COURSES OF STUDY
M.Sc (Biotechnology): Session (2017-2019)

DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS
SAMBALPUR UNIVERSITY, JYOTI VIHAR
BURLA- 768019, ODISHA

OUTLINE OF COURSE STRUCTURE

M.Sc. BIOTECHNOLOGY (Session: 2017-19)

SEMESTER-I

Course Code	Course Name	Credits hours	Marks
BT-411	(A) Physical Sciences (B) Fundamental Biology	3	50
BT-412	Chemistry of Biomolecules	3	50
BT-413	Genetics	3	50
BT-414	Microbiology	3	50
BT-415	Molecular Biology- I	3	50
BT-416	Instrumentation and Techniques	3	50
BT-417	Practical (Genetics and Microbiology)	2	50
BT-418	Practical (Biochemistry)	2	50

NON CREDIT COURSE: Communication Skills

SEMESTER-II

Course Code	Course Name	Credit hours	Marks
BT-421	Probability and Biostatistics	3	50
BT-422	Bioenergetics and Metabolism	3	50
BT-423	Immunology	3	50
BT-424	Molecular Biology- II	3	50
BT-425	Cell and Developmental Biology	3	50
BT-426	Industrial Biotechnology	3	50
BT-427	Practical (Immunology & Molecular Biology)	2	50
BT-428	Practical (Cell Biology & Industrial Biotechnology)	2	50

NON CREDIT COURSE: Personal Development

SEMESTER-III

Course Code	Course Name	Credit hours	Marks
BT-531	Recombinant DNA Technology	3	50
BT-532	Bioinformatics	3	50
BT-533	Bioprocess Engineering & Technology	3	50
BT-534	Cell Culture Techniques	3	50
BT-535 (A/B)	(A) Plant Biotechnology (B) Animal Biotechnology	3	50
BT-536 Elective Paper (Any one)	(A) Agricultural Biotechnology (B) Clinical Pathology & Diagnostics (C) Environmental Biotechnology (D) Pharmaceutical Biotechnology	3	50
BT-537	Practical (Cell Culture & Recombinant DNA Tech.)	2	50
BT-538	Practical (Bioinformatics)	2	50

IV SEMESTER

Course Code	Course Name	Credit hours	Marks
BT-541	Genomics, Proteomics and Metabolomics	3	50
BT-542	IPRs, Biosafety and Bioethics	3	50
BT-543	Seminar	3	50
BT-544	Project work and Viva Voce	(12+3)	250
Total Course Credit		**90 CH**	**1600**

FIRST SEMESTER

BT-411(A)	PHYSICAL SCIENCES	3 CH	50 marks

Unit-I

Basic Mathematics: Logarithms, exponential series, factorials, graphs, Coordinate geometry – straight line and non-linear relationships. Differentiation– Rates and limits, Differential coefficients, Differentiation of a function. Integration – Basic concepts of integration, integration by substitution, integration by parts. Matrix algebra – linear transformation between vector spaces, Representation of linear transformation by matrices, Algebra of matrices, Eigen values and Eigen vectors of linear transformation.

Unit-II

Basic Physics and Computer Fundamentals: Surface tension, Viscosity, Photoelectric effect, Basic characteristics of electricity and magnetism, charge, current, voltage, resistance, capacitor, electric field and impedence diodes, Photoresistors, Semiconductors, transistors, Integrated circuits and chips.

Computers: types, basic organization of computers, computer languages, software and hardware, operating systems, bit, byte, word, computer memory – types, data processing and storage.

Unit-III

Basic Chemistry: Atomic structure – waves and wave functions, quantum numbers, Atomic orbitals, electronic configuration of atoms and periodic properties of elements, ionic radii's, ionization potential, electronic configuration of molecules. Bond lengths, Bond angles, bond order and bond energies, types of chemical bond (weak and strong), intermolecular forces, structure of simple ionic and covalent bonds, carboxylic acids, aldehydes and ketones, amines (overview).

BT-411(B)	FOUNDATION BIOLOGY	3 CH	50 marks

Unit I

Chemistry of Living Organisms: Biomolecules, Origin of Life, Cell- unit of living organisms and multicellular organisms, Structure of animal, plant and bacterial cell, Sub-cellular organelles (Cytoskeleton, Mitochondria, Golgi complex, Endoplasmic reticulum, Chloroplast, Ribosome, Lysosome, nucleus).

Unit II

Classification and nomenclature of living organisms (plant and animal): Survey of microbial world, Diversity in animal and plant kingdom, Phylogeny, Organic evolution, Evidences in support of evolution (morphological, embryological, taxonomy, genetic, biochemical and molecular), Origin of species and Speciation; Environmental and anthopogenic impact on living organisms.

Unit III

Genetics- Science of heredity: Chromosome number and structure, Cell division- meiosis and Mitosis, Mendelian principle of heredity; Monohydrid and Dihybrid cross (Examples); Physiological basis of life (Locomotion, Respiration, Digestion, Circulation, Excretion); Reproduction in plants and animals; Hormonal regulation of physiological processes.

BT-412	CHEMISTRY OF BIOMOLECULES	3 CH	50 marks

Unit I

Biomolecules: carbohydrates (monosaccharides, configurations and conformations of monosachharides, formations of polysaccharides and structural diversity), Lipids (types of fatty acids and lipids), Spingolipids, Conjugated and Complex lipids; DNA structures: Nucleotides and nucleosides, DNA double helix, DNA structure (Z-DNA, B-DNA, A-DNA), Triple Helix DNA, Tetraplex DNA, DNA binding proteins, Sequence specific Protein – DNA interactions, RNA secondary and tertiary structure.

Unit II

Protein structure: chemical building blocks, Hierarchical organization of protein structure (Primary, Secondary Super-secondary, Tertiary, Quaternary), Peptide bond, phi, psi and chi torsion angles, Ramachandran map, Protein folding, Protein motifs, and domains; Protein function. Protein structure determination; Purification of proteins, Crystallization of proteins, X-ray crystallography, NMR and its limitations, Detection of errors in low resolution X-ray crystal structure.

Unit III

Engineering & design of protein structure, Homologous protein, Protein sequencing, Site-directed mutagenisis, Protein flexibility and stability, Engineering of protein structure and applications (case studies). Membrane proteins and its function, Metalloproteins, Carbohydrate binding proteins, Metalloenzymes: structure and function.

BT-413	GENETICS	3 CH	50 marks

Unit-I

Mendelian principle: Dominance, Segregation and Independent assortment; Extensions of Mendelian principle: Co-dominance, Incomplete dominance, gene interactions, plieotropy, genomic imprinting, penetrance and expressivity, phenocopy; Linkage and Crossing over; Sex linkage, Sex limited and sex influenced characters; Sex determination in plants and animals; Extra chromosomal inheritance; Inheritance of mitochondrial and chloroplast genes, Maternal inheritance.

Unit-II

Concept of gene: allele, multiple alleles, pseudoallele, complementation tests; Gene mapping (Linkage maps, Tetrad analysis, Pedigree analysis, lod score for linkage testing), Mapping with molecular markers (RAPD, RFLP, ISSR), Development of mapping population in plants; Quantitative genetics (Polygenic inheritance, heritability and its measurements, QTL analysis).

Unit-III

Mutation: types, causes and detection; Mutant types – lethal, conditional, biochemical, loss of function, gain of function; Germinal verses somatic mutants, Insertional mutagenesis; Structural and numerical alterations in chromosomes (deletion, duplication, inversion, translocation, ploidy and their genetic implications); Population Genetics: Gene pool, Gene frequency, Hardy Weinberg genetic equilibrium; Gene flow and Genetic drift.

BT-414	MICROBIOLOGY	3 CH	50 marks

Unit-I

An overview of the microbial world (Bacteria, Archea, Eukaryote). Classification of Archea and Eubacteria as per Bergey's manual; Microbial phylogeny. Structural organization of prokaryotic cell (bacterial wall, capsule, flagella, pilli, pronucleus, ribosomes, plasmid).

Unit-II

Bacterial nutrition and nutritional category, Bacterial culture: Synchronomous and asynchronous culture, continuous culture and chemostat. Bacterial growth kinetics, Mathematical expression of growth, generation time, specific growth rate.
Bacterial metabolism: Glucose dissimilation pathways, Bacterial respiration with organic and inorganic reluctant, Chemolithotrophy. General principle of bacterial conjugation, transduction and transformation. Bacterial pathogenecity and anti-microbial compounds.

Unit-III

Virus**:** General properties, structure, purification, cultivation; Principle of viral taxonomy. Bacteriophage: structure, classification, one-step growth experiment. Production of DNA phage, RNA phage, Temperate phage, Lytic and Lysogenic cycle. Animal virus and its reproduction, Viral infection (Presistent, Latent and Slow virus infection). Plant virus and their transmission. Anti-viral agents; M-13, Lambda, HIV, Influenza virus, Viriods and Prions.

BT-415	MOLECULAR BIOLOGY- I	3 CH	50 marks

Unit-I

Genetic organization of Prokaryotes and Eukaryotes including nuclear genome and organelle genome; DNA as the genetic material (Experimental evidences); Central dogma; C-value paradox, Cot value, Genome complexity; Repetitive DNA, Satellite DNA; Gene structure in Prokaryotes and Eukaryotes; Cistron, Recon, Muton; split genes, pseudogenes, clusters and repeats.

Unit-II

Condensation of chromosome, Lampbrush chromosome, Polytene chromosome, Supercoiling of DNA, Nucleosomes, DNA methylation, Genetic imprinting, Epigenetic inheritance, Transposable elements, types of transposable elements, Mechanism of transposition, Retroposons and its types, Mechanism of retrotransposition, Rearrangement of DNA.

Unit-III

DNA replication: Models of DNA replication, Enzymes of DNA replication, DNA replication (initiation, elongation, termination) in prokaryotes and eukaryotes, DNA replication at telomere; Replication of extranuclear genome (Mitochondrial and Chloroplast), DNA recombination (site specific and homologous); DNA repair (direct, base-excision, mis-match, SOS, recombination).

BT-416	INSTRUMENTATION & TECHNIQUES	3 CH	50 marks

Unit-I

Spectrophotometry – laws of absorption of light, Beer-Lambert's Law, absorption spectra. Instrumentation for measurement of absorption of light, Factors affecting the absorption properties of chromophores, Fluorescence and Flurometry. Centrifugation – Principles and types (Density gradient and differential centrifugation); Chromatography (Paper, Column, Affinity and Ion-exchange): Principle, instrumentation and application.

Principle and types of

Unit-II

pH metry, Bomb calorimetry, Flame photometer, Electrophoresis (Agarose, PAGE, SDS-PAGE and IEF): Principle, instrumentation and application; GLC, HPLC, Infrared spectroscopy, Atomic absorption spectroscopy, Mass spectroscopy (LC-MS, GC-MS, MALDI-TOF, Fluorescent spectroscopy, FTIR.

Unit-III

Radioactivity; Principle and application of G.M. Counter and Liquid Scintillation counter, ELISA, RIA, Microscopy (Compound, Phase contrast, Fluorescence, Confocal); Electron Microscopy (TEM, SEM), Principle and application of blotting (Southern, Northern).

BT-417	Practical (Genetics and Microbiology)	2 CH	50 marks
BT-418	Practical (Biomolecules)	2 CH	50 marks

SECOND SEMESTER

BT-421	PROBABILITY AND BIOSTATISTICS	3 CH	50 marks

Unit I

Concepts from probability: elementary sets as events and their complements, Independent and disjoint events, Probability rules, Permutations and Combinations, Probability distributions, Binomial distribution, Poisson distribution, Random variables and their properties, Continuous random variables, Conditional probability and Bayes theorem.

Unit II

Systematic organization and display of data**:** populations, samples, types of data, frequency tables and histograms; Graphical methods (histograms, box and whisker plots), Measure of central tendency (arithmetic mean, median, mode, geometrical mean), Measure of dispersion (range, mean deviation, variance and standard deviation, coefficient of variation, Normal distribution: importance and properties; Areas under standard normal distribution; Central limit theorem, Skewness and Kurtosis.

Unit III

Tests of hypothesis**:** one-tailed versus two-tailed tests, p-values, type-I and type-II errors; Student's t-test, Paired t-test, Hypothesis testing; Categorical data and Chi-square tests: understanding Chi-square, Chi-square distributions and tables, 2 x 2 contingency table, Goodness of fit tests; 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 way analysis of variance, F distribution and application, Non-parametric methods and its advantages and disadvantages, Wilcoxon rank-sum test, Wilcoxon signed-rank test. Principal component analysis.

BT-422	BIOENERGETICS AND METABOLISM	3 CH	50 marks

Unit I

Enzymes: basic concepts and kinetics, Classification of enzymes, Coenzymes and cofactors, Effect of temperature and pH on enzyme activity, Michaelis-Menten kinetics, inhibitors and activators, Enzyme inhibition (competititive, non-competitive, uncompetitive), Allosteric enzymes and regulation, Concepts of bioenergetics, Enzyme chains, Multi-enzyme complexes, Regulatory enzymes, feedback and feed forward systems, Bioenergetics and biochemical reaction.

Unit II

Metabolism and regulation of carbohydrate (Glycolysis, Gluconeogenesis, Pentose phosphate phathway and its physiological significance); Carbohydrate biosynthesis in plants, Co-ordinated regulation of glycogen synthesis and breakdown; Citric acid cycle, Regulation of citric acid cycle, Glyoxylate cycle, Fatty acid catabolism (digestion, metabolism and transport of fats), Oxidation of fatty acids, ketone bodies, lipid biosynthesis, Electron transport in mitochondria and chloroplast; Principle of oxidative and photophosphorylation.

Unit III

Amino acid oxidation and production of urea (metabolic fates of amino groups, nitrogen excretion and urea cycle, pathway of amino acid degradation), Biosynthesis of amino acids, Biosynthesis of nucleotides (purines and pyrimidines), Metabolic disorders, Inborn error due to metabolism, Hormonal regulation of metabolism.

BT-423	IMMUNOLOGY	3 CH	50 marks

Unit-I

Basics of immunity, Immunity related organs in the human body, Leucocyte in immune function, B and T cells- structure and differentiation, Antigen and antibody, Properties of antigen, haptens, antigenicity, Antigen processing and presentation, Complement activation.

Unit-II

Immunoglobulins – classification, structure and properties, Primary and secondary immune response, Genetic basis of generation of antibody diversity, Antigen-antibody interaction. T-cell receptors, Major histocompatibility complex proteins. Interleukins. Brief idea regarding immunology of Allergy, AIDS, Organ transplantation; Autoimmune diseases; Cancer types, causes and mechanisms.

Unit-III

Immunotechnology – agglutination, precipitin formation, Immunodiffusion (SRID and DRID). Immunoelectrophoresis – types and uses, Radio Immuno Assay, ELISA, Western Blotting, ELISPOT assay, Immunofluorescence, Immunoelectron microscopy; Surface plasmon resonance, Biosensor assays for assessing ligand-receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction.

BT-424	MOLECULAR BIOLOGY- II	3 CH	50 marks

Unit-I

Transcription: Components of transcription machinery in Prokaryotes and Eukaryotes, Trancriptional factors, Transcription process (initiation, elongation and termination); Post-transcriptional processing, Regulation of transcription (protein-DNA interaction: zinc finger motif, homeodomain, helix-loop-helix, leucine zipper), m-RNA stability, m-RNA editing; Nuclear splicing, Catalytic RNA, Mechanism of gene silencing.

Unit-II

Translation: Genetic Code- Principle of translation, Translation machinery in Prokaryotes and Eukaryotes (t-RNA, Aminoacyl synthetase, Ribosome), Translation process (initiation, elongation and termination). Regulation of gene expression: Constitutive and Induced gene expression; Regulation of gene expression in Prokaryotes and Eukaryotes; Operon concept (Lac, Ara, Trp and His).

Unit-III

Protein trafficking (glycosylation, coated vesicles, budding and fusion reactions, protein localization, receptor recycle), Signal transduction (carriers and channels, G protein mediated, Ras/MAPK pathway, MAP kinase pathway, cAMP mediated, JAK-STAT pathway), Cell cycle and its regulation, Genetics of cancer (Proto-Oncogenes, Tumor Suppressor genes), Signaling pathways.

BT-425	CELL & DEVELOPMENTAL BIOLOGY	3 CH	50 marks

Unit-I

Structural organization and function of intracellular organelles: Cell wall, Nucleus, Mitochondria, Golgi bodies, Endoplasmic reticulum, Plastids, Ribosome, Structure & function of cytoskeleton and its role in motility; Cell Division (Mitosis and Meiosis), Cell cycle and its regulation.

Membrane structure and function: Structural model of biomembrane, composition and dynamics; Transport of ions and macromolecules; Membrane carbohydrates and their role in cellular recognition; Mechanism of sorting and regulation of intracellular transport.

Unit-II

Cell-Cell Interaction and cellular signaling: Cellular response to environmental signals in plants, animals and bacteria- Extra-cellular signaling, Cell receptors, Second messenger, Signal transduction pathways and regulation.

Signaling cascades involved in the control of developmental program, Cell specification *w.r.t.* amphibian, chick, Phenomenon of the Organizer *w.r.t.* amphibians: Progressive determination, Regional specificity of induction,

Unit-III

Cellular basis of differentiation and development: Gametogenesis; Fertilization, Cleavage – types and mechanism, Gastrulation, Anterior/posterior, Dorsal/ventral polarity development of Drosophilla, Tetrapod limb development; Axes formation, Coordination of the three axes, Regeneration: epimorphic, morphallactic and compensatory; Plant meristem organization and differentiation in Arabidopsis, Spatial and temporal regulations of gene expression during development and differentiation, Programmed cell death, Aging and Senescence.

BT-426	INDUSTRIAL BIOTECHNOLOGY	3 CH	50 marks

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, hydrogen, 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).

BT-427	**Practical (Immunology and Molecular Biology)**	**2 CH**	**50 marks**
BT-428	**Practical (Cell Biology and Industrial Biotechnology)**	**2 CH**	**50 marks**

THIRD SEMESTER

BT-531	**RECOMBINANT DNA TECHNOLOGY**	**3 CH**	**50 marks**

Unit-I

DNA isolation and purification; Restriction endonuclease, Ligase and other modifying enzymes; DNA & RNA Markers, Linker, Adapter and MCS; Gene cloning vectors- Plasmid, bacteriophage, cosmid, BAC, YAC; Expression vectors: bacteria and yeast based expression vector; Gene library- genomic and c-DNA, contig library; PCR, Blotting techniques: Southern, Northern, Western, Dot and Slot; Nucleic acid hybridization.

Unit-II

Concept of gene cloning; Cloning of interacting gene: two hybrid and three hybrid assay; Cloning of differentially expressed gene, Gene regulation analysis-DNA transfection, Northern blot, Primer extension, SI mapping, RNase protection assay, Reporter assay and Phage display; DNA microarrays and Chips- principle and process; DNA finger printing and DNA foot printing; DNA Sequencing; Site directed mutagenesis; Expression of heterologous gene; *In vitro* transcription and translation; Gene knock out strategies; RNA interference: Antisense RNA, siRNA, mi RNA; Ribozyme Technology.

Unit-III

Molecular markers- Types (RFLP, RAPD, AFLP, SCAR, SSR, SNP, EST), Principle and methodology; Application of molecular markers: in diagnostics, gene tagging, gene mapping, Physical mapping, Map based cloning of gene and cloning of QTLs. Gene therapy and its applications; DNA vaccines and rDNA products; Genetic engineering regulations and safety guidelines.

BT-532	**BIOINFORMATICS**	**3 CH**	**50 marks**

Unit-I

Major Bioinformatics Resources: NCBI, EBI, ExPASy, RCSB; Open access bibliographic resources and literature databases: PubMed, BioMed Central; Sequence database; Structural database; Genomic resources; Data access, retrieval and submission; Data access standard search engines, Data retrieval tools Entrez, DBGET and SRS.

Unit-II

Sequence analysis: Introduction to sequence analysis; Local and Global alignment; Pairwise and Multiple string alignment, Sequence alignment algorithm: Dot matrix, Needleman and Wunsch algorithm, Smith-Waterman algorithm; Substitution Matrix (PAM, BLOSUM), BLAST, FASTA algorithms. Methods of phylogenetic analysis; Steps of phylogenetic analysis; Classification of phylogeny: graphs, trees and cladograms.

Unit-III

Patterns, motifs and Profiles in sequences; Structure classification of proteins (SCOP, CATH); Protein Secondary structure prediction; Tertiary structure prediction methods; Protein structure prediction by comparative modeling approaches. Introduction to Molecular modeling and Drug designing.

BT-533	BIOPROCESS ENGINEERING & TECHNOLOGY	3 CH	50 marks

Unit-I

Concepts of Bioprocesses: Concepts of basic modes of fermentation (Batch, Fed batch and Continuous); Types of Fermenter, Solid substrate fermentation and submerged fermentation, Conventional fermentation v/s biotransformation; Fermentation economics. Upstream processes: media formulation; sterilization; aeration and agitation; heat transfer and mass transfer; Fermenter design- mechanically agitated; Pneumatic and hydrodynamic fermenters. Measurement and control of parameters; Scale up and scale down process.

Unit II

Bioreactor specific applications: Tubular flow, Packed Bed, Plug flow reactor, CSTR, Bubble columns, fluidized bed and trickle bed bioreactors. Bioreactor design and analysis: Ideal and non-ideal reactors; Residence time distribution in bioreactor.

Growth Models: Unstructured models of growth, Substrate inhibition kinetics; Product formation, Transient growth kinetics, Structured kinetic models of growth and product formation, Compartment models, Metabolic models, Cybernetic models. Modeling mass and heat transfer in bioreactor.

Unit-III

Downstream processing: Bioseparation (filtration, ultrafiltration, centrifugation and sedimentation, flocculation); Cell disruption; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and; Drying; Crystallization; Storage and packaging.
Immobilized cell based bioreactor; Immobilized enzyme and its application in bioreactor; Bioreactor design for animal cell culture; Strategies of maximizing the productivity of amino acid and SCP; Bioreactor design for waste treatment.

BT-534	CELL CULTURE TECHNIQUES	3 CH	50 marks

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

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*.
Immunolabeling of cells to study molecular expression pattern– Microscopy, Flow cytometry, Cytospin, Immunohistochemistry, Transfection, Transient and stable cell line generation.

BT-535 (A)	**PLANT BIOTECHNOLOGY**	**3 CH**	**50 marks**

Unit-I

Tools of Plant Genetic Engineering: *Agrobacterium* biology, Basis of tumor and hairy root formation, Mechanisms of T-DNA transfer, Role of virulence genes, Plant gene vector based on Ti plasmid, Direct transformation (Gene gun, Electroporation, Microinjection, calcium phosphate, PEG, DEAE, liposomes *etc.*); Selection of clones, marker and reporter genes involved in screening, Application of genetic transformation: promoter tagging, activation tagging; Terminator Seed Technology; Transgene stability and gene silencing; Chloroplast transformation – advantages sectors success with tobacco and potato.

Unit-II

Biotechnology of secondary metabolites: Secondary metabolites of plant origin and its types; Production of secondary metabolites through tissue culture, Factors affecting the production and its optimization, Bioreactor based production of secondary metabolites and its kinetics; Isolation and purification of secondary metabolites, Biotransformation (case studies).
Molecular breeding: Molecular markers- types, principle and applications in plant biotechnology; SITL and QTL mapping, Physical mapping, Map based cloning; Molecular marker-assisted selection.

Unit-III

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.

BT-535 (B)	ANIMAL BIOTECHNOLOGY	3 CH	50 marks

Unit-I

Micromanipulation of animal cells, cell cloning, cell fusion and somatic cell hybrids, Principles and methods of hybridoma technology, Production and characterization of monoclonal antibodies and their application in animal health and production. Cytokines: structure and function, Cytokine receptors, Regulation of immune response, Cytokine related diseases, diagnosis and therapeutic application. Immune system in health and disease: Immune response and bacterial, parasitic and viral infections, congenital and acquired immunodeficiency; tolerance and autoimmune diseases, Transplantation and Tumor Immunology, diagnosis and therapeutic approaches.

Unit-II

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.

Unit-III

Immune studies *in vivo* animal models and human subjects: Assessment of protective immunity, Transfer of protective immunity, Assessment of immune responses in humans, Adoptive transfer of lymphocytes and hematopoietic stem-cell transfers, Animal models: Transgenic mice and gene knockout by targeted disruption, *In vivo* cell tracking techniques, Cell imaging techniques *in vitro* and *in vivo*.

BT-536 (A)	AGRICULTURAL BIOTECHNOLOGY	3 CH	50 marks

Unit -I

Introduction to Agricultural Biotechnology: Conventional method of crop improvements vs. Biotechnological interventions, Manipulation of resistance: fungal and bacterial disease, viral disease, strategies for engineering insect resistance (Bt genes, protease inhibitors, α-amylase inhibitors), strategies for engineering herbicide resistance, strategies for engineering stress resistance (drought stress, salt stress, temperature stress).

Unit-II

Plant disease resistance: Introduction, plant pathogen interaction, Major type of plant pathogens, Natural Disease resistance pathways, Biotechnological approaches to disease resistance (case studies), Improvement of crop yield and quality: long shelf life of fruits and flowers, use of ACC synthase, poly-galactorunase, ACC oxidase; Modification of fruit and flower color, Seed storage protein quality, vitamin E fortification, Fe and mineral fortification, case studies of phytase production and Golden rice.

Unit-III

Genetic manipulation of crop yield by photosynthesis, Nitrogen fixation, Advances in Agricultural Biotechnology: Molecular Farming: Plants as factories for pharmaceuticals and biomaterials, Smart Breeding: Marker-assisted selection: Non-invasive biotechnology alternative to genetic engineering of plant varieties, Biofertilizers and biopesticides.

BT-536 (B)	CLINICAL PATHOLOGY & DIAGNOSTICS	3 CH	50 marks

Unit- I

General Pathology: introduction to Systemic Pathology Haematology, Cytopathology, Chemical Pathology, immunopathology, and General neoplasia. Histopathology: Collection of specimen, labelling, documentation, fixation. Grossing techniques and tissue processing. Cutting and staining of sections, use of special stains and immunocytochemistry, frozen sections, Interpretation and reporting.

Unit- II

Haematology: Haemoglobin estimation , blood counts, Staining and reporting of smears, LE cells , ESR , Packed cell volume and absolute values, Staining methods for blood cells, Blood bank serology , ABO grouping , Rh typing , special blood groups, Blood banking
Clinical and chemical pathology: Examination of urine, body fluids and stool, Collection of blood , anti-coagulants, protein precipitants, Estimation of blood sugar, urea, creatinine, proteins, bilirubin, cholesterol, uric acid, electrolytes, calcium and enzymes, Use of autoanalyzer techniques.

Unit-III

Microbiology and serology: Collection , handling , documentation and section of material for important procedures, Use of various microbiological stains, Use of various culture media and identification of bacterias by specific procedures, Antibiotic sensitivity tests, Sterilization and disinfection . Identification of fungi in specimen and culture. Diagnostic procedures in important viral infections. Serological techniques, Widal, Weil Felix, VDRL, HIV, HBV, CRP, RF, ASO and pregnancy tests. ELISA and CLIA, Medical imaging techniques: CT Scan, X-ray, Ultrra Sound.

BT-536 (C)	ENVIRONMENTAL BIOTECHNOLOGY	3 CH	50 marks

Unit-I

Biological treatment of waste water: microbial processes in waste water treatment, microbial bioflim and waste water treatment, secondary treatment system, microbial removal of nitrogen and phosphorous, nutrient removal through biomass production. Bioremediation: bioreactors for bioremediation, types of bioremediation, application of bioremediation, biodegradation of xenobiotics and pollutants, biodegradation of pesticides, Biosorption: use of bacteria, fungi and algae in biosorption, biomineralization and bioleaching.

Unit-II

Biotechnology for pollution control: air pollution abatement (bioscrubber and biofilter), water pollution abatement: Aerobic (activated sludge process, biological filters, rotating biological contractors, fluidized bed reactors, inverse fluidized bed bioflim reactor, expanded bed reactor); Anaerobic biological treatment (contact digester, packed bed or packed volume reactor, anaerobic baffled digester, upflow anaerobic sludge blanket reactors); Membrane bioreactor and biocatalyst.

Unit-III

Management and remediation of problem/contaminated soil: bioremediation of organic pollutant contaminated soil, Biotechnology for solid waste management (composting of crop residue, Principles and advantages of composting, Factors influencing composting, techniques of compost enrichment), Vermicomposting and crop productivity.

Bioleaching. Biotechnology of waste land reclamation and restoration. Biomass as source of energy, Concept of Biofuels, Bioethanol and Biohydrogen.

BT-536 (D)	**PHARMACEUTICAL BIOTECHNOLOGY**	**3 CH**	**50 marks**

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.

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.

BT-537	**Practical (Cell Culture and Recombinant DNA Technology)**	**2 CH**	**50 marks**
BT-538	**Practical (Bioinformatics)**	**2 CH**	**50 marks**

FOURTH SEMESTER

BT-541	GENOMICS, PROTEOMICS & METABOLOMICS	3 CH	50 marks

Unit I

Concept of genome organization and minimal cell genome; Genome sequencing strategies, principles and methodology; Genome sequencing projects- Microbes, plants and animals; Accessing and retrieving genome project information from web; Recognition of coding and non-coding sequences and gene annotation.

Reverse genetics- strategies and applications, Concept of TILLING, Structural genomics, Functional genomics and Comparative genomics; High throughput screening in genome for drug discovery-identification of gene targets and drug development.

Unit II

Introduction to proteome, Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Isoelectrofocusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics, Protein-protein interactions, Yeast two hybrid and three hybrid system; Protein microarray; Structural proteomics; Proteomics and Drug delivery.

Unit-III

Introduction to metabolomics: Metabolome, Metabonomics, Metabolite profiling, Metabolome fingerprinting, Role of Biomarker in metabolomics, Tools of metabolome studies: NMR, MS, GC, LC, IR and its application, Metabolome projects of plant and human, Future prospective of metabolomics.

BT-542	IPRs, BIOSAETY AND BIOETHICS	3 CH	50 marks

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. 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).

BT-543	Seminar	3 CH	50 marks
BT-544	Project work and Viva Voce	15 CH	250 marks

*** $$ ***

COURSES OF STUDY
M.Sc (Bioinformatics): Session (2017-2019)

DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS
SAMBALPUR UNIVERSITY, JYOTI VIHAR
BURLA- 768019, ODISHA

OUTLINE OF COURSE STRUCTURE
M.Sc. BIOINFORMATICS (Session: 2017-19)

SEMESTER-I

Course Code	Course Name	Credits hours	Marks
BI-411	(A) Physical Sciences (B) Foundation Biology	3	50
BI-412	Chemistry of Biomolecules	3	50
BI-413	Genetics	3	50
BI-414	Microbiology	3	50
BI-415	Molecular Biology- I	3	50
BI-416	Concepts in Computing	3	50
BI-417	Practical (Genetics and Microbiology)	2	50
BI-418	Practical (Biochemistry)	2	50

NON CREDIT COURSE: Communication Skills

SEMESTER-II

Course Code	Course Name	Credit hours	Marks
BI-421	Probability and Biostatistics	3	50
BI-422	Bioenergetics and Metabolism	3	50
BI-423	Immunology	3	50
BI-424	Molecular Biology- II	3	50
BI-425	Bioinformatics Resources	3	50
BI-426	Bioinformatics Programming	3	50
BI-427	Practical (Immunology and Molecular Biology)	2	50
BI-428	Practical (Bioinformatics Resources & Programming)	2	50

NON CREDIT COURSE: Personal Development

SEMESTER-III

Course Code	Course Name	Credit hours	Marks
BI-531	Recombinant DNA Technology	3	50
BI-532	Computational Biology	3	50
BI-533	Molecular Modeling and Simulation	3	50
BI-534	Database Management System	3	50
BI-535	Data Warehouse and Data mining	3	50
BI-536	Python and R language programming	3	50
BI-537	Practical (DBMS, Data warehouse and Data mining)	2	50
BI-538	Practical (Python and R language programming)	2	50

SEMESTER-IV

Course Code	Course Name	Credit hours	Marks
BI-541	Genomics, Proteomics and Metabolomics	3	50
BI-542	Computer Aided Drug Design	3	50
BI-543	Seminar	3	50
BI-544	Project work and Viva voce	(10+3)	200
BI-545	Practical (Computer Aided Drug Design)	2	50
Total Course Credit		**90 CH**	**1600**

FIRST SEMESTER

BI-411(A)	PHYSICAL SCIENCES	3 CH	50 marks

Unit-I

Basic Mathematics: Logarithms, exponential series, factorials, graphs, Coordinate geometry – straight line and non-linear relationships. Differentiation– Rates and limits, Differential coefficients, Differentiation of a function. Integration – Basic concepts of integration, integration by substitution, integration by parts. Matrix algebra – linear transformation between vector spaces, Representation of linear transformation by matrices, Algebra of matrices, Eigen values and Eigen vectors of linear transformation.

Unit-II

Basic Physics and Computer Fundamentals: Surface tension, Viscosity, Photoelectric effect, Basic characteristics of electricity and magnetism, charge, current, voltage, resistance, capacitor, electric field and impedence diodes, Photoresistors, Semiconductors, transistors, Integrated circuits and chips.

Computers: types, basic organization of computers, computer languages, software and hardware, operating systems, bit, byte, word, computer memory – types, data processing and storage.

Unit-III

Basic Chemistry: Atomic structure – waves and wave functions, quantum numbers, Atomic orbitals, electronic configuration of atoms and periodic properties of elements, ionic radii's, ionization potential, electronic configuration of molecules. Bond lengths, Bond angles, bond order and bond energies, types of chemical bond (weak and strong), intermolecular forces, structure of simple ionic and covalent bonds, carboxylic acids, aldehydes and ketones, amines (overview).

BI-411(B)	FOUNDATION BIOLOGY	3 CH	50 marks

Unit I

Chemistry of Living Organisms: Biomolecules, Origin of Life, Cell- unit of living organisms and multicellular organisms, Structure of animal, plant and bacterial cell, Sub-cellular organelles (Cytoskeleton, Mitochondria, Golgi complex, Endoplasmic reticulum, Chloroplast, Ribosome, Lysosome, nucleus).

Unit II

Classification and nomenclature of living organisms (plant and animal): Survey of microbial world, Diversity in animal and plant kingdom, Phylogeny, Organic evolution, Evidences in support of evolution (morphological, embryological, taxonomy, genetic, biochemical and molecular), Origin of species and Speciation; Environmental and anthopogenic impact on living organisms.

Unit III

Genetics- Science of heredity: Chromosome number and structure, Cell division- meiosis and Mitosis, Mendelian principle of heredity; Monohydrid and Dihybrid cross (Examples); Physiological basis of life (Locomotion, Respiration, Digestion, Circulation, Excretion); Reproduction in plants and animals; Hormonal integration of physiological processes.

BI-412	CHEMISTRY OF BIOMOLECULES	3 CH	50 marks

Unit I

Biomolecules: carbohydrates (monosaccharides, configurations and conformations of monosachharides, formations of polysaccharides and structural diversity), Lipids (types of fatty acids and lipids), Spingolipids, Conjugated and Complex lipids; DNA structures: Nucleotides and nucleosides, DNA double helix, DNA structure (Z-DNA, B-DNA, A-DNA), Triple Helix DNA, Tetraplex DNA, DNA binding proteins, Sequence specific Protein – DNA interactions, RNA secondary and tertiary structures.

Unit II

Protein structure: chemical building blocks, Peptide bond, phi, psi and chi torsion angles, Ramachandran map, Hierarchical organization of protein structure (Primary, Secondary Super-secondary, Tertiary, Quaternary), Protein folding, Protein Motifs, and Domains; Protein function. Protein structure determination; Purification of proteins, Crystallization of proteins, X-ray crystallography, NMR and its limitations, Detection of errors in low resolution X-ray crystal structure;

Unit III

Engineering & design of protein structure, Homologous protein, Protein sequencing, Site-directed mutagenisis, Protein flexibility and stability, Engineering of protein structure and applications (case studies). Membrane proteins and its function, Metalloproteins, Carbohydrate binding proteins, Metalloenzymes: Structure and Function.

BI-413	GENETICS	3 CH	50 marks

Unit-I

Mendelian principle: Dominance, Segregation and Independent assortment; Extensions of Mendelian principle: Co-dominance, Incomplete dominance, gene interactions, plieotropy, genomic imprinting, penetrance and expressivity, phenocopy; Linkage and Crossing over; Sex linkage, Sex limited and sex influenced characters; Sex determination in plants and animals; Extra chromosomal inheritance; Inheritance of mitochondrial and chloroplast genes, Maternal inheritance.

Unit-II

Concept of gene: allele, multiple alleles, pseudoallele, complementation tests; Gene mapping (Linkage maps, Tetrad analysis, Pedigree analysis, lod score for linkage testing), Mapping with molecular markers (RAPD, RFLP, ISSR), Development of mapping population in plants; Quantitative genetics (Polygenic inheritance, heritability and its measurements, QTL analysis).

Unit-III

Mutation: types, causes and detection; Mutant types – lethal, conditional, biochemical, loss of function, gain of function; Germinal verses somatic mutants, Insertional mutagenesis; Structural and numerical alterations in chromosomes (deletion, duplication, inversion, translocation, ploidy and their genetic implications); Population Genetics: Gene pool, Gene frequency, Hardy Weinberg genetic equilibrium; Gene flow and Genetic drift.

BI-414	MICROBIOLOGY	3 CH	50 marks

Unit-I

An overview of the microbial world (Bacteria, Archea, Eukaryote). Classification of Archea and Eubacteria as per Bergey's manual; Microbial phylogeny. Structural organization of prokaryotic cell (bacterial wall, capsule, flagella, pilli, pronucleus, ribosomes, plasmid).

Unit-II

Bacterial nutrition and nutritional category, Bacterial culture: Synchronomous and asynchronous culture, continuous culture and chemostat. Bacterial growth, Mathematical expression of growth, generation time, specific growth rate.
Bacterial metabolism: Glucose dissimilation pathways, Bacterial respiration with organic and inorganic reluctant, Chemolithotrophy. General principle of bacterial conjugation, transduction and transformation. Bacterial pathogenecity and anti-microbial compounds.

Unit-III

Virus**:** General properties, structure, purification, cultivation; Principle of viral taxonomy. Bacteriophage: structure, classification, one-step growth experiment. Production of DNA phage, RNA phage, Lytic cycle, Temperate phage and Lysogeny. Animal virus and its reproduction, Viral infection (Presistent, Latent and Slow virus infection). Plant virus and their transmission. Anti-viral agents; M-13, Lambda, HIV, Influenza virus, Viriods and Prions.

BI-415	MOLECULAR BIOLOGY- I	3 CH	50 marks

Unit-I

Genetic organization of Prokaryotes and Eukaryotes including nuclear genome and organelle genome; DNA as the genetic material (Experimental evidences); Central dogma; Genome complexity; C-value paradox, Cot value, Repetitive DNA, Satellite DNA; Gene structure in Prokaryotes and Eukaryotes; Cistron, Recon, Muton; split genes, pseudogenes, clusters and repeats.

Unit-II

Condensation of chromosome, Lampbrush chromosome, Polytene chromosome, Supercoiling of DNA, Nucleosomes, DNA methylation, Genetic imprinting, Epigenetic inheritance, Transposable elements, types of transposable elements, Mechanism of transposition, Retroposons and its types, Mechanism of retrotransposition, Rearrangement of DNA.

Unit-III

DNA replication: Models of DNA replication, Enzymes of DNA replication, Process of DNA replication (initiation, elongation, termination), DNA replication at the telomere; Organization and Replication of extranuclear genome (Mitochondrial and Chloroplast) genome, DNA recombination (site specific and homologous); DNA repair (base-excision, mis-match, SOS, recombination); Phage strategies (lysogenic cycle and lytic cycle).

BI-416	CONCEPTS IN COMPUTING	3 CH	50 marks

Unit -I

Introduction to computers – data and information, Basic structure of computer: CPU, I/O devices, memory, secondary storage devices; Data representation: Overview of binary, octal and hexadecimal number system; concept of low-level and high-level language, compiler, interpreter; Application programs: Basic concept of word processing, spreadsheet, presentation and other application software.

Unit-II

Classification of computers (mainframes, mini computers, microcomputers, special purpose computers); Types of modern computing: Workstations, Servers, Grid computing, Cloud computing; An overview of computer viruses; Internet and its Resources, World Wide Web (www): Associated tools, services, resources and various terminologies; Computer networking; computer security.

Unit-III

Operating system concepts, salient features of Windows, UNIX and GNU/Linux; Unix file system, file and directory commands, file permissions. Basic commands, I/O redirection and piping, simple and advanced filters, *sed* command, *vi* as text editor, archives and file compressions. Processes: background processes and scheduled processes. Alias and environmental variables.

BI-417	Practical (Genetics and Microbiology)	2 CH	50 marks
BI-418	Practical (Biochemistry)	2 CH	50 marks

SECOND SEMESTER

BI-421	PROBABILITY AND BIOSTATISTICS	3 CH	50 marks

Unit I

Concepts from probability: elementary sets as events and their complements, Independent and disjoint events, Probability rules, Permutations and Combinations, Probability distributions, Binomial distribution, Poisson distribution, Random variables and their properties, Continuous random variables, Conditional probability and Bayes theorem.

Unit II

Systematic organization and display of data**:** populations, samples, types of data, frequency tables and histograms; Graphical methods (histograms, box and whisker plots), Measure of central tendency (arithmetic mean, median, mode, geometrical mean), Measure of dispersion (range, mean deviation, variance and standard deviation, coefficient of variation, Normal distribution: importance and properties; Areas under standard normal distribution; Central limit theorem, Skewness and Kurtosis. Principal component analysis.

Unit III

Tests of hypothesis**:** one-tailed versus two-tailed tests, p-values, type-I and type-II errors; Student's t-test, Paired t-test, Hypothesis testing; Categorical data and Chi-square tests: understanding Chi-square, Chi-square distributions and tables, 2 x 2 contingency table, Goodness of fit tests; 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 way analysis of variance, F distribution and application, Non-parametric methods and its advantages and disadvantages, Wilcoxon rank-sum test, Wilcoxon signed-rank test.

BI-422	BIOENERGETICS AND METABOLISM	3 CH	50 marks

Unit I

Enzymes: basic concepts and kinetics, Classification of enzymes, Coenzymes and cofactors, Effect of temperature and pH on enzyme activity, Michaelis-Menten kinetics, inhibitors and activators, Enzyme inhibition (competititive, non-competitive, uncompetitive), Allosteric enzymes and regulation, Concepts of bioenergetics, Enzyme chains, Multi-enzyme complexes, Regulatory enzymes, feedback and feed forward systems, Bioenergetics and biochemical reaction.

Unit II

Metabolism and regulation of carbohydrate (Glycolysis, Gluconeogenesis, Pentose phosphate phathway and its physiological significance); Carbohydrate biosynthesis in plants, Co-ordinated regulation of glycogen synthesis and breakdown; Citric acid cycle, Regulation of citric acid cycle, Glyoxylate cycle, Fatty acid catabolism (digestion, metabolism and transport of fats), Oxidation of fatty acids, ketone bodies, lipid biosynthesis, Electron transport in mitochondria and chloroplast; Basic principles of oxidative and photophosphorylation.

Unit III

Amino acid oxidation and production of urea (metabolic fates of amino groups, nitrogen excretion and urea cycle, pathway of amino acid degradation), Biosynthesis of amino acids, Biosynthesis of nucleotides (purines and pyrimidines), Metabolic disorders, Inborn error due to metabolism, Hormonal regulation of metabolism.

BI-423	IMMUNOLOGY	3 CH	50 marks

Unit-I

Basics of immunity, Immunity related organs in the human body, Leucocyte in immune function, B and T cells- structure and differentiation, Antigen and antibody, Properties of antigen, haptens, antigenicity, Antigen processing and presentation, Complement activation.

Unit-II

Immunoglobulins – classification, structure and properties, Primary and secondary immune response, Genetic basis of generation of antibody diversity, Antigen-antibody interaction. T-cell receptors, Major histocompatibility complex proteins. Interleukins. Brief idea regarding immunology of Allergy, AIDS, Organ transplantation; Autoimmune diseases; Cancer types, causes and mechanisms.

Unit-III

Immunotechnology – agglutination, precipitin formation, Immunodiffusion (SRID and DRID). Immunoelectrophoresis – types and uses, Radio Immuno Assay, ELISA, Western Blotting, ELISPOT assay, Immunofluorescence, Immunoelectron microscopy; Surface plasmon resonance, Biosensor assays for assessing ligand-receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction.

BI-424	MOLECULAR BIOLOGY- II	3 CH	50 marks

Unit-I

Transcription: Components of transcription machinery in Prokaryotes and Eukaryotes, Trancriptional factors, Transcription process (initiation, elongation and termination); Post-transcriptional processing, Regulation of transcription (protein-DNA interaction: zinc finger motif, homeodomain, helix-loop-helix, leucine zipper), m-RNA stability, m-RNA editing; Nuclear splicing, Catalytic RNA, Mechanism of gene silencing.

Unit-II

Translation: Genetic Code- Principle of translation, Translation machinery in Prokaryotes and Eukaryotes (t-RNA, Aminoacyl synthetase, Ribosome), Translation process (initiation, elongation and termination). Regulation of gene expression: Constitutive and Induced gene expression; Regulation of gene expression in Prokaryotes and Eukaryotes; Operon concept (Lac, Ara, Trp and His).

Unit-III

Protein trafficking (glycosylation, coated vesicles, budding and fusion reactions, protein localization, receptor recycle), Signal transduction (carriers and channels, G protein mediated, Ras/MAPK pathway, MAP kinase pathway, cAMP mediated, JAK-STAT pathway), Cell cycle and its regulation, Genetics of cancer (Proto-Oncogenes, Tumor Suppressor genes), Signaling pathways.

BI-425	BIOINFORMATICS RESOURCES	3 CH	50 marks

Unit I

Bioinformatics: Origin and applications; Biological databases and bioinformatics tools, Organization of databases: Data contents and formats, purpose and utility in Life Sciences. Major Bioinformatics Resources: NCBI, EBI, ExPASy, RCSB; Open access bibliographic resources and literature databases: PubMed, BioMed Central, Public Library of Sciences (PloS), CiteXplore.

Unit II

Sequence databases: Formats, querying and retrieval; Nucleic acid sequence databases: GenBank, EMBL, DDBJ; Protein sequence databases: Uniprot-KB: SWISS-PROT, TrEMBL, UniParc; Repositories for high throughput genomic sequences: EST, STS GSS; Genome databases at NCBI, EBI, TIGR, SANGER; Viral genomes, Archea and bacterial genomes; Eukaryotic genomes (Yeast, Drosophila, *C. elegans*, Rat, Mouse, Human, plants such as *Arabidopsis thaliana*, Rice).

Unit III

Structure Databases: PDB, NDB, PubChem, ChemBank. Derived Databases: Basic concept, Collection of primary data and basic principles for deriving secondary data, organization of data, contents and formats of database entries, Identification and interpretation of patterns in sequences; Sequence patterns: InterPro, Prosite, Pfam, ProDom; Structure patterns: FSSP, DSSP. Extraction of knowledge resources on immunology, plant, animal and infectious diseases: databases and servers published in NAR Database and Webserver issues; Bioinformatics journals viz. BMC Bioinformatics.

BI-426	BIOINFORMATICS PROGRAMMING	3 CH	50 marks

Unit I

Perl programming: Introduction to Perl, Installation & running programs, Sequences & Strings: Strings, String functions, transcription, reverse complement, Reading Files, Introduction to Arrays, Motifs & Loops: Arrays to Strings, Writing to Files, Subroutines: Creating Subroutines, Command line Arguments, Modules & Libraries, Randomization, Hashes, Translation, Introduction to regular expressions & restriction enzymes, GenBank & PDB, Parsing BLAST, Introduction to Object Oriented Perl, Bioperl & modules.

Unit II

Web Programming: Basics of HTML tags – Document tags, paragraph and lines, Lists, images, links, text, tables, forms, CSS, JavaScript Basics, Variables, subroutines, event handling, form handling, PERL- CGI Scripting

Unit III

Server Side Scripting: Introduction to web servers – setup and configuration, Introduction to PHP- variables, loop construction, arrays and objects, MySQL basics and Database Integration- SQL commands, integration of SQL in PHP, retrieval and update of data, Building web applications using PHP and MySQL- full stack development with development and deployment.

BI-427	**Practical (Immunology and Molecular Biology)**	**2 CH**	**50 marks**
BI-428	**Practical (Bioinformatics Resources and Programming)**	**2 CH**	**50 marks**

THIRD SEMESTER

BI-531	**RECOMBINANT DNA TECHNOLOGY**	**3 CH**	**50 marks**

Unit-I

DNA isolation and purification; Restriction endonuclease, Ligase and other modifying enzymes; DNA & RNA Markers, Linker, Adapter and MCS; Gene cloning vectors- Plasmid, bacteriophage, cosmid, BAC, YAC; Expression vectors: bacteria and yeast based expression vector; Gene library- genomic and c-DNA, contig library; PCR, Blotting techniques: Southern, Northern, Western, Dot and Slot; Nucleic acid hybridization;

Unit-II

Concept of gene cloning; Cloning of interacting gene: two hybrid and three hybrid assay; Cloning of differentially expressed gene, Gene regulation analysis-DNA transfection, Northern blot, Primer extension, SI mapping, RNase protection assay, Reporter assay and Phage display; DNA microarrays and Chips- principle and process; DNA finger printing and DNA foot printing; DNA Sequencing; Site directed mutagenesis; Expression of heterologous gene; *In vitro* transcription and translation; Gene knock out strategies; RNA interference: Antisense RNA, siRNA, mi RNA; Ribozyme Technology.

Unit-III

Molecular markers- Types (RFLP, RAPD, AFLP, SCAR, SSR, SNP, EST), Principle and methodology; Application of molecular markers: in diagnostics, gene tagging, gene mapping, Physical mapping, Map based cloning of gene and cloning of QTLs. Gene therapy and its applications; DNA vaccines and rDNA products; Genetic engineering regulations and safety guidelines.

BI-532	**COMPUTATIONAL BIOLOGY**	**3 CH**	**50 marks**

Unit I

Introduction of Computational Biology: Sequence similarity, Homology, Sequence alignment; Different scoring models, Substitution matrices (PAM and BLOSUM), Pairwise sequence alignment: Concept of global and local alignment, Dot matrix method, Dynamic programming (Needleman-Wunsch algorithm, Smith-Waterman algorithm), BLAST and FASTA, FASTA and BLAST algorithms, Multiple Sequence alignment: (methods, scoring of MSA, profile, BLOCK analysis and pattern searching).

Unit II

Markov Chains and HMM: Frequent words in DNA, Consensus word analysis, Transaction and emission matrix, Development of training set, CpG island prediction using HMM and its application; Artificial neural network and its application; Phylogenetic analysis: Concepts and terminology, Phylogenetic tree prediction algorithms: Distance-based methods (UPGMA, NJ), Character-based methods (Maximum parsimony, Maximum likelihood), Bootstrapping; Protein sequence analysis (compute pI/MW, RADAR, hydrophobic cluster analysis, ExPAsy).

Unit III

DNA sequencing & Human Genome Project, Dinucleotide abundance, Codon biases, GC reach prediction and relationship to gene density, GC and AT skewness and prediction of Ori and Ter site, Pattern searches, Primer design for PCR, Promoter analysis using PSSM, Methods for gene finding; RNA Structure Analysis: RNA secondary structure prediction: Nussinov folding algorithm, energy minimization and Zuker folding algorithm.

BI-533	MOLECULAR MODELING AND SIMULATION	3 CH	50 marks

Unit I

Protein structure prediction: Computational methods for protein Secondary structure prediction (Chou-Fasmann, GOR and Neural Networks) and reliability (Q3 value and SOV score), Tertiary structure prediction methods: Essentiality, Types of predictions methods, Homology, Fold recognition method, Validation of protein structure (Ramachandran plot analysis, ERRAT score, VERIFY3D), Analysis of 3D structures: secondary structure assignment, assignment of hydrogen bonds, coulomb hydrogen bond calculation, empirical hydrogen bond calculation, assignment methods of secondary structure (DSSP, STRIDE, DEFINE, P-Curve).

Unit II

Protein structures comparison and alignment: General approach, Comparison algorithm and optimization (CE, VAST, DALI), Concept of coordinate transformation, RMSD, Z score for structural comparison; Identifying structural domains in protein, First and second generation algorithms for domain assignments, Domain assignment based on graph theoretical methods, Prediction of binding sites and characterization.

Unit III

Ab initio protein structure prediction: Empirical force field for biomolecular simulations, Potential Energy Function (bond length potential, bond angle potential, torsional potential, van der wals potential and coulomb potential), Classical representations of electrostatics (Poisson-Boltzmann, Generalized Born and Colombic).

Energy minimization techniques: Concept of local and global minima, Energy minimization protocol, Energy minimization algorithms (steepest descent, conjugate gradient, Newton Raphson); Molecular Dynamics simulations, Monte Carlo Simulations, Techniques for efficient conformational search: Simulated Annealing, Calculation of Free energy using simulation techniques.

BI-534	DATABASE MANAGEMENT SYSTEM	3 CH	50 marks

Unit I

Database, Database concepts, Schemas and instances, DBMS architecture and Data independence, Data models, Database languages and interfaces, View of data, Database users and administrators, Database system structure, Database system applications; Data models – ER Model: Keys, Constraints, Design issues, Extended ER features, Reductions of ER schema to tables. Relational model: structure, relational algebra, hierarchical model, network model, object oriented model.

Unit II

Structured query language – Basic structure, Set operations, Aggregate functions, Null values, Nested sub queries, Views, Integrity: Domain constraints, Joined relations, Data-definition language; Relational database and storage- Pitfalls in relational design database, Functional dependencies, Decomposition normal forms – 1NF, 2NF, 3NF and Boyce-Codd NF, Data storage- Ordered indices, Hashing concepts- Security and authorization.

Unit III

Concurrency control techniques and information retrieval – Transactions: Properties of transactions: Concurrency problems, Serialisability and locking techniques, Data items – Database system architecture and information retrieval: Centralized and client- Server architecture.

BI-535	DATA WAREHOUSE AND DATA MINING	3 CH	50 marks

Unit I

Introduction to data warehousing – Concept of data warehouse and its advantages, Components of data warehouse, Architecture and lifecycle of a data warehouse, Related core terms; Types of data warehouse design methodologies – Top down approach, Bottom down approach, Hybrid design approach.

Unit II

Data Models - Dimensional data modeling (Star Schema, Snowflake Schema); Relational data modeling; Conceptual, Physical & Logical data model; Multidimensional analysis – OLAP and OLTP approaches; Building and maintaining the data warehouse – ETL design and development; ETL application; Management of metadata: Clinical data classification and its data warehouse design, Challenges in clinical data warehouse design.

Unit III

Introduction to data mining: Business problems for data mining, Data mining tasks (classification, clustering, association, regression, forecasting, sequence analysis), Data mining project cycle (data collection, data cleaning and transformation, model building, model assessment, reporting and prediction, model management), Data compression, Text mining, Web mining, Image mining, Classification, Clustering, Rule mining, String matching; Data mining concepts to build applications and systems, Preparation of raw data for mining process, Training, Modeling, prediction, Evaluation of mining process.

BI-536	PYTHON & R LANGUAGE PROGRAMMING	3 CH	50 marks

Unit I

Introduction to Python programming: basics, Interpreter and Compiler, Variables, expressions, Operators, Statements; Conditional execution: Conditional and logical operators; Functions: In-built functions, User defined functions; Iteration: Iterative operators; Strings: String structure and functions; Files: Creation, Writing and updating files; Lists: Elements, Methods, Functions; Dictionaries: Structure and methods, Text parsing; Tuples: Methods and uses; Regular expressions: Matching and Extraction.

Unit II

Applications of Python; Networked programs: Retrieval and parsing HTML; Using web services: XML, JSON, APIs; Object-Oriented programming using Python: Creating objects, Encapsulation, Inheritance; Using databases and SQL: Database concepts using SQLite, Creation of tables, SQL querying, JOIN Operator; BioPython and applications: Various classes in Python, Applications to sequence and structure files.

Unit III

R Programming: Introduction, Installing R; R basics, Graphics; Simple plotting, Advanced plotting, Using color in plots, Using subscripts and superscripts in graph labels, Interactive graphics, Saving graphical output, loops. Working with data sets: Data structures, Moving to and from files, Statistical distributions.

BI-537	**Practical (DBMS, Data Warehouse and Data mining)**	**2 CH**	**50 marks**
BI-538	**Practical (Python and R Language Programming)**	**2 CH**	**50 marks**

FOURTH SEMESTER

BI-541	**GENOMICS, PROTEOMICS & METABOLOMICS**	**3 CH**	**50 marks**

Unit I

Concept of genome organization and minimal cell genome; Genome sequencing strategies, principles and methodology; Genome sequencing projects- Microbes, plants and animals; Accessing and retrieving genome project information from web; Recognition of coding and non-coding sequences and gene annotation.

Reverse genetics- strategies and applications, Concept of TILLING, Structural genomics, Functional genomics and Comparative genomics; High throughput screening in genome for drug discovery-identification of gene targets and drug development.

Unit II

Introduction to proteome, Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Isoelectrofocusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics, Protein-protein interactions, Yeast two hybrid and three hybrid system; Protein microarray; Structural proteomics; Proteomics and Drug delivery.

Unit-III

Introduction to metabolomics: Metabolome, Metabonomics, Metabolite profiling, Metabolome fingerprinting, Role of Biomarker in metabolomics, Tools of metabolome studies: NMR, MS, GC, LC, IR and its application, Metabolome projects of plant and human, Future prospective of metabolomics.

BI-542	COMPUTER AIDED DRUG DESIGN	3 CH	50 marks

Unit I

Introduction to chemical informatics, Application in pharmaceutical industry; Representation of 2D structures; Atom lookup and connection tables; SMILES; SD files; Fragment codes and Fingerprints; 2D chemical database applications, Substructure searching with SMARTS, Similarity searching with fingerprints; Representing 3D structures. Sources of 3D information; Experimental 3D databases; Conformational flexibility; Distance matrices; Estimation of 3D structure; Conformational search and minimization; 3D descriptors and fingerprint.

Unit II

Molecular descriptors, Kinds of descriptor (2D, 3D descriptors); Biological descriptors and their application in ADME/Tox; Data verification and manipulation; Quantitative structure-property relationships (QSPR): Feature selection, Model building, examples of QSPR studies and application; QSAR in drug design: QSAR methodology, QSAR applications in drug design, QSAR model selection and validation, CoMFA, 3D and nD-QSAR methods; Pharmacophore and Drug Discovery: Pharmacophore generation, Query generation and submission, Searches in the database, Software for pharmacophore generation, Application and limitation of pharmacophore concept.

Unit III

High-Throughput chemistry (CombiChem): Mix and split synthesis, Solid-phase synthesis, Solution-phase synthesis, Combinatorial biosynthesis, Library design, Virtual high-throughput screening; De-novo design system: Generating the constraints model, Finding structure, Ssorting and selection, Synthetic accessibility, Experimental validation; Computational models for ADME/Tox, Application of predictive models to pharmacology and toxicity testing; Target identification and characterization, Structure based process for designing drug molecules (docking algorithms, MM-GBSA, MM-PBSA, LIE-SGB, Free energy perturbation, Thermodynamics integration, Refinement methods.

BI-543	**Seminar**	**3 CH**	**50 marks**
BI-544	**Project work and Viva Voce**	**15 CH**	**250 marks**
BI-545	**Practical (Computer Aided Drug Design)**	**2 CH**	**50 marks**

*** $$ ***

COURSES OF STUDY
MASTER OF PHILOSOPHY (BIOTECHNOLOGY)
(SESSION: 2018-2019)

DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS
SAMBALPUR UNIVERSITY, JYOTI VIHAR
BURLA- 768019 (ODISHA)

MASTER OF PHILOSOPHY (BIOTECHNOLOGY)
DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS
SAMBALPUR UNIVERSITY

OUTLINE COURSE STRUCTURE

Course	Course Title	Credit hours	Marks
FIRST SEMESTER			
BT-611	Instrumentation and Techniques	4 CH	100
BT-612 (A to G)	Elective Papers (Any one):	4 CH	100
	(A) Applied Immunology		
	(B) Bioprocess Engineering & Technology		
	(C) Computational Biology		
	(D) Rational Drug Design & Evaluation		
	(E) Genomics & Proteomics		
	(F) Medical Microbiology		
	(G) Plant Genome Mapping and Genomics		
BT-613	Research Methodology (Quantitative Analysis and Computer Applications)	4 CH	100
BT-614	Practical (Based on BT-611 and BT-612)	4 CH	100
BT-615	Review of Research papers published in Journals (Review Report- 2 CH and Seminar- 2 CH)	(2+2) CH	100
Semester Total Credit		**20 CH**	**500**
SECOND SEMESTER			
BT-621	Seminar (At least two)	2 CH	50 + 50
BT-622	Dissertation (Interim Report- 8 CH & Final presentation- 10 CH)	(8+10) CH	100 + 200
Semester Total Credit		**20 CH**	**400**
Total Course Credit		**40 CH**	**900**

FIRST SEMESTER

BT-611	INSTRUMENTATION & TECHNIQUES	4 CH	100

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 (Gel 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.

BT-612 (A –F) (ELECTIVE PAPER: ANY ONE)

BT-612(A)	APPLIED IMMUNOLOGY	4 CH	100

Unit-I

Basic and Engineering aspect of molecules and receptors involved in immune function and dysfunction: 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, Gene transfer techniques, Microarray for gene expression analysis, 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.

BT-612(B)	**BIOPROCESS ENGINEERING & TECHNOLOGY**	**4 CH**	**100**

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).

BT-612(C)	COMPUTATIONAL BIOLOGY	4 CH	100

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.

BT-612(D)	RATIONAL DRUG DESIGN AND EVALUATION	4 CH	100

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.

BT-612(E)	GENOMICS AND PROTEOMICS	4 CH	100

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*), Prédiction 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.

BT-612(F)	MEDICAL MICROBIOLOGY	4 CH	100

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.

BT-612(G)	PLANT GENOME MAPPING AND GENOMICS	4 CH	100

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.

BT-613	RESEARCH METHODOLOGY (Quantitative Analysis & Computer Applications)	4 CH	100

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.

BT-614	**PRACTICAL (Based on BT-611 and BT-612)**	**4 CH**	**100**

BT-615	**REV IEW OF RESEARCH PAPERS IN REFERRED JOURNALS** **(Review Report: 2 CH & Seminar: 2 CH)**	**2+2 CH**	**100**

SECOND SEMESTER

BT-621	**SEMINAR (At least two)**	**2 CH**	**50 + 50**

BT-622	**DISSERTATION** **(Interim Report: 8 CH & Final Presentation: 10 CH)**	**18 CH**	**100 + 200**

***** $$ *****