and metabolome profiling; characterization and functional analysis of genes: TILLING, reverse genetics, gene knockout system and heterologous expression system.

Suggested readings:

1. Principles of Gene Manipulation by S.B. Primrose, RM Twyman and RW Old (6^{th} Edition)
2. From Genes to Genomes: Concepts and Applications of DNA Technology by JW Dale and M Schantz
3. Biotechnology by BD Singh
4. Biotechnology by PK Gupta
5. Recombinant DNA: A Short Course by JD Watson, J. Tooze and DT Kurtz
6. Plant Biotechnology- Adrian Slater, Nigel W. Scott and Mark R. Fowler (Text Book)
7. Biotechnology- Expanding Horizons by B.D. Singh
8. Introduction to Plant Biotechnology by H S Chawla
9. Elements of Biotechnology by P K Gupta

MBT-233	GENOMICS AND PROTEOMICS	4 CH	100 marks

Objective: The course is intended to provide thorough understanding modern technologies of the genomics pertaining to whole genome sequencing, genome mining, comparative genomics, global gene function technologies, protein structure & function technologies at the genome level, etc.

Learning outcome: Students will have a thorough understanding of various genomic technologies such as whole genome mapping & sequencing, genome annotation, global gene cloning and gene expression technologies, comparative genomics, Concept of haplotyping, introduction to pharmacogenomics, proteomics, etc. The students will know the vast amount of genome information in publicaly available databases and how to access and best utilize for practical purposes.

Unit-I

Genome sequencing techniques (sanger and pyrosequencing methods), NGS sequencing techniques (Roche/454 FLX, illumina genome analyzer, SOLiD™ sequencing, Ion Torrent™, Nanopore), NGS data quality control methods, NGS data structure, resources and repositories, genome assembly and annotation, gene prediction methods, comparative genomics, trascriptome preparation and annotation, transcriptome abundancy calculation and pathway mapping.

Unit-II

Global gene cloning expression platforms & technologies (microarrays, affymatrix, cDNA-AFLP), image segmentation, normalization techniques and expression analysis, RT-PCR, pharmacogenomics: concepts and applications in healthcare, SNP technologies: platforms and analysis; haplotyping: concepts and applications, gene function technologies (gene targeting, gene silencing (RNAi)).

Unit-III

Proteomics: protein sequencing ; protein-protein interactions; protein arrays, global analysis of protein modifications, protein structure determination (X-ray, NMR), protein structure prediction (homology, threading and *ab initio*), prediction of protein function, protein biomarkers: identification and utilization.

Unit-IV

Molecular phylogeny (phylogenetic tree and terminology, methods of phylogenetic tree prediction: maximum parsimony, distance (UPGMA, NJ), maximum likelihood methods, bootstrapping), EST sequence and mining of simple repeats, types of DNA bands, scoring and distance matrix, population genetic analysis, Analysis of molecular variance, DNA barcoding techniques, Mt DNA & cpDNA and their uses in phylogenetic analysis.

Suggested readings:

1. Introduction to Genomics by Arthur M. Lesk
2. Genomes-3 by T.A. Brown
3. Functional Genomics by
4. Introduction to Proteomics : Daniel C. Liebler and John R. Yates from "Humana Press" (2002)
5. Proteome Research : New Frontiers in Functional Genomics (Principles and Practice) by M. R. Wilkins (Editor) 1997

MBT-234	PHARMACEUTICAL BIOTECHNOLOGY	4 CH	100 marks

Objective: This job oriented elective subject is designed for students who are interested to know techniques used in testing and validating drug formulations. It educates the students regarding step wise development of drug formulations, regulations for new drugs, different dosage forms, drug delivery systems, pharmacodyanamics of drugs.

Learning outcome: After studying this subject the students can be eligible to join research organization or pharmaceutical company involved in new drug formulations.

Unit- I

Introduction to pharmaceutical industry & development of drugs; economics and regulatory aspects; quality management; GMP.

Bioavailability and factor affecting bioavailability; drug kinetics and biopharmaceutics mechanism of drug absorption, distribution, biotransformation and excretion; factors affecting the ADME process; bioequivalence; pharmacokinetics.

Unit- II

Principles of drug manufacture; liquid dosage forms (solutions, suspensions and emulsions); topical applications (ointments, creams, suppositories); solid dosage forms (powders, granules, capsules, tablets, coating of tablets); aerosols; preservation; packing techniques. Advanced drug delivery systems; sustained release drug delivery system and controlled release; transdermals, liposomes; drug targeting.

Unit-III

Biopharmaceuticals understanding principles of pharmacology, pharmacodynamics; study of a few classes of therapeutics like recombinant therapeutics, monoclonal antibodies, vaccines, gene therapy, antibiotics and hormones.

Unit-IV

Immunogenicity of biopharmaceuticals: immunogenicity; factors contributing to immunogenicity (product related factors, host- related factors), consequence of immunogenicity to biopharmaceuticals; measurement of immunogenicity. Case studies: insulin, somatotropin, interleukin-2, interferon, Factor VIIa, Factor IX, Factor VIII, monoclonal antibodies etc.

Suggested readings:

1. Textbok of Pharmaceutical Biotechnology, 1st Edition by Elsevier publications
2. Pharmaceutical Biotechnology: Fundamentals and Applications, Third Edition by Daan J. A. Crommelin, Robert D. Sindelar, Bernd Meibohm
3. Handbook of Pharmaceutical Biotechnology by Shayne Cox Gad
4. Biopharmaceuticals: Biochemistry and Biotechnology, Second Edition by Gary Walsh
5. Pharmaceutical Biotechnlogy: Concepts and Applications by Dr. Gary Walsh
6. Handbook of Pharmaceutical Biotechnology by Jay P Rho, Stan G Louie

MBT-235	PRACTICALS RELATED TO PHARMACEUTICAL BIOTECHNOLOGY, GENOMICS AND PROTEOMICS	3 CH	50 marks

MBT-236	SEMINAR	3 CH	50 marks

FOURTH SEMESTER

MBT-241	**IPR, BIOSAFETY AND BIOETHICS IN BIOTECHNOLOGY**	**4 CH**	**100 marks**

Objective: To educate the students on rules and regulations for producing, expanding, storing and selling genetically modified organisms or products in addition to ethical practices in genetic modification and gene identification. Besides the subject teaches how to handle biological samples safely without getting any infection or spreading the infection.

Learning outcome: After studying this subject the students can be eligible to maintain ethics and follow rules and regulations while working on genetic discrimination and manipulation in plants and animals and can handle biological samples safely.

Unit I

Intellectual property rights and its types-patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; process patent vs product patent; IPs of relevance to biotechnology and few case studies; introduction to GATT, WTO, WIPO and TRIPS.

Unit II

Basic requirement of a patentable invention, prior art and state of art; patent databases; Indian Patent Act 1970 and recent amendments; patent database; procedure for filing a patent, international patenting-requirement, patent infringement- meaning, scope, litigation, remedies; case studies and examples- Rice, Neem *etc*.

Unit-III

Introduction to biosafety regulations; primary containment for biohazards and biosafety levels; biosafety guidelines - government of india. definition of GMOs & LMOs; roles of institutional biosafety committee, RCGM, GEAC.

Unit-IV

Bioethics, public concerns on human genome research and transgenics- genetic testing and screening, ethics in clinical trials and GCP, ELSI & human genome project; ethics in human cloning (case study).

Suggested readings:

1. Biotechnology and Intellectual Property Rights, by Kshitij Kumar Singh
2. Intellectual Property and Biotechnology : Biological Inventions by Matthew Rimmer
3. Synthetic Biology and Intellectual Property Rights by Rajendra K. Bera
4. Intellectual Property Rights and the Life Science Industries: Past, Present and Future by Graham Dutfield
5. Bioethics and Biosafety by M. K. Sateesh
6. Biosafety and Bioethics by Rajmohan Josi
7. IPR, Biosafety and Bioethics by Deepa Goel, Shomini Parshar

MBT-242	**REVIEW PAPER AND PRESENTATION**	**2+2 CH**	**100 marks**

MBT-243	**PROJECT WORK**	**16 CH**	**300 marks**

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