Department of BIOTECHNOLOGY

Deen Dayal Upadhyaya Gorakhpur University

M.Sc. Biotechnology

Syllabus for Two Year Post Graduate Programme

As per New Education Policy - 2020

W.e.f. Session 2024 - 25

AFFILIATION

The proposed programme shall be governed by the Department of Biotechnology, Faculty of Science, D.D.U. Gorakhpur University, Gorakhpur– 273009.

PROGRAMME STRUCTURE

The M. Sc. Programme is divided into two Parts as under. Each part will consist of two Semesters as given below.

		Semester – Odd	**Semester – Even**
Part I	First Year	Semester – 1	Semester – 2
Part II	Second Year	Semester – 3	Semester – 4

For semester-1 and 2 would consist of four theory papers of 4 credits each, one laboratory course of 4 credits and Project/Review/Industrial Training of 4 credits. In Semester 1, there would be one open/minor elective course of 4 credit. Total credit in Semester 1 will be 20+4. Each student will carry research project/review/industrial training under the supervision of a faculty of the department. There may be a co-supervisor also from any industry/institute etc. The project/review/industrial training will be related to main subject. The students will submit the joint Research Project of Semester 1 and 2 at the end of 2nd Semester for evaluation. In semester 3, there would be two core courses of 4 credit each and two optional/elective courses having at least 3 options each. Semester 3 would also contain Laboratory course based on the theory papers of 4 credit. There would be a Project/review of 4 credit. In Semester 4, in addition to two core courses, there would be 2 optional courses having 3 options in each. At the end of 4th Semester, students will submit their research project/Review carried out in 3rd and 4th Semester for evaluation

MASTER OF SCIENCE
(BIOTECHNOLOGY)
TWO-YEAR FULL-TIME PROGRAMME

Curriculum Structure

Year	Course No.	Course Title	Credit	Course Type (Core/Elective)
		Semester 1		
	BT-501N	Microbiology	4+0	Core
	BT-502N	Molecular Biology	4+0	Core
	BT-503N	Biochemistry	4+0	Core
	BT-504N	Cell biology	4+0	Core
	BT-506N	Laboratory Course-I (based on core courses)	0+4	Core
FIRST YEAR	**Total**		20	
		Semester 2		
	BT 508N	Recombinant DNA Technology	4+0	Core
	BT 509N	Enzyme Technology	4+0	Core
	BT 510N	Immunology	4+0	Core
	BT 511N	Bio-analytical techniques	4+0	Core
	BT 512N	Laboratory Course-II (based on core courses)	0+4	Core
	BT-505N	Introductory Biotechnology/MOOC or SWAYAM courses*	4+0	Open elective
		Total	20+4	
		Semester 3		
	BT 514N	Animal Cell Culture	4+0	Core
	BT 515N	Bioprocess technology	4+0	Core
	BT 516 N BT 517N BT 518N	Omics Technology Food Biotechnology Bio-entrepreneurship	4+0	Optional (only one)
SECOND YEAR	BT 519N BT 520N BT 521N	Plant Tissue Culture Transgenic Technology Molecular Diagnostics	4+0	Optional (only one)
	BT 522N	Laboratory course-III (based on core and optional courses)	0+4	Core
	BT 523N	Project/review	0+4	Core
		Total	24	
		Semester 4		
	BT 524N	Environmental Biotechnology	4+0	Core
	BT 525N	Bioinformatics	4+0	Core
	BT 526N BT 527N BT 528N	Stem cell Technology Developmental Biology Scientific Writing and communication	4+0	Optional (only one)
	BT 529N BT 530N BT 531N	Biosafety, IPR and Bioethics Molecular Genetics Nanobiotechnology	4+0	Optional (only one)
	BT 532N	Project/review	0+4	Core
		Total	24	

*** Students may take MOOC or SWAYAM courses of 4 credits that are similar in nature.**

Semester-I

BT 501N   MICROBIOLOGY   4+0

Unit-1:
Microbial diversity and systematics, Modern approaches to bacterial taxonomy, Nomenclature and outline of bacterial classification as per Bergey's Manual, General characteristics of viruses of bacteria, plants, and animals, prions. Accessing microbial diversity using molecular methods, 16S rDNA sequencing, metagenomics: principle, methodology, types, and applications.

Unit-2
Methods in Microbiology: Theory and practice of sterilization, Pure culture techniques, Construction of culture media, Enrichment culture techniques, Isolation and culture of aerobic and anaerobic bacteria, Culture collection, preservation, and maintenance of microbial cultures.

Unit-3:
Metabolic diversity among microorganisms: Microbial Nutrition: nutritional types and modes of nutrition in bacteria, Extremophiles. Microbial growth: The definition of growth, mathematical expression of growth, growth curve, measurement of growth, and growth yields.

Unit-4:
Types of antimicrobial agents; Classes of antibiotics (β-lactams, tetracyclins, aminoglycosides, macrolids, Polypeptides antibiotics & their mode of action; Antiviral, antifungal, antiprotozoan antibiotics; Development of resistance to antibiotics; Bacterial Genetic System: Transformation, Conjugation, Transduction ,and Recombination

Suggested Reading:
- Brock Biology of Microorganisms, 9th Edition. By *Michael T. Madigan, John M. Martinko*, *Jack Parker*. Prentice Hall, Inc.
- Microbiology, 4th Edition. By *Lansing M. Prescott, John P. Harley, Donald A. Klein*. WCB McGraw Hill.
- General Microbiology, 5th Edition by *Roger Y. Stanier, John L. Ingraham, Mark L. Wheelis, Page R. Painter*, Macmillan Press Limited.
- Microbiology: Principles and Explorations, 5th Edition. By *Jacquelyn G. Black*, John Wiley& Son, Inc.

BT 502N   MOLECULAR BIOLOGY   4+0

Unit 1:
Prokaryotic and eukaryotic genome organization, structural elements of chromosome and construction of artificial chromosome. DNA replication: Enzymes, accessory proteins and mechanisms of prokaryotic and eukaryotic DNA replication.

Unit 2:
Fine structure of gene, molecular basis of spontaneous and induced mutations and their role in evolution; DNA damage and repair, DNA amplification and rearrangement. Anti-sense and Ribozyme Technology: Inhibition of splicing, polyadenylation and translation, disruption of RNA structure and capping, Biochemistry of ribozyme, hammerhead, hairpin and other ribozymes, applications of anti-sense and ribozyme technologies.

Unit 3:
Transcription: Organization of transcriptional units, mechanisms of transcription and its regulation in prokaryotes and eukaryotes, Operon concept, attenuation and antitermination controls, RNA processing

(capping, polyadenylation, splicing), DNA methylation, heterochromatization, General and specific transcription factors, regulatory elements and mechanism of transcription regulation, transcriptional and post-transcriptional gene silencing, environmental regulation of gene expression.

Unit-4:
Translation: Genetic code, Prokaryotic and Eukaryotic translation, mechanisms for initiation, elongation and termination, regulation of translation, co-and post- translational modifications of proteins. Homologous Recombination and Site-specific recombination.

Suggested Reading:
- Molecular Biology of the Gene (4th Edition) *J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A. Steitz and A.M Weiner*, The Benjamin/ Cummings Publ. Co. Inc, California
- Molecular Biology of the cell (3rd Edition) by *Bruce Alberts, Dennis Bray, Julian Lewis, martin Raff, Keith Roberts and James D. Watson,* Garland Publishing, Inc, New York & London
- Gene Cloning and DNA Analysis (4th Edition) by *T.A Brown*, Blackwell Science
- Essential of Molecular Biology (3rd edition) by *G.M. Malacinski& D. Freifelder,* Jones & Bartlett Publisher

BT 503N   BIOCHEMISTRY   4+0

Unit 1
Amino acids and proteins: Classification, structure and properties of amino acids; primary, secondary, tertiary, quaternary and domain structure of proteins, forces stabilizing protein structure, Ramachandran plot, DNA-protein and protein-protein interactions, protein folding, protein misfolding and related diseases; protein sequencing.

Unit 2
Nucleic acids: Primary and secondary structure of nucleic acids, Watson-Crick model of DNA, structural polymorphism of DNA and RNA, the three-dimensional structure of RNA, biosynthesis of purines and pyrimidines.

Unit 3
Carbohydrates: Classification and structure of carbohydrates, polysaccharides, glycoproteins and peptidoglycans, glycolysis, TCA cycle, oxidative phosphorylation, glycogen synthesis and breakdown, gluconeogenesis, interconversion of pentoses and hexoses.

Unit 4
Lipids: Classification, structure and functions, biosynthesis of fatty acids, oxidation of lipids, triglycerides, phospholipids, sterols.

Suggested Reading:
- Biochemistry by Stryer, Freeman publisher
- Biochemistry, Vol I, II, III by GeofferyZubey, WCB press
- Fundamentals of Biochemistry by Voet, Voet& Pratt, John Wiley publisher
- Principles of biochemistry by Albert Lehninger, David L Nelson & Michael M Cox, Mac Milan worth publisher.

BT 504N   CELL BIOLOGY   4+0

Unit 1:

Cellular organelles: Cell types (prokaryotes/ eukaryotes), Plasma membrane, cell wall, cytoskeleton-their structural organization; Mitochondria; Chloroplast; Nucleus and other organelles and their organization and function, genetic constitution of mitochondria and chloroplast, artificial membrane Liposomes.

Unit 2:

Structure and organization of cell skeleton; Microfilaments and Microtubule-structure and assembly, actins, myosin muscle contraction, cilia, flagella-structure and function

Unit 3:

Biological membranes: Physicochemical properties of cell membranes and their structural constitution. Transport of nutrients across the membranes: simple, passive, facilitated diffusion, Protein targeting and sorting- Post transitional import of proteins to mitochondria lysosomes, nucleus, secretory vesicles, chloroplast and peroxisomes.

Unit 4:

Cell cycle: Mitosis, meiosis, the role of cyclins and cyclin-dependent kinases, regulation of Cdk-cyclin activity, Cdk inhibitors, induction of cancer with respect to cell cycle, molecular events and regulation in model systems, cell surface receptors, second messenger system, MAP kinase pathways, mechanism of signal transduction pathway. Molecular biology and biochemistry of cancer, oncogenes, tumour suppressor genes, chemical carcinogenesis

Suggested Reading:

- Essential Cell Biology by Bruce Alberts et.al., Garland Publisher.
- Cell and Molecular Biology by F. D P deRobertes, LW & W Publisher.
- Molecular Biology of the Cell by Alberts, Bray, Lewis, Raff, Roberts and Watson, Garland Publishers.
- Molecular Cell Biology by H. Lodish, D. Baltimore, A. Bark, S. L. Zipursky, P.Matsudaira and J. Darnell, Scientific American Books.

BT 506N   LABORATORY COURSE-I BASED ON CORE COURSES   0+4

The Laboratory course will based on the core courses

Semester-II

BT 508N   RECOMBINANT DNA TECHNOLOGY   4+0

Unit 1:
Molecular tools and their applications: Restriction endonucleases, polymerases, nucleases, kinases, topoisomerases, gyrases, methylases, and ligases. Adapters, Linkers and Homopolymer tailing, Cloning vectors: Plasmids, Bacteriophages, Cosmids, Phagemids, Artificial chromosomes (BAC, PAC, MAC).
Unit 2:
Construction and screening of genomic and cDNA libraries, EMSA (Electrophoretic mobility shift assay), DNA footprinting, Primer extension, SI mapping, RNase protection assay, Reporter assays, Principles and techniques of nucleic acid hybridization,
Unit 3
Polymerase chain reaction: principle, types, and applications of PCR in different fields. DNA microarray-fabrications, variations, and applications, Serial Analysis of Gene Expression (SAGE)-principle and applications.
Unit 4
Expression strategies for heterologous genes: expression in bacteria, yeast, insects, mammalian cells and plants, *in-vitro* transcription and translation, T-DNA, and transposon tagging.
Suggested Reading:
- iGenetics by *Peter J Russell*, Benjamin/ Cummings, New York
- From Genes to Clones: Introduction to gene technology, by *Ernst-L Winnacker*, VCH Publication, Germany
- Principles of Gene Manipulation: An Introduction to Genetic Engineering (6th Edition) by R.W. *Old and S.B. Primrose*, Blackwell Publication
- Genes IX by *Benjamin Lewin*, Oxford University Press, U.K.

BT 509N   ENZYME TECHNOLOGY   4+0

Unit 1
Nomenclature and classification of enzymes, general properties of enzymes, active sites, cofactors and specificity.Isolation, purification and large scale production of enzymes with principles and applications of the involved techniques, viz gel filtration, ion exchange and affinity chromatography, centrifugation and electrophoretic techniques.
Unit 2
Enzyme kinetics: Enzymatic reaction mechanisms, Michaelis-Menten equation, Effect of substrate, pH, temperature and inhibitors on enzyme activity.Mechanism of enzyme action and regulation: Active and regulatory sites, chemical modification, feedback inhibition, positive and negative cooperativity, allosteric enzymes.
Unit 3
Isozymes, multienzyme complexes, artificial enzymes, catalytic antibodies. Enzyme engineering-strategies, directed evolution, degradation of unnatural substrates.
Unit 4
Industrial enzymes: In detergent, food, leather, dairy, medicines and chemical industries.
Enzyme immobilization: Introduction, methods, applications and limitations.
Suggested Reading:

- Enzymes: Biochemistry, Clinical Chemistry by T. Palmor, Harwood press
- Fundamentals of Enzymology: The cell and molecular biology of catalytic proteins, by NC Price and Steven, Oxford press.
- Biochemistry, Vol I, II, III by GeofferyZubey, WCB press

- Fundamentals of Biochemistry by Voet, Voet& Pratt, John Wiley publisher

BT 510N   IMMUNOLOGY   4+0

Unit 1:
Introduction: Phylogeny of Immune System, Innate and acquired immunity, Clonal nature of immune response, Primary and secondary immune response, Organization and structure of lymphoid organs, Cells of the immune system:Haematopoesis and differentiation, lymphocyte trafficking, B lymphocytes, T-lymphocytes, Macrophages, dendritic cells, natural killer and lymphokine activated killer cells, Eosinophils, Neutrophils and mast cells.Antigens and superantigens.Structure and function of immunoglobulins.

Unit 2:
Major histocompatibility complex; Antigen processing and presentation, BCR and TCR, generation of immunological diversity, Complement system.Cell- mediated cytotoxicity : Mechanism of T cell and NK cell mediated lysis, antibody dependent cell mediated cytotoxicity, macrophage mediated cytotoxicity, effector mechanism.

Unit 3:
Regulation of immune response:Generation of humoral and cell medicated immune responses, Activation of B-and T-lymphoeytes, cytokines and their role in immune regulation, Immunological tolerance, Genetic control of immune responses. Immunoprophylatic intervention: Basic concepts of vaccination and different types of vaccines.

Unit 4:
Hypersensitivity, Autoimmunity, Tumor immunology, AIDS and other immune-deficiencies.Antigen and antibody interactions, Immunodiffusion, Immunoelectrophoresis, RIA, ELISA, Hybridoma technology and monoclonal antibodies.

Suggested Reading:
- Cellular and Molecular Immunology by *Abbas et al.*, Saunder Publication.
- Essential Immunology by *Roitt*, Blackwell Publisher.
- Immunology by *Kuby*, Freeman Publisher.
- Immunology-a short course by *Benjamini*, Wiley-Liss Publisher.

BT 511N   BIOANALYTICAL TECHNIQUES   4+0

Unit 1 :
Microscopic techniques: Principles and application of light, phase contrast, fluorescence, confocal, scanning and transmission electron microscopy, cytophotometry and flow cytometry, fixation and staining, Fluorescence in-situ hybridization (FISH), GISH (Genomic in-situ hybridization).

Unit 2
Chromatography & Spectroscopy: column chromatography (ion exchange, gel permeation, affinity), GLC and HPLC. Principles of colorimetry and UV-Vis spectrophotometry, Mass spectrometry, MALDI, X-Ray Crystallography

Unit 3:
Electrophoresis and Radiation Biophysics: chromatography Agarose and polyacrylamide gel electrophoresis (native and denaturing), Immuno-electrophoresis, Isoelectric Focusing, Capillary electrophoresis. Principles of fluorescence, Tracer Technology, Dose-response relationship, Radioisotopes in Diagnostics and Biotechnology

Unit 4:

Gene Editing: History of its discovery, elucidation of the mechanism including an introduction to all the molecular players, development of applications for in vivo genome engineering for genetic studies, and promise of the technology as a next-generation therapeutic method.

Suggested Readings
- Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.
- Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 5th Edition, Cambridge University Press, 2000.
- D. Holme & H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998

BT 512N   LABORATORY COURSE-III (based on core courses)   0+4

Laboratory course will based on core courses

BT 505N   INTRODUCTORY BIOTECHNOLOGY   0+4

Unit–1:
Scope of biotechnology, conventional and modern biotechnology; Basic structure of prokaryotic and eukaryotic cell; Central dogma of molecular biology; Genetic engineering: Basic cloning strategy.
Unit–2
Plant and Animal Biotechnology; Concept of plant tissue culture, micropropagation and transgenic plants; Transgenic animals and concept of bio-pharming
Unit–3
Industrial and Environmental Biotechnology; Basic Design of Fermenter, Food and Beverages Fermentation, Probiotics and Antibiotics; Bioremediation of Soil and Water, Biotechnological Approaches for management of environment.
Unit– 4
Biotechnology and Social Welfare; Microbial Diseases of Humans; Stem Cells and Gene Therapy., Development of vaccines; Bio-safety: Definition, Requirement, Bio-safety Containment Facilities and Biohazards;

Suggested Reading:

- Albert B; Bray D; Raff M; Roberts K and Watson JD. (2004). Molecular Biology of the Cell, Garland Publishing Inc., New York. 6th Ed.
- Bhohwani, S. S. (1990) Plant Tissue Culture: Applications and Limitations, Elsevier, Amsterdam.
- Clark, D. P (2005). Molecular Biology: Understanding the Genetic Revolution. Academic press
- Bernard R. Glick, Jack J. Pasternak, Cheryl L. Pattten. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th Ed. ASM press.
- S. Primrose, R. Twyman, B. Old, and G. Bertola (2006), Principles of Gene Manipulation and Genomics, Blackwell Publishing Limited; 7th Edition

SEMESTER-III

BT 514N   ANIMAL CELL & TISSUE CULTURE   4+0

Unit 1
Introduction to animal cell and tissue culture, its advantages and limitations, Applications of animal cell and tissue culture.
Basic techniques in animal cell culture: Disaggregation of tissue and setting up of primary culture, established cell line cultures, maintenance of cell culture, culture media and role of serum in cell culture, organ culture.
Unit 2
Biology and characterization of the cultured cells, measurement of growth, measurement of viability and cytotoxicity.
Scale up of animal cell culture, cell cloning, cell synchronization and transformation.
Unit 3
Stem cell cultures: Embryonic and adult stem cells, their isolation, culture and applications, animal cloning.
Transgenic animals: Construction of transgenic animals, gene knockouts, ethical and biosafety considerations.
Unit 4
Gene therapy: Genetic disorders, vector engineering, types of gene therapy, strategies of gene delivery, targeted gene replacement/augmentation, gene editing, gene correction, gene silencing.
Molecular markers linked to disease resistance genes, Application of RFLP in forensic, disease prognosis, genetic counseling and pedigree analysis.

Suggested Reading:

- Animal Cell Culture: A practical approach by R.I. Freshney, IRL press.
- Culture of animal cells: A manual of basic techniques by R.I. Freshney, Willy-Liss and Sons publication.
- Animal cell culture technique by Martin Clynes, Springer publication.

BT 515N   BIOPROCESS TECHNOLOGY   4+0

Unit 1:
Introduction to bioprocess technology, bioreactors, Isolation, preservation and maintenance of industrial microorganisms, kinetics of microbial growth and death, media for industrial fermentation, air and media sterilization.
Unit 2:
Types of fermentation processes: Analysis of batch, fed-batch, and continuous bioreactors, stability of microbial reactors, analysis of mixed microbial populations, specialized bioreactors (pulsed, photobioreactors etc.), measurement and control of bioprocess parameters.
Unit 3:
Downstream processing: Introduction, removal of microbial cells and solid matter, foam separation, precipitation, filtration, centrifugation, cell disruptions, liquid-liquid extraction, chromatography, Membrane process, Drying and crystallization, Whole-cell immobilization and its industrial application.

Unit 4:

Industrial production of chemicals: Alcohol (ethanol), acids (citric, acetic and gluconic), Solvents (glycerol, acetone, butanol), Antibiotics (penicillin, streptomycin, tetracycline). Amino acids (lysine, glutamic acid), Single cell protein, Use of microbes in mineral beneficiation and oil recovery.

Suggested Reading
- Principles of fermentation technology by PF Stanbury, A Whitekar and SJ Hall, Aditya Books.
- Bioprocess Engineering; Basic Concept by ML Suler& F Kargi, PHI Press.
- Operational modes of bioreactors (BIOTAL Series), ButterworhHeineman.
- A Textbook of Industrial Microbiology by W Cruger&ACruger, W. H Freeman (Panima) Publisher

BT 516N   OMICS TECHNOLOGY   4+0

Unit I:
Introductory genomics Introduction to Genomics, Anatomy of prokaryotic and eukaryotic genome, the content of the genome, C-value paradox, CoT curve analysis, repetitive DNA, tools to study genome diversity.

Unit II:
Applied Genomics Strategies for major genome sequencing projects, approaches and assembly methods, NGS methods and advantages, gene analysis, and annotation.

Unit III:
Transcriptomics and expression profiling Genome expression analysis, RNA content and profiling, genetic mapping, Microarray (cDNA and protein microarray)

Unit IV:
Introductory proteomics Importance of proteomics, strategies in the analysis of proteome: 2-D PAGE, Mass spectrometry, Protein sequencing method (Edman degradation, MALDI TOF/TOF).

Suggested Reading:
- Database Annotation in Molecular Biology: Principles and Practice, Arthur M. Lesk
- Bioinformatics : Sequence and genomic analysis by D. W. Mount, Cold Spring Harbour Laboratory Press.
- Recombinant DNA (Second Edition), James D. Watson and Mark Zoller
- Gene Cloning and DNA Analysis – An Introduction (Fourth Edition), T.A. Brown
- Protein array, Biochips and Proteomics by Smith and Albala (Eds), Marcel Dekkar, New York.
- Introduction to proteomics: Tools for new biology by Daniel C. Liebler, Humana Press.

BT 517N   FOOD BIOTECHNOLOGY   4+0

Unit 1:
Introduction and history of food microbiology, General characteristics, classification and importance of microorganisms important in food microbiology, Principles of food preservation. Factors influencing microbial growth in food – Extrinsic and intrinsic factors; Chemical preservatives.

Unit 2:
Contamination and spoilage: Detection of spoilage and characterization. Food-borne infections and intoxications: Bacterial and nonbacterial toxins with examples of infective and toxic types – Brucella, Bacillus, Clostridium, Escherichia, Salmonella, Shigella, Staphylococcus, Vibrio, Yersinia, Nematodes, protozoa, algae, fungi, and viruses.

Unit 3:

Food fermentations: Industrial production method for microbial starters, bread, cheese, vinegar, fermented vegetables, fermented dairy products; fermented foods, microbial cells as food (single cell proteins, mushrooms), fermented beverages: beer and wine. Amino acid production: glutamic acid and lysine. Production of probiotics and prebiotics, nutraceuticals, low calorie sweetener, food coloring and naturally occurring flavor modifiers.

Unit 4:
Food quality standards, Monitoring and control, Food Adulteration, R&D innovations in food microbiology, genetically modified foods, Need and requirements of food packaging; Containers for packaging, Dispensing devices, Food Regulations/Safety & Quality Standards & Food Laws

Suggested Reading:
- Food microbiology- Royal society of chemistry: MR Adams and MO Moss.
- Principles of fermentation technology: PF Stanbury, A Whitekar and SJ Hall, Pergamon Press.
- Basic Food Microbiology: GJ Banwart, CBS Publishers.

BT 518N   BIO-INTREPRENEURSHIP   4+0

Unit-1:
Introduction to Bioentrepreneurship: concepts and overview of entrepreneurship, evolution and growth of entrepreneurship in India; Trends in entrepreneurship development, entrepreneurial potential and potential entrepreneur, finance management, Personal development and etiquette training.

Unit-2:
Human resource development, team building, and teamwork for entrepreneurship, small-scale set-up; Support mechanism for Biotechnology entrepreneurship in India, Preparation of proposal for funding

Unit-3:
Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies. Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP)

Unit-4:
Knowledge center and R&D: Knowledge centers like Universities and Research Institutions, Technology and upgradation, managing technology transfer, regulations for the transfer of foreign technologies, and Technology transfer agencies.

Suggested Reading
- The Business of Biotechnology: From the Bench of the Street: By Richard Dana Ono Published Butterworth- Heinemann, 1991.
- Entrepreneurship in Biotechnology: Managing for growth from start-up By Martin Gross Mann, 2003
- Innovation and entrepreneurship in biotechnology: Concepts, theories & cases by D. Hyne & John Kapeleris, 2006
- Dynamics of Entrepreneurial Development and Management by Vasant Desai, Himalaya Publishing House, 2005.
- Projects Planning Analysis, Selection, Implementation & Review by Prasannan. 6. Best Practices in Biotechnology Education: By Yali Friedman, Published by Logos Press, 2008.

BT 519N   PLANT TISSUE CULTURE   4+0

Unit 1:

History of plant cell and tissue culture; Culture media; various types of culture; callus, suspension, nurse, root, meristem, etc.; *In vitro* differentiation; organogenesis and somatic embryogenesis.Micropropagation; Anther and microspore culture; Somaclonal variation; *In vitro* fertilization; *In vitro* germplasm conservation; Production of secondary metabolites; Synthetic seeds.

Unit 2:

Embryo culture and embryo rescue; Protoplast isolation, culture and fusion; selection of hybrid cells and regeneration of hybrid plants; symmetric and asymmetric hybrids, cybrids. Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available molecular markers, transformation and genomic tools for crop improvements. Molecular marker-aided breeding, QTL, molecular marker assisted selection.

Unit 3:

Plant transformation technology: *Agrobacterium* mediated, Particle bombardment, Electroporation; transgene stability and gene silencing. Chloroplast Transformation, Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature, etc.) and biotic (insect pest, fungal, viral and bacterial diseases, weeds, etc.) stresses; Genetic engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency; Genetic engineering for quality improvement (protein, essential amino acids, vitamins, minerals nutrients, etc.) etc.

Unit 4:

Metabolic Engineering and Industrial Products: Plant secondary metabolites, control mechanisms and mainipulation of phenylpropanoid pathway, shikimate pathway; alkaloids, biodegradable plastics, therapeutic proteins, edible vaccines, purification strategies.

Suggested Reading:

- Plant Tissue Culture: Application and Limitation by *S. S. Bhojwani and M. K. Razdan,* Elsevier Publication
- Plants, Genes and Agriculture by *Maarten J Chrispeels and David E. Sadava*, Jones & Bartlett Publishers
- An Introduction to Plant Tissue Culture by *M. K. Razdan*, Oxford & IBH Publishing Co. Pvt. Ltd.
- Plant Biotechnology: The genetic manipulation of plants by *Adrian Slater, Nigel Scott, and Mark Fowler,* Oxford University Press

BT 520N   TRANSGENIC TECHNOLOGY   4+0

Unit 1

Introduction to transgenic technology in plants and animals, and its applications to basic research and commercial benefit. Tools, techniques and methodologies for developing transgenic plants and animals. Strategies and methodologies of screening, selection, verification and characterization of transformed tissues of plants and animals.

Unit 2

Molecular farming- production of high value pharmaceutical products in plant and animal systems. Innovation and Entrepreneurship development from the knowledge of transgenic technology.

Unit 3

Transgenic technology for basic and applied research in plant systems: Transgenic technology in plant functional genomics- random insertional mutagenesis of genes, silencing of specific endogenous gene and concept of gene targeting. Application of transgenic technology for enhancement of crop yield and nutritional quality of food constituents (carbohydrates, proteins and lipids); and improvement of quantity and quality of plant biomass required for non-food industrial raw materials.

Unit 4

Transgenic technology for basic and applied research in animal systems: Transgenic animals for functional genomics through random insertional mutagenesis and gene targeting. Transgenic farm

animals, poultry birds and fishes for vaccine development, production of growth hormones and other commercial products; Improving the nutritional quality of milk and meat by transgenic approach. Transgenic mammals for gene therapy.

Suggested Reading
1. Transgenic animal technology by Karl A. Pinkert, Gulf Professional Publishing
2. Trnasgenic technology based value addition in plant biotechnology by Usha Kiran, M Z Abdin, Kamaluddin, London Academic Press, 2020
3. Strategies in Transgenic Animal Science, by Glenn M., James M. Robl, Monastersky, ASM Press.

BT 521N   Molecular Diagnostics   4+0

Unit I

Basic idea of Molecular Diagnostics, Technologies related to Molecular Diagnostic: PCR-Based Methods for Mutation Detection, Other Methods for Mutation Detection. Sequencing of DNA for Disease Association, Gene Expression Analysis through Microarray Approaches, Methods for Analysis of DNA Methylation, Other Clinical Diagnostic Technologies: Flow Cytometry, Medical Cytogenetics, Fluorescence In Situ Hybridization, Immunohistochemistry, Laser 22 Capture Microdissection (FFPE).

Unit 2

Quality Assurance in the Molecular Diagnostics Laboratory: Framework for Quality Assurance in Molecular Diagnostics, Verification of Molecular Assays, Standards and Standardization of Molecular Diagnostics, Laboratory Developed Tests in Molecular Diagnostics.

Unit 3

Applications of Molecular Diagnostics for Genetic Diseases, Molecular diagnostics of Coagulation, Cystic Fibrosis; Prenatal Genotyping for Identification of Fetuses at Risk for Immune Cytopenic Disorders. Applications of Molecular Diagnostics for Human Cancers and Infectious Diseases. Molecular Analysis for Forensic Casework and Parentage Testing.

Unit 4

Personalized Medicine, Genetic Counseling Considerations in Molecular Diagnosis, Ethical, Social, and Legal Issues Related to Molecular Genetic Testing…

Suggested Reading:

1. Molecular Diagnostics: For the Clinical Laboratorian / Edition 2 William B. Coleman (Editor), Gregory J. Tsongalis (Editor) Publisher: Springer-Verlag New York, LLC.
2. Molecular Diagnostics: Fundamentals, Methods and Clinical Applications, April 2019 by Lela Buckingham (Author), Publisher: FA Davis Company.
3. Molecular Diagnostics, Edited by George Patrinos, Wilhelm Ansorge, Phillip B. Danielson, Elsevier Publication
4. Molecular Diagnostics For the Clinical Laboratorian, Edited by William B. Coleman, Gregory J. Tsongalis. Springer publication.

BT 522N   LABORATORY COURSES (based on core and optional courses)   0+4

Laboratory course will be based on core and optional courses

BT 523N   PROJECT/REVIEW/INDUSTRIAL TRAINING   0+4

Each student must conduct a project/review/ industrial training in the third semester under the guidance of the allotted advisor/supervisor. The evaluation of the same will be done at the end of the fourth semester as per the guideline issued by the university authority.

SEMESTER-IV

BT 524N   ENVIRONMENTAL BIOTECHNOLOGY   4+0

Unit 1:
Environmental Pollution: Classification of pollutants, Air, Water, Soil, Noise, and Thermal pollution: Their source, Effect, and biotechnology-based control measures. Solid waste pollution and its management.

Unit 2:
Wastewater Treatment: Physical, chemical, and Biological methods; activated sludge treatment, Treatment scheme of Dairy, Distillery, Tannery, Sugar, Fertilizers, Refinery, Chemical, and Antibiotic waste.

Unit 3:
Bioremediation & Phytoremediation: Principles, types, and applications; Biomining and recovery of metals from solutions, Microbes in petroleum extraction, Microbial desulfurization of coal, Biodegradation of chlorinated hydrocarbons and xenobiotic compounds

Unit 4:
Biofertilizers, biopesticides, and Integrated pest management (IPM). Non-conventional or renewable sources of energy, Energy from Biomass, Biosensors, and biochips. Ozone depletion, Greenhouse effect, and acid rain, their impact and biotechnological approaches for management.

Suggested Reading:

- Biotechnology – Expanding Horizons by *B.D. Singh*. 2nd Edition Kalyani Publishers.
- Microbial Ecology: Fundamentals & Applications by *Atlas, R.M.*Wc Brown.
- Environmental Microbiology by *A.H. Varman*, ASM Press.
- Biodegradation and Bioremediation by *Alexandar, M*. Wiley International.

BT 525N   BIOINFORMATICS   4+0

Unit 1
Introduction to Bioinformatics, use of Internet and search engines (WWW, HTML, URLs, Netscape, Explorer, Google, PUBMED), database management system, database browsing, data retrieval, sequence and genome database, databases such as GenBank, EMBL, DDBJ, Swissprot, PIR, TIGR, TAIR, Searching for sequence database like FASTA and BLAST algorithm, multiple sequence alignment, phylogenetic analysis and detection of open reading frames (ORFs).

Unit 2
DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing

Unit 3
Multiple sequence analysis: multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

Unit 4
Computational structural biology and Biostatistics: computational structural biology, in-silico methods for structural predictions, Homology threading and modeling, ab-initio modelling; Validation of in-silico determined 3D structures of proteins, Computer aided drug design-tools and applications.

Selection of sample or sampling, theory: qualitative, random and non-random sample. Collection of data, their classification, tabulation, graphic representation and diagrammatic representation, measures of central tendency and dispersion: mean, median, mode.

Suggested Reading
- Bioinformatics: A practical guide to the analysis of genes and proteins (3rd Edition) D. Baxevanis and F. Oulette, Wiley Indian Edition.17
- Bioinformatics Methods And Applications: Genomics Proteomics And Drug Discovery (3rd Edition) Rastogi SC, Rastogi P, Mendiratta N.. PHI Learning Pvt. Ltd.; 2008.
- Mount, D.W., Bioinformatics: 2001, Sequence and Genome Analysis. CSHL Press.
- Claverie, J.M. and Notredame C. 2003 Bioinformatics for Dummies. Wiley Editor

BT 526N   STEM CELL TECHNOLOGY   4+0

Unit 1
Stem cells: Definition, Classification, Sources and Properties –Types of stem cells: methods of isolation, study of stem cells and their viability, cancer stem cells. Preservations of Stem cell. Embryonic stem cell: Isolation, Culturing, Differentiation, Adult stem cell: Isolation, Culturing, Differentiation, Trans-differentiation
Unit 2
Factors influencing proliferation, physical, chemical and molecular methods for differentiation of stem cells – hormonal role in differentiation, Plasticity.
Unit 3
Germ cells, hematopoietic organs, and kidney, cord blood transplantation, donor selection, HLA matching, patient selection, peripheral blood and bone marrow transplantation, - Stem cell Techniques: fluorescence activated cell sorting (FACS), time lapse video, green fluorescent protein tagging
Unit 4
Stem cell Therapy for neurodegenerative diseases, spinal cord injury, heart disease, diabetes, burns, skin ulcers, muscular dystrophy and orthopaedic applications. Stem cell policy and ethics, stem cell research: Hype, hope and controversy.

Suggested Reading
- Stem Cell Biology, Daniel Marshak, Richard L. Gardener and David Gottlieb, Cold Spring Harbour Laboratory Press
- Stem cell biology and gene therapy, Booth C., Cell Biology International, Academic Press
- Stem Cell and Gene-Based Therapy: Frontiers in Regenerative Medicine, Alexander Battler, Jonathan Leo, Springer,

BT 527N   DEVELOPMENTAL BIOLOGY   4+0

Unit 1
Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis –vulva formation in Caenorhabditis elegans, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post-embryonic development-larval formation, metamorphosis; environmental regulation of normal development; sex determination.
Unit 2
Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.

Unit 3

Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum.

Unit 4

Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, the establishment of symmetry in plants; seed formation and germination.

Suggested Reading

- Sastry & Shukla; Development Biology; Rastogi Publication, Meerut.
- Bhojwani & Bhatnagar; The Embryology of Angiosperms; Vikas Publishing House, New Delhi.
- Balinsky B. I; An Introduction to Embryology; W. B. Saunders, New Delhi.
- Verma P.S., Agarwal V.K. and Tyagi B.S; Chordate Embryology. S. Chand and Co., New Delhi.
- Berrill N. J; Developmental Biology; Mc Graw Hill, New York

BT 528N   SCIENTIFIC WRITING AND COMMUNICATION   4+0

Unit 1

Presentation techniques: structure of presentations, interacting with PowerPoint, slide design, body language and positioning, presentation of participants, feedback.

Unit 2

Scientific writing: academic language, structure of scientific documents, scientific sources, thesis writing, Selection of journal with appropriate Impact factor, Effective Literature Review, Inclusion and sequencing of authors based on their roles.

Unit 3

Preparation of title and abstract of manuscript, Preparation of Experimental Design, Discussion and conclusion, Graphical abstract/Image representation, obtaining permission for reproduction of data from other journals, Statistical tools in research.

Unit 4

Compilation of discussion and future directions in a review article, Respond to the reviewer's comments, Inter- and intra-departmental collaborations, Guide for SCOPUS/WOS/SCI Journals and Predatory Journals

Suggested Reading

- Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
- Day, R.A., 1992. How to write and publish a Scientific paper, Cambridge University Press.
- Fink, A.,2009. Conducting Research Literature Reviews: From the internet to paper. Sage Publications.

BT 529N   BIOSAFETY, IPR AND BIOETHICS   4+0

Unit-1

Introduction To Intellectual Property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, IP as a factor in R&D; IPs of relevance to biotechnology; introduction of GATT, WTO, WIPO, and TRIPS; plant variety protection and farmers rights act; concept of prior art': invention in the context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

Unit-2:

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; the role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure /non-disclosure -patent application forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies; patent infringement.

Unit-3

Biosafety and Biosecurity; introduction to biological safety; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs LMOs; principles of safety assessment of transgenic plants. International Regulations –Cartagena Protocol, OECD consensus documents, and Codex Alimentarius; India Regulations –EPA act and rules, guidance documents, regulatory framework–RCGM, GEAC, IBSC, and other regulatory bodies.

Unit-4

Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, human and animal experimentation, animal rights/welfare, Genetically engineered food, environmental risk, labeling, and public opinion, biopiracy

Suggested Reading:

:
- Ganguli,P.(2001).Intellectual Property Rights: Unleashing The Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
- National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
- Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication.
- Kuhse, H. (2010). Bioethics: An Anthology. Malden, MA: Blackwell.
- Karen F.Greif and Jon F. Merz, Current Controversies in the Biological Sciences -Case Studies of Policy Challenge

 BT 530N   MOLECULAR GENETICS   4+0

Unit 1

Molecular pathology of Chromosome anomalies: Numerical chromosomal disorders, Structural chromosomal disorders, Chromosome instability syndromes.

Unit 2

Inherited biochemical diseases: Enzyme defects- amino acid metabolism, Lipid metabolic disorders, Carbohydrate associated disorders: Complex genetic diseases – Hypertension, Diabetes mellitus, Mitochondrial diseases, Cancer as a genetic disease.

Unit 3

Low resolution mapping: Sub- chromosomal mapping, Chromosomal break points, FISH, cytogenetic methods, Somatic cell hybrid mapping, Radiation hybrid mapping.

Unit 4

 High resolution mapping: DNA FIBRE FISH, Restriction mapping, VNTR microsatellite markers for mapping, EST mapping, STS mapping, SNP mapping, Conserved region mapping: IRE, CpG site mapping, Promoter site recognition

Suggested Readings:
1. Concepts of Genetics by Clugs, Cummings, Spencer etc
2. Molecular Biology of the Gene, 6th Ed., Watson et al, CSH Press,
3. Genes IX (VII, VIII), Benjamin Lewin, Jones and Bartlett
4. Genes and Genome, Singer & Berg, USB,

5. Genetic Analysis of Genes and Genomes, 6th Ed, Hartl & Jones, Jones and Bartlett,
6. Fundamental Bacterial Genetics, Trun & Trempy, Blackwell,
7. Genomes 3, TA Brown, Garland,

BT 531N   NANOBIOTECHNOLOGY   4+0

Unit 1
Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with examples for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.
Unit 2
Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterization. Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in synthesis
Unit 3
Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.
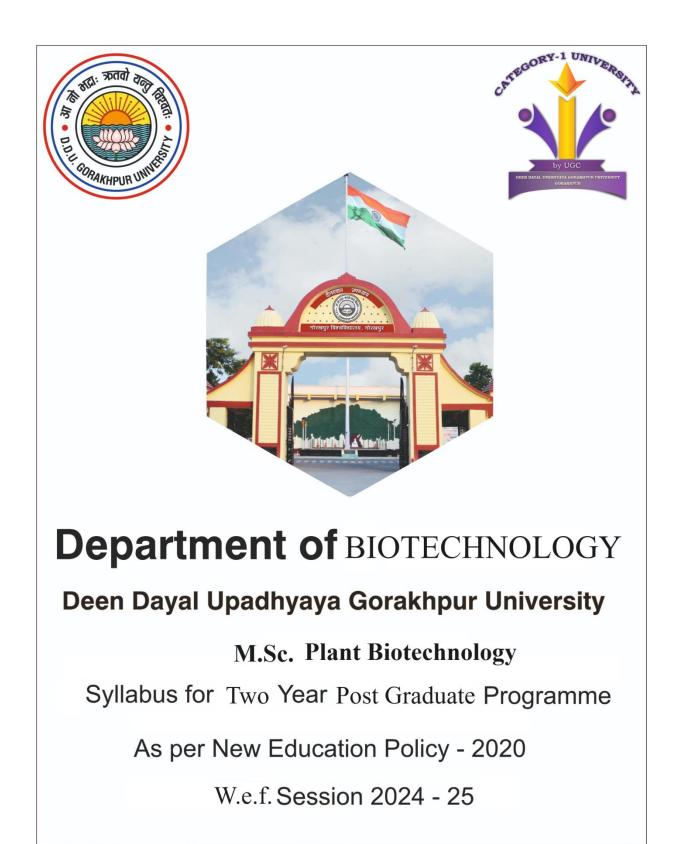**Unit 4**
Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli-responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

Suggested Readings

1. The 2023-2028 World Outlook for Pharmaceuticals and Biotechnology Nanobiotechnology. By Prof Philip M. Parker, Published by ICON Group International, Inc.
2. Microbial Interactions at Nanobiotechnology Interfaces Molecular Mechanisms and Applications R. Navanietha Krishnaraj, Rajesh K. Sani, Published by Wiley Science
3. Nanobiotechnology for Green Environment Edited by Amit Kumar, Chhotu Ram, CRC Press
4. Microbial Nanobiotechnology:Principles and Applications, By Agbaje Lateef, Evariste Bosco Gueguim-Kana, Nandita Dasgupta, Shivendu Ranjan, Springer Publication.

BT 532N   Project/Review   0+8

Each student must conduct a project/review in the fourth semester under the guidance of the allotted advisor/supervisor. The evaluation of the same will be done at the end of the fourth semester as per the guideline issued by the university authority.

Department of BIOTECHNOLOGY

Deen Dayal Upadhyaya Gorakhpur University

M.Sc. Plant Biotechnology

Syllabus for Two Year Post Graduate Programme

As per New Education Policy - 2020

W.e.f. Session 2024 - 25

AFFILIATION

The proposed programme shall be governed by the Department of Biotechnology, Faculty of Science, D.D.U. Gorakhpur University, Gorakhpur– 273009.

PROGRAMME STRUCTURE

The M. Sc. Programme is divided into two Parts as under. Each part will consist of two Semesters as given below.

		Semester – Odd	**Semester – Even**
Part I	First Year	Semester – 1	Semester – 2
Part II	Second Year	Semester – 3	Semester – 4

For semester-1 and 2 would consist of four theory papers of 4 credits each, one laboratory course of 4 credits and Project/Review/Industrial Training of 4 credits. In Semester 1, there would be one open/minor elective course of 4 credit. Total credit in Semester 1 will be 20+4. Each student will carry research project/review/industrial training under the supervision of a faculty of the department. There may be a co-supervisor also from any industry/institute etc. The project/review/industrial training will be related to main subject. The students will submit the joint Research Project of Semester 1 and 2 at the end of 2nd Semester for evaluation. In semester 3, there would be two core courses of 4 credit each and two optional/elective courses having at least 3 options each. Semester 3 would also contain Laboratory course based on the theory papers of 4 credit. There would be a Project/review of 4 credit. In Semester 4, in addition to two core courses, there would be 2 optional courses having 3 options in each. At the end of 4th Semester, students will submit their research project/Review carried out in 3rd and 4th Semester for evaluation

MASTER OF SCIENCE
(PLANT BIOTECHNOLOGY)
TWO-YEAR FULL-TIME PROGRAMME

Curriculum Structure

Year	Course No.	Course Title	Type (Core/Elective)	Credit
		Semester 1		
	PBT-501	Microbiology	4+0	Core
	PBT-502	Molecular Biology	4+0	Core
	PBT-503	Biochemistry	4+0	Core
	PBT-504	Cell biology	4+0	Core
	PBT-506	Laboratory Course-I (based on core courses)	0+4	Core
		Total:16+4		
		Semester 2		
FIRST YEAR	PBT 508	Recombinant DNA Technology	4+0	Core
	PBT 509	Enzyme Technology	4+0	Core
	PBT 510	Immunology	4+0	Core
	PBT 511	Bio-analytical techniques	4+0	Core
	PBT 512	Laboratory Course-II (based on core courses)	0+4	Core
	PBT-505	Introductory Plant Biotechnology	4+0	Open elective
		Total: 24		
		Semester 3		
	PBT 514	Plant Microbial Diversity	4+0	Core
	PBT 515	Fundamental Genetics	4+0	Core
	PBT 516 PBT 517 PBT 518	Plant Biotechnology Plant Physiology and Metabolism Plant Stress Biology	4+0	Optional (only one)
	PBT 519 PBT 520 PBT 521	Molecular Plant breeding Molecular Plant Pathology Molecular Diagnostics	4+0	Optional (only one)
SECOND YEAR	PBT 522	Laboratory course-III (based on core and optional courses)	0+4	Core
	PBT 523	Project/review	0+4	Core
		Total: 24		
		Semester 4		
	PBT 524	Genomics for crop improvement	4+0	Core
	PBT 525	Bioinformatics	4+0	Core
	PBT 526 PBT 527 PBT 528	Proteomics and Metabolomics Plant Developmental Biology Scientific Writing and communication	4+0	Optional (only one)
	PBT 529 PBT 530 PBT 531	Biosafety, IPR and Bioethics Molecular Genetics Photochemistry and Pharmacognosy	4+0	Optional (only one)
	PBT 532	Project/review	0+4	Core
		Total: 20		

*Evaluation of the project will be in the second semester

Semester-I

PBT 501N   MICROBIOLOGY   4+0

Unit-1:
Microbial diversity and systematics, Modern approaches to bacterial taxonomy, Nomenclature and outline of bacterial classification as per Bergey's Manual, General characteristics of viruses of bacteria, plants, and animals, prions. Accessing microbial diversity using molecular methods, 16S rDNA sequencing, metagenomics: principle, methodology, types, and applications.

Unit-2
Methods in Microbiology: Theory and practice of sterilization, Pure culture techniques, Construction of culture media, Enrichment culture techniques, Isolation and culture of aerobic and anaerobic bacteria, Culture collection, preservation, and maintenance of microbial cultures.

Unit-3:
Metabolic diversity among microorganisms: Microbial Nutrition: nutritional types and modes of nutrition in bacteria, Extremophiles. Microbial growth: The definition of growth, mathematical expression of growth, growth curve, measurement of growth, and growth yields.

Unit-4:
Types of antimicrobial agents; Classes of antibiotics (β-lactams, tetracyclins, aminoglycosides, macrolids, Polypeptides antibiotics & their mode of action; Antiviral, antifungal, antiprotozoan antibiotics; Development of resistance to antibiotics; Bacterial Genetic System: Transformation, Conjugation, Transduction ,and Recombination

Suggested Reading:
- Brock Biology of Microorganisms, 9th Edition. By *Michael T. Madigan, John M. Martinko*, *Jack Parker*. Prentice Hall, Inc.
- Microbiology, 4th Edition. By *Lansing M. Prescott, John P. Harley, Donald A. Klein*. WCB McGraw Hill.
- General Microbiology, 5th Edition by *Roger Y. Stanier, John L. Ingraham, Mark L. Wheelis, Page R. Painter*, Macmillan Press Limited.
- Microbiology: Principles and Explorations, 5th Edition. By *Jacquelyn G. Black*, John Wiley& Son, Inc.

PBT 502N   MOLECULAR BIOLOGY   4+0

Unit 1:
Prokaryotic and eukaryotic genome organization, structural elements of chromosome and construction of artificial chromosome. DNA replication: Enzymes, accessory proteins and mechanisms of prokaryotic and eukaryotic DNA replication.

Unit 2:
Fine structure of gene, molecular basis of spontaneous and induced mutations and their role in evolution; DNA damage and repair, DNA amplification and rearrangement. Anti-sense and Ribozyme Technology: Inhibition of splicing, polyadenylation and translation, disruption of RNA structure and capping, Biochemistry of ribozyme, hammerhead, hairpin and other ribozymes, applications of anti-sense and ribozyme technologies.

Unit 3:
Transcription: Organization of transcriptional units, mechanisms of transcription and its regulation in prokaryotes and eukaryotes, Operon concept, attenuation and antitermination controls, RNA processing (capping, polyadenylation, splicing), DNA methylation, heterochromatization, General and specific

transcription factors, regulatory elements and mechanism of transcription regulation, transcriptional and post-transcriptional gene silencing, environmental regulation of gene expression.

Unit-4:
Translation: Genetic code, Prokaryotic and Eukaryotic translation, mechanisms for initiation, elongation and termination, regulation of translation, co-and post- translational modifications of proteins. Homologous Recombination and Site-specific recombination.

Suggested Reading:
- Molecular Biology of the Gene (4ᵗʰ Edition) *J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A. Steitz and A.M Weiner*, The Benjamin/ Cummings Publ. Co. Inc, California
- Molecular Biology of the cell (3ʳᵈ Edition) by *Bruce Alberts, Dennis Bray, Julian Lewis, martin Raff, Keith Roberts and James D. Watson,* Garland Publishing, Inc, New York & London
- Gene Cloning and DNA Analysis (4ᵗʰ Edition) by *T.A Brown*, Blackwell Science
- Essential of Molecular Biology (3ʳᵈ edition) by *G.M. Malacinski& D. Freifelder,* Jones & Bartlett Publisher

PBT 503N   BIOCHEMISTRY   4+0

Unit 1
Amino acids and proteins: Classification, structure and properties of amino acids; primary, secondary, tertiary, quaternary and domain structure of proteins, forces stabilizing protein structure, Ramachandran plot, DNA-protein and protein-protein interactions, protein folding, protein misfolding and related diseases; protein sequencing.

Unit 2
Nucleic acids: Primary and secondary structure of nucleic acids, Watson-Crick model of DNA, structural polymorphism of DNA and RNA, the three-dimensional structure of RNA, biosynthesis of purines and pyrimidines.

Unit 3
Carbohydrates: Classification and structure of carbohydrates, polysaccharides, glycoproteins and peptidoglycans, glycolysis, TCA cycle, oxidative phosphorylation, glycogen synthesis and breakdown, gluconeogenesis, interconversion of pentoses and hexoses.

Unit 4
Lipids: Classification, structure and functions, biosynthesis of fatty acids, oxidation of lipids, triglycerides, phospholipids, sterols.

Suggested Reading:
- Biochemistry by Stryer, Freeman publisher
- Biochemistry, Vol I, II, III by GeofferyZubey, WCB press
- Fundamentals of Biochemistry by Voet, Voet& Pratt, John Wiley publisher
- Principles of biochemistry by Albert Lehninger, David L Nelson & Michael M Cox, Mac Milan worth publisher.

PBT 504N   CELL BIOLOGY   4+0

Unit 1:
Cellular organelles: Cell types (prokaryotes/ eukaryotes), Plasma membrane, cell wall, cytoskeleton-their structural organization; Mitochondria; Chloroplast; Nucleus and other organelles and their organization and function, genetic constitution of mitochondria and chloroplast, artificial membrane Liposomes.

Unit 2:

Structure and organization of cell skeleton; Microfilaments and Microtubule-structure and assembly, actins, myosin muscle contraction, cilia, flagella-structure and function

Unit 3:

Biological membranes: Physicochemical properties of cell membranes and their structural constitution. Transport of nutrients across the membranes: simple, passive, facilitated diffusion, Protein targeting and sorting- Post transitional import of proteins to mitochondria lysosomes, nucleus, secretory vesicles, chloroplast and peroxisomes.

Unit 4:

Cell cycle: Mitosis, meiosis, the role of cyclins and cyclin-dependent kinases, regulation of Cdk-cyclin activity, Cdk inhibitors, induction of cancer with respect to cell cycle, molecular events and regulation in model systems, cell surface receptors, second messenger system, MAP kinase pathways, mechanism of signal transduction pathway. Molecular biology and biochemistry of cancer, oncogenes, tumour suppressor genes, chemical carcinogenesis

Suggested Reading:

- Essential Cell Biology by Bruce Alberts et.al., Garland Publisher.
- Cell and Molecular Biology by F. D P deRobertes, LW & W Publisher.
- Molecular Biology of the Cell by Alberts, Bray, Lewis, Raff, Roberts and Watson, Garland Publishers.
- Molecular Cell Biology by H. Lodish, D. Baltimore, A. Bark, S. L. Zipursky, P.Matsudaira and J. Darnell, Scientific American Books.

PBT 505N   LABORATORY COURSE-I BASED ON CORE COURSES   0+4

Laboratory course will be based on core courses

PBT 508N   RECOMBINANT DNA TECHNOLOGY   4+0

Unit 1:
Molecular tools and their applications: Restriction endonucleases, polymerases, nucleases, kinases, topoisomerases, gyrases, methylases, and ligases. Adapters, Linkers and Homopolymer tailing, Cloning vectors: Plasmids, Bacteriophages, Cosmids, Phagemids, Artificial chromosomes (BAC, PAC, MAC).

Unit 2:
Construction and screening of genomic and cDNA libraries, EMSA (Electrophoretic mobility shift assay), DNA footprinting, Primer extension, SI mapping, RNase protection assay, Reporter assays, Principles and techniques of nucleic acid hybridization,

Unit 3
Polymerase chain reaction: principle, types, and applications of PCR in different fields. DNA microarray-fabrications, variations, and applications, Serial Analysis of Gene Expression (SAGE)-principle and applications.

Unit 4
Expression strategies for heterologous genes: expression in bacteria, yeast, insects, mammalian cells and plants, *in-vitro* transcription and translation, T-DNA, and transposon tagging.

Suggested Reading:

- iGenetics by *Peter J Russell*, Benjamin/ Cummings, New York
- From Genes to Clones: Introduction to gene technology, by *Ernst-L Winnacker*, VCH Publication, Germany
- Principles of Gene Manipulation: An Introduction to genetic Engineering (6th Edition) by R.W. *Old and S.B. Primrose*, Blackwell Publication
- Genes IX by *Benjamin Lewin*, Oxford University Press, U.K.

PBT 509N   ENZYME TECHNOLOGY   4+0

Unit 1
Nomenclature and classification of enzymes, general properties of enzymes, active sites, cofactors and specificity.Isolation, purification and large scale production of enzymes with principles and applications of the involved techniques, viz gel filtration, ion exchange and affinity chromatography, centrifugation and electrophoretic techniques.

Unit 2
Enzyme kinetics: Enzymatic reaction mechanisms, Michaelis-Menten equation, Effect of substrate, pH, temperature and inhibitors on enzyme activity.Mechanism of enzyme action and regulation: Active and regulatory sites, chemical modification, feedback inhibition, positive and negative cooperativity, allosteric enzymes.

Unit 3
Isozymes, multienzyme complexes, artificial enzymes, catalytic antibodies. Enzyme engineering-strategies, directed evolution, degradation of unnatural substrates.

Unit 4
Industrial enzymes: In detergent, food, leather, dairy, medicines and chemical industries.
Enzyme immobilization: Introduction, methods, applications and limitations.

Suggested Reading:
- Enzymes: Biochemistry, Clinical Chemistry by T. Palmor, Harwood press

- Fundamentals of Enzymology: The cell and molecular biology of catalytic proteins, by NC Price and Steven, Oxford press.
- Biochemistry, Vol I, II, III by GeofferyZubey, WCB press
- Fundamentals of Biochemistry by Voet, Voet& Pratt, John Wiley publisher

PBT 510N   IMMUNOLOGY   4+0

Unit 1:
Introduction: Phylogeny of Immune System, Innate and acquired immunity, Clonal nature of immune response, Primary and secondary immune response, Organization and structure of lymphoid organs, Cells of the immune system:Haematopoesis and differentiation, lymphocyte trafficking, B lymphocytes, T-lymphocytes, Macrophages, dendritic cells, natural killer and lymphokine activated killer cells, Eosinophils, Neutrophils and mast cells.Antigens and superantigens.Structure and function of immunoglobulins.

Unit 2:
Major histocompatibility complex; Antigen processing and presentation, BCR and TCR, generation of immunological diversity, Complement system.Cell- mediated cytotoxicity : Mechanism of T cell and NK cell mediated lysis, antibody dependent cell mediated cytotoxicity, macrophage mediated cytotoxicity, effector mechanism.

Unit 3:
Regulation of immune response:Generation of humoral and cell medicated immune responses, Activation of B-and T-lymphoeytes, cytokines and their role in immune regulation, Immunological tolerance, Genetic control of immune responses. Immunoprophylatic intervention: Basic concepts of vaccination and different types of vaccines.

Unit 4:
Hypersensitivity, Autoimmunity, Tumor immunology, AIDS and other immune-deficiencies.Antigen and antibody interactions, Immunodiffusion, Immunoelectrophoresis, RIA, ELISA, Hybridoma technology and monoclonal antibodies.

Books Recommended:
- Cellular and Molecular Immunology by *Abbas et al.*, Saunder Publication.
- Essential Immunology by *Roitt*, Blackwell Publisher.
- Immunology by *Kuby*, Freeman Publisher.
- Immunology-a short course by *Benjamini*, Wiley-Liss Publisher.

PBT 511N   Bio-analytical techniques   4+0

Unit I :
Microscopic techniques: Principles and application of light, phase contrast, fluorescence, confocal, scanning and transmission electron microscopy, cytophotometry and flow cytometry, fixation and staining, Fluorescence in-situ hybridization (FISH), GISH (Genomic in-situ hybridization).

Unit II
Chromatography & Spectroscopy: column chromatography (ion exchange, gel permeation, affinity), GLC and HPLC. Principles of colorimetry and UV-Vis spectrophotometry, Mass spectrometry, MALDI, X-Ray Crystallography

Unit III:
Electrophoresis and Radiation Biophysics: chromatography Agarose and polyacrylamide gel electrophoresis (native and denaturing), Immuno-electrophoresis, Isoelectric Focusing, Capillary electrophoresis. Principles of fluorescence, Tracer Technology, Dose-response relationship, Radioisotopes in Diagnostics and Biotechnology

Unit IV:
Gene Editing: History of its discovery, elucidation of the mechanism including an introduction to all the molecular players, development of applications for in vivo genome engineering for genetic studies, and promise of the technology as a next-generation therapeutic method.

Suggested Readings
- Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.
- Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 5th Edition, Cambridge University Press, 2000.
- D. Holme & H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998

PBT 512N   Laboratory Course-III (based on core courses)   0+4

Laboratory course will be based on core courses

PBT 506N   Introductory Plant Biotechnology   0+4

Unit 1: Basis of Plant Tissue Culture
Introduction-Concepts and principles. History of Plant tissue culture. Sterilization techniques- Nutritional requirements for plant tissue culture - Factors affecting plant tissue culture

Unit 2: Pathways of Plant Regeneration
Morphogenesis – direct and indirect, organogenesis and somatic embryogenesis. Callus initiation - establishment and maintenance. Establishment of suspension culture .Synthetic seeds and applications.

Unit 3: Plant Tissue Culture Techniques for Propagation
Meristem culture and virus elimination - virus indexing methods. Shoot tip culture and in vitro clonal multiplication-Applications. Micropropagation techniques in roses, banana and advantages

Unit 4: Organ Culture
Embryo culture and embryo rescue-applications. In vitro fertilization techniques. Ovule, ovary and endosperm culture. Anther and microspore culture - production of haploids. Protoplast isolation, culture and protoplast fusion - applications -. Somaclonal variation - applications. In vitro germplasm conservation – Secondary metabolites production through cell culture -bioreactors.

Suggested Reading:

- Bhojwani, S.S and Dantu, P. 2013. Plant Tissue Culture – An Introductory Text. Springer Publications
- Karl-Hermann Neumann, Ashwani Kumar and Jafargholi Imani. 2009. Plant Cell and Tissue Culture- A Tool in Biotechnology- Basics and Application. Springer-Verlag, Berlin Heidelberg
- Acram Taji, Prakash P. Kumar, Prakash Lakshmanan, 2002.In vitro plant breeding. The Haworth Press Inc., New York.
- Cassells, A. C and Peter B. Gahan. 2006. Dictionary of plant tissue culture. Food Products Press, an Imprint of the Haworth Press, Inc., New York-London-Oxford
- Gamborg, O.L and G.C.Philips (eds.). 2013. Plant Cell, Tissue and Organ culture-Lab Manual. Springer Science & Business media.
- Razdan, M.K. 2003. Introduction to Plant Tissue Culture. (II Edn.). Science Publishers Inc, Enfield (NH) U.S.A.
  Roberta H. Smith, 2000. Plant tissue culture: Techniques and Experiments. Gulf Professional Publishing.

PBT 514N   Plant Microbial Diversity   4+0

Unit-1
Different interfaces of interactions - Plant-microbe, microbe-microbe, soil microbe, soil-plant-microbe interactions leading to symbiotic (rhizobial, algal, actinomycetous, and mycorrhizal), associative, endophytic, and pathogenic interactions. Microbial communities in the soil. Community dynamics and population interactions employing DGGE, TGGE, and TRFLP.

Unit-2
Molecular approaches in the study of plant-microbe interactions, the genetic basis of pathogenicity and parasitism, signal transduction, compatibility and incompatibility, gene-for-gene concept. Plant interaction with endophytic bacteria and fungi, Use of Avirulent mutants in control of bacterial, fungal, and viral disease of plants. Interactions of plants with soil pathogens and their antagonists in the natural ecosystem.

Unit-3
Plant and microbial gene expression and signal exchange, global and specific regulators for different interactions. Molecular diversity of microbes, plants, and their interactions including transgenic microbes and plants

Unit-4
Transgenic approaches for crop protection pathogen-derived resistance, plantibodies, overexpressing defense genes, use of cloned resistance genes, expression of vaccines in plants, and engineering broad-spectrum resistance. Systemic acquired resistance in plants: Hypersensitive response and associated defense reactions in plants, induced structural and biochemical defense mechanisms.

Suggested Reading:

- Brock Biology of Microorganisms, 9th Edition. By Michael T. Madigan, John M.Martinko, Jack Parker. Prentice Hall, Inc.
- Microbiology, 4th Edition. By Lansing M. Prescott, John P. Harley, Donald A. Klein. WCB McGraw Hill.
- General Microbiology, 5th Edition by Roger Y. Stanier, John L. Ingraham, Mark L.Wheelis, Page R. Painter, Macmillan Press Limited.
- Microbiology: Principles and Explorations, 5th Edition. By Jacquelyn G. Black, John Wiley& Son, Inc.
- Martin Alexander 1983. Introduction to Soil Microbiology, Wiley eastern Ltd., New Delhi.
- Newton, W.E and Orme, Johnson, W.H.1980. Nitrogen fixation vol II: Symbiotic Associations and Cyanaobacteria. University park Press Baltimore, USA.
- Wheeler, B. E. 1976. An Introduction to Plant Disease. ELBS and John Wiley and Sons, Ltd.

BT 515N   Fundamental Genetics   4+0

Unit 1:
Introduction to genetics - Great milestones in genetics, Levels of genetic analysis, Genetics in agriculture, medicine and society, Basic cell.

Unit 2:
Basic principles of Heredity, Mendelian principle of inheritance - Experiments of Mendel, Principle of segregation of genes, Principle of independent assortment, test cross and back cross with unlinked genes, Extensions and modifications of Mendelian principles – Complete, incomplete & codominance, Penetrance and Expressivity, Gene interaction with epistasis. Application of probability and chi-square in genetics, Multiple alleles, Complex genetics of coat color in dogs, lethal alleles.

Unit 3:
Linkage, recombination and crossing over - Linked genes, Coupling and repulsion, Crossing over and recombination with linked genes, Linkage and recombination between two genes and three genes, Linkage mapping with recombination frequency, Physical chromosome mapping, Effect of multiple crossovers, Tetrad analysis. Quantitative genetics & polygenic inheritance - Inheritance of quantitative traits, Genetic analysis of quantitative traits using statistics, Polygenic inheritance, Determining gene number for a polygenic character, Usage of heritability in predicting the variation of phenotypes.

Unit 4:
Genetics of organelles - Biology of mitochondria & chloroplasts. Mitochondrial genome, Chloroplast genome, Organelle heredity, Evolutionary origin of organelles, Cytoplasmic inheritance, Patterns of extra nuclear inheritance, Inter genomic exchange of genetic Information,

Unit 5:
Microbial genetics - Bacterial genetics, Mutant phenotype, Mechanism of genetic exchange, DNA-mediated transformation, Conjugation, Transduction, Genetic mapping in prokaryotes, Developmental genetics of drosophila, Population genetics, Environment and genetics, Clinical genetics, Evolutionary genetics.

Suggested Reading:
- Principles of Genetics by Snustad& Simmons, 6th edition
- Genetics: A conceptual approach by Benjamin Pierce, 4th edition
- Essential Genetics - A genomic perspective by Hartl& Jones, 4th edition
- Genetics: A molecular approach by Peter Russell, 2nd edition
- Principles of Genetics by Robert H Tamarin, 7th edition
- Schaum's outline genetics by Elrod & Stansfield, 4th edition

PBT 516N   Plant Tissue Culture   4+0

Unit 1:
History of plant cell and tissue culture; Culture media; various types of culture; callus, suspension, nurse, root, meristem, etc.; *In vitro* differentiation; organogenesis and somatic embryogenesis.Micropropagation; Anther and microspore culture; Somaclonal variation; *In vitro* fertilization; *In vitro* germplasm conservation; Production of secondary metabolites; Synthetic seeds.

Unit 2:
Embryo culture and embryo rescue; Protoplast isolation, culture and fusion; selection of hybrid cells and regeneration of hybrid plants; symmetric and asymmetric hybrids, cybrids. Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available

molecular markers, transformation and genomic tools for crop improvements. Molecular marker-aided breeding, QTL, molecular marker assisted selection.

Unit 3:
Plant transformation technology: *Agrobacterium* mediated, Particle bombardment, Electroporation; transgene stability and gene silencing. Chloroplast Transformation, Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature, etc.) and biotic (insect pest, fungal, viral and bacterial diseases, weeds, etc.) stresses; Genetic engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency; Genetic engineering for quality improvement (protein, essential amino acids, vitamins, minerals nutrients, etc.) etc.

Unit 4:
Metabolic Engineering and Industrial Products: Plant secondary metabolites, control mechanisms and mainipulation of phenylpropanoid pathway, shikimate pathway; alkaloids, biodegradable plastics, therapeutic proteins, edible vaccines, purification strategies.

Suggested Reading:

- Plant Tissue Culture: Application and Limitation by *S. S. Bhojwani and M. K. Razdan,* Elsevier Publication
- Plants, Genes and Agriculture by *Maarten J Chrispeels and David E. Sadava*, Jones & Bartlett Publishers
- An Introduction to Plant Tissue Culture by *M. K. Razdan*, Oxford & IBH Publishing Co. Pvt. Ltd.
- Plant Biotechnology: The genetic manipulation of plants by *Adrian Slater, Nigel Scott, and Mark Fowler,* Oxford University Press

PBT-517 N   Plant Physiology and Metabolism   4+0

Unit 1
Photosynthesis and chemosythesis, Quantasomes, biosynthesis of chlorophylls, conversion of solar energy into chemical energy and its utilization in CO2 reduction cycles, Efficient and inefficient plants, bacterial photosynthesis and its utility in nature. Organic acid metabolism, succulent, CAM pathway and their significance Plant Energetic as controlled by Photosynthesis, Respiration and

Unit 2
Photorespiration Respiration: Biological oxidations of carbohydrates and inter conversions of the products, terminal oxidation electron transport, role of cytochromes and other heme compounds.

Nitrogen Metabolism: Synthesis and activation of amino acids, transcription and translations, genetic code the template, chemical regulation and biosynthesis of proteins and enzymes, Biochemistry of biological nitrogen fixation and its significance.

Unit 3
Phosphorus metabolism, Metabolism of phosphorylated compounds and their role Lipid Metabolism: Classification of fat and fatty acids, biosynthesis and breakdown of fat and lipids, its significance, Unsaturated fatty acids. Secondary plant products and their biosynthesis

Unit 4
Growth analysis and control mechanism, biological clocks Germination of photo and non-photoblastic seeds; physiology of seed and dormancy Factors affecting growth and plant growth under different stresses, role of phytochrome and mechanism of its action in growth, morphogenesis and differentiation Physiology of abscission; biosynthesis of auxins; gibberellins and cytokinins and their mechanism of action Physiology of flower initiation and floral expression Physiology and biosynthesis of alkaloids, vitamins and sterols

Suggested Reading:
- Biochemistry & Molecular Biology of Plants. Authors: Buchanan BB, Gruissem W and Jones

RL (2000), American Society of Plant Physiologists.

- Lehninger Principles of Biochemistry, Authors: David L. Nelson and Michael M.Cox.
- Plant Physiology. Authors: Taiz L, and Zeizer E, (2006), Sinauer Associates, Inc.
  Biochemistry. Authors: Berg JM, Tymoczko, JL, and Stryer L (2006). W. H. Freeman.
- Plant Pathology. Authors: Agrios GN 5 ed; 2005, Elsevier Academic Press, 2005

PBT 518N   Plant Stress Biology   4+0

Unit 1
Water stress: a. Membranes and water stress b. Stomatal response to water stress. Role of ABA c. Photosynthesis and water stress d. Osmotic adjustment e. Mechanism of drought tolerance 2. Flooding stress a. Flooding injury b. Metabolic damage c. Hormonal imbalance d. Soil toxins e. Tolerance mechanisms

Unit 2
Low temperature stress a. Chilling and freezing effects on germination b. Physiological and molecular mechanism of low temperature tolerance c. Effect of low temperature on plant productivity 4. Heat stress a. Cellular responses to high temperature: enzyme activities, photosynthesis, ultra structural effects b. Molecular responses to high temperature. Heat shock proteins. c. High temperature tolerance mechanisms in plants

Unit 3
Metal stress a. Metal toxicity and tolerance with special reference to i) Aluminum ii) Manganese iii) Iron iv) Zinc b. Phytochelations c. Differential plant tolerance to heavy metals 6. Allelochemicals a. Chemical nature of allelochemicals b. Mode of release of allelochemicals c. Regulation ofallelochemical production and release d. Mode of action of allelochemicals on plant physiological processes

Unit 4
Salt stress a. Effect of high salt concentration of plants – water stress, nutrient ion deficiency, ion toxicity b. Regulation of salt content – Salt exclusion, salt elimination, salt succulency c. Mechanism of salt resistance and tolerance 8. Ultra violet – B (UV-B radiation): a. Plant response to UV radiation b. Effect of UV-B on chemical composition c. Effect of UV-B radiation on photosynthesis d. UV-B defense and gene expression

Suggested Reading:

- Doby, G.: Plant Biochemistry. Inter Science Publishers, New York
- Lehninger, A. L., D. L. Nelson and M. M. Cox 2000: Principles of Biochemistry. CBS Publishers and Distributors, New Delhi.
- Witham et. al. Experiments in Plant Physiology. Van Nostrand Renhold Company, New York. Meidner, H. Class experiments in Physiology. George Allen & Unwin Publishers Ltd., London
- Kalra, Y. P. (ed.). Hand book of reference methods for plant analysis. CRC Press, USA.
- Hopkins, W. G., Introduction to Plant Physiology. 3rd Edition. John Wiley & Sons, New York. Salisbury, F. B. and Ross, C. W., Plant Physiology, 4th Edition. Wadsworth Publishing Company, California.
- Marschner, H., Water relations of plants. Academic Press, New York

PBT 519N   Molecular Plant Breeding   4+0

Unit 1
The dynamic plant genomes: Natural genetic Variation; mechanisms and causes of DNA

polymorphisms: Recombination and DNA rearrangements, Point mutations-topolyploidy; SNP as a concept. Genome Organization: Nuclear and organellar genomes; C-Value paradox, Unique and repeat DNA sequences; Classification of Repeat elements: Tandem, Interspersed (Impact of transposable elements in modelling genomes), Micro-satellites, Minisatellites, hyper-variability of VNTRs,

Unit 2

Assessment of genetic diversity: Introduction to geographical diversity, center of origin and diversity of plant species, gene pools (primary, secondary and tertiary), Principles of numerical taxonomy, Case studies, binary matrix to phenetic dendograms, structure analysis and other software tools for phenetics,. Forward mapping for gene discovery and functional genomics: Traits (simple and complex; continuous and dis-continuous variation), Construction of genetic linkage maps; Linkage mapping software packages and interfaces; Trait Mapping; Map based cloning/ positional cloning for gene discovery, Navigating from genetic to physical map (methodologies and challenges).

Unit 3

Mapping populations in plants: F2 populations, RILs (recombinant inbred lines), Backcross lines, NILS (Near Isogenic Lines), HIF (Heterogeneous Inbred Families), AILs (Advanced Intercross Lines), Pseudo-test-cross mapping, NAM (Nested Association mapping), MAGIC (Multi-parent advanced generation inter-cross), Biparental mapping vs Multi-parent mapping.. Breeding by design: Marker Assisted Selection (MAS), gene/QTL introgression and pyramiding, Foreground and back ground selection for introgression of QTL by SSR markers, BSA (Bulked Segregant Analysis), Leveraging genetic resources from wild (Exotic genetic libraries and introgression lines)..

Unit 4

Genotyping tools as plant variety protection, DNA bar-coding technology, hybrid purity tests, diagnostics (transgenics, forensics), establishing clonal fidelity, Fingerprinting for BAC assembly for physical maps. Supplementary mapping tools and methodologies: Radiation Hybrid Maps, HAPPY mapping, Comparative/Synteny mapping.. Genomics platforms for genome-wide analysis: DARTseq, GBS (genotyping by sequencing) and other third generation sequencing platforms, GEBVs (Genomics estimated breeding values), GWAS (Genome-wide association studies).

Suggested Reading:

- Kole C, Genome mapping and molecular breeding in plants. Springer Verlag, Berlin H John Newbury (2003) Plant Molecular Breeding. CRC Press, US
- Kole C and Abott AG Molecular breeding: principles and practices of plant genomics. Science Publishers, US
- Griffiths AF, Miller JH, Suzuki DT, Lewontin RC, Gelbart WM An introduction to genetic analysis. WH Freeman & Co, US
- Vos P, Hogers R, Bleeker M, Reijans M, van de Lee T, Hornes M, Frijters A, Plot J, Peleman J, Kuiper M, Zabeau M AFLP: a new technique for DNA fingerprinting. Nucl Acids Res 23: 4407- 4414
- Peleman JD and van der Voort JR Breeding by design. Trends in Plant Science.8: 330-339.
- Collard BCY, Jahufer MZZ, Brouwer JB and Pang ECK An introduction to markers, quantitative trait loci (QTL) mapping and marker assisted selection for crop improvement: The basic concepts. Euphytica 142: 169-196

PBT-520 N **Molecular Plant Pathology** **4+0**

Unit 1

An overview of nature of pathogens and pests, pathogen penetration, establishment, colonization in host., Genetic and molecular basis for disease resistance, Flor's hypothesis, Koch postulates, disease

epidemics and epidemiology.

Unit 2
Preformed plant defenses, induced host defenses, biochemical and physiological responses, host-pathogen interaction mechanisms, Physiology and biochemistry of plant disease, Primary metabolism, Secondary metabolism, role of cell wall in plant defense

Unit 3
Molecular determinants of pathogenicity, effectors, elicitors, defensins, phytoalexins, common phenolics, plant cell wall degrading enzymes, host specific toxins, host nonspecific toxins, hormones and signaling.

Unit 4
Plant disease resistance, classes of resistance genes, adapted host resistance, non-adapted host resistance, Systemic acquired resistance, Induce Systemic acquired resistance, Pathogenesis-related (PR)-proteins, Transgenic and genetic manipulation approach and molecular marker approach to tag disease resistance and avirulence genes

Suggested Reading:

- Diseases of Crop Plants in India, Rangaswamy & Mahadevan.
- Plant Pathology, GN Agrios (2006), fifth Edn, Elsevier Academic Press.
- Molecular Plant Pathology, Dickinson CM (2003), Bios Scientific Publisher
- Plant Pathology: Concepts and Laboratory Exercises, NT Robert, MT Windham, AS Windham (2003), CRC Press.
- Plant Diseases, RS Singh (2008), Oxford and IBH Publishing Co. Pvt Ltd 15. Principles of Plant Pathology, RS Singh (2008), Oxford and IBH Publishing Co. Pvt Ltd

PBT 521N   Molecular Diagnostics   4+0

Unit I
Basic idea of Molecular Diagnostics, Technologies related to Molecular Diagnostic: PCR-Based Methods for Mutation Detection, Other Methods for Mutation Detection. Sequencing of DNA for Disease Association, Gene Expression Analysis through Microarray Approaches, Methods for Analysis of DNA Methylation, Other Clinical Diagnostic Technologies: Flow Cytometry, Medical Cytogenetics, Fluorescence In Situ Hybridization, Immunohistochemistry, Laser 22 Capture Microdissection (FFPE).

Unit 2
Quality Assurance in the Molecular Diagnostics Laboratory: Framework for Quality Assurance in Molecular Diagnostics, Verification of Molecular Assays, Standards and Standardization of Molecular Diagnostics, Laboratory Developed Tests in Molecular Diagnostics.

Unit 3
Applications of Molecular Diagnostics for Genetic Diseases, Molecular diagnostics of Coagulation, Cystic Fibrosis; Prenatal Genotyping for Identification of Fetuses at Risk for Immune Cytopenic Disorders. Applications of Molecular Diagnostics for Human Cancers and Infectious Diseases. Molecular Analysis for Forensic Casework and Parentage Testing.

Unit 4
Personalized Medicine, Genetic Counseling Considerations in Molecular Diagnosis, Ethical, Social, and Legal Issues Related to Molecular Genetic Testing…

Suggested Reading:

5. Molecular Diagnostics: For the Clinical Laboratorian / Edition 2 William B. Coleman (Editor), Gregory J. Tsongalis (Editor) Publisher: Springer-Verlag New York, LLC.
6. Molecular Diagnostics: Fundamentals, Methods and Clinical Applications, April 2019 by Lela Buckingham (Author), Publisher: FA Davis Company.
7. Molecular Diagnostics, Edited by George Patrinos, Wilhelm Ansorge, Phillip B. Danielson, Elsevier Publication
8. Molecular Diagnostics For the Clinical Laboratorian, Edited by William B. Coleman, Gregory J. Tsongalis. Springer publication.

PBT 522N **Laboratory Courses (based on core and optional courses)** **0+4**

Laboratory course will be based on core and optional courses

PBT 523N **Project/Review/Industrial training** **-**

Each student must conduct a project/review/ industrial training in the third semester under the guidance of the allotted advisor/supervisor. The evaluation of the same will be done at the end of the fourth semester as per the guideline issued by the university authority.

Semester-IV

PBT 524N **Genomics for crop improvement** **4+0**

Unit 1
Introduction to science of omics for crop improvement, Introduction to the plant genomenuclear, chloroplast and mitochondrial genomes, genome size and complexity, mapping of genome: genetic and physical maps, map-based cloning, molecular markers in plant genome analysis; RFLP, RAPD,

STS, Microsatellite, SCAR (Sequence characterized amplified regions), SSCP (single strand conformational Polymorphism), and AFLP analysis, FISH and GISH for genome analysis.

Unit 2

Plant gene expression and regulation, functional genomics-expression analysis using microarrays, transposon tagging and Insertional mutagenesis - methods and significance, TILLING and EcoTILLING, Diversity Array Technology, transcriptomics.

Unit 3

Whole genome analysis: Genome size, strategies for sequencing genome, ordered genomic libraries (Cosmid, YAC, BAC libraries), Genome sequencing in plants–Principles and Techniques; Next generation sequencing technologies, Applications of sequence information in plant genome analyses; Comparative genomics, Detection of Single Nucleotide Polymorphism; Role of transcriptomics, proteomics and metabolomics in linking genome and phenome.

Unit 4

Marker assisted selection (MAS), Genomic assisted breeding approaches, Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding, tagging of agronomically important traits, RNA interference in crop improvement.

Suggested Reading:

- Genomes by T.A. Brown, John Wiley & Sons Ltd, New York
- Genome analysis (Volume I, II, III and IV) a Laboratory Manual by Bruce Birren,Eric D. Green, Sue Klapholz, Richard M. Myers and Jane Roskams, Cold SpringHarbor Laboratory Press.
- Discovery Genomics, Proteomics and Bioinformatics, Campbell AM &Heyer L, 2004,

PBT 525N   BIOINFORMATICS   4+0

Unit I:

Introduction to Bioinformatics, use of Internet and search engines (WWW, HTML, URLs, Netscape, Explorer, Google, PUBMED), database management system, database browsing, data retrieval, sequence and genome database, databases such as GenBank, EMBL, DDBJ, Swissprot, PIR, TIGR, TAIR, Searching for sequence database like FASTA and BLAST algorithm, multiple sequence alignment, phylogenetic analysis and detection of open reading frames (ORFs).

Unit II

DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing

Unit III

Multiple sequence analysis: multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

Unit IV

Computational structural biology and Biostatistics: computational structural biology, in-silico methods for structural predictions, Homology threading and modeling, ab-initio modelling; Validation of in-silico determined 3D structures of proteins, Computer aided drug design-tools and applications.

Selection of sample or sampling, theory: qualitative, random and non-random sample. Collection of data, their classification, tabulation, graphic representation and diagrammatic representation, measures of central tendency and dispersion: mean, median, mode.

Suggested Reading
- Bioinformatics: A practical guide to the analysis of genes and proteins (3rd Edition) D. Baxevanis and F. Oulette, Wiley Indian Edition.38
- Bioinformatics Methods And Applications: Genomics Proteomics And Drug Discovery (3rd Edition) Rastogi SC, Rastogi P, Mendiratta N.. PHI Learning Pvt. Ltd.; 2008.
- Mount, D.W., Bioinformatics: 2001, Sequence and Genome Analysis. CSHL Press.
- Claverie, J.M. and Notredame C. 2003 Bioinformatics for Dummies. Wiley Editor

PBT 526N   Proteomics and Metabolomics   4+0
Unit 1
Proteomics technology: Gel electrophoresis of protein- SDS-PAGE, Native gel electrophoresis, zymography, identification and analysis of proteins by 2D analysis, mass spectrometry, MALDITOF, NMR and X-ray crystallography.
Unit 2
Differential display proteomics, protein-protein interactions, yeast two hybrid system and phage display, GFP and RFP, western blot, metabolic engineering.
Unit 3
Chemical, physical and biological properties of biomaterials and bioresponse, biomineralization, biosynthesis and properties of natural materials (protein, DNA &polysaccharides).
Unit 4
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, Future prospective of metabolomics.

Suggested Reading:

- Discovery genomics, proteomics and bioinformatics, Campbell AM &Heyer L, 2004, Pearson education.
- Methods in proteome and protein analysis, Kamp RM, 2004, Springer.
- Handbook of nanostructured biomaterials and their applications in Nanobiotechnology, Nalwa HS, 2005, American Scientific Publication
- Mark Y. Stoeckle and Paul D. N. Hebert, Barcode of Life, Scientific American.
- Sujeevan Ratnasingham and Paul D. N. Hebert, BOLD: The Barcode of Life Data System (http://www.barcodinglife.org), Molecular Ecology Notes,

PBT 527 N   Plant Developmental Biology   4+0
Unit 1
Introduction to plant development- Comparison of Plant and animal development, Evolution of developmental complexity from algae to angiosperm. Role of Plant Cell Division and Expansion in development, Plant cell cycle and control of plant cell size.

Unit 2
Regulation of Plant Architecture , Shoot apical meristem, Root apical meristem and positional control of root development, Phyllotaxy , Lateral organ development- Leaf primordia imitation, Leaf development, Generation of patterns regulation of stomatal patterning in plants.

Unit 3

Plant Hormones- biosynthesis and mode of action of Auxin, Gibberellins, Cytokinins, Ethylene, Abscisic acid, Brassinosteroids, Salicyclic and Jasmonic acid, Strigolactones, karrikins, Peptide and other novel hormones of plants. Environmental regulation of Plant Development, Photoperiodism and circadian rhythms and biological clock, Phytochrome, cryptochrome, UVR8 and phototropins, Vernalization of plants.

Unit 4

Seed germination and dormancy, Plant Senescence, Reproductive development of Plants, Inflorescence initiation, Flower development in plants, Embryogenesis in higher plants.

Suggested Reading:

- Cutter, D. F., Applied Plant Anatomy, Logman, London.
- Cutter, E. G. Plant Aatomy : Experiment and Interpretation : Part 2 – Orgnas. Edward Arnold, London. Cutter, E. G., Plant Anatomy : Part – 1 Cells and Tissues, 2nd Edition, Edward Arnold, London.
- Eames, A. J. and Mac Daniels, L. H. An Introduction to Plant Anatomy, 2nd Edition, McGraw – Hill, New York.
- Fahn, A., Plant Anatomy, 4th Edition, Butterworth, Heinemann Ltd.
- Fosket, D. E., Plant Growth and Development : A Molecular Approach. Academic press,
- San Diego. Kozolowski, T. T., Growth and Development of Trees. Vols. I and II. Academic Press, New York.
- Lyndon, R. F., Plant Development: The cellular basis. Unwin Hyman, London.
- Maheswari, P. An Introduction to the Embryology of Agiosperms. McGraw-Hill Book Co., New York. Mauseth, J. D. Plant Anatomy, The Benjamin/Cummings Publishing Co. California.
- , Oxford. Murphy, T. M. and Thompson, W. F. Molecular Plant Development, Prentice Hall, New Jersey

PBT 528N   Scientific Writing and Communication   4+0

Unit 1

Presentation techniques: structure of presentations, interacting with PowerPoint, slide design, body language and positioning, presentation of participants, feedback.

Unit 2

Scientific writing: academic language, structure of scientific documents, scientific sources, thesis writing, Selection of journal with appropriate Impact factor, Effective Literature Review, Inclusion and sequencing of authors based on their roles.

Unit 3

Preparation of title and abstract of manuscript, Preparation of Experimental Design, Discussion and conclusion, Graphical abstract/Image representation, obtaining permission for reproduction of data from other journals, Statistical tools in research.

Unit 4

Compilation of discussion and future directions in a review article, Respond to the reviewer's comments, Inter- and intra-departmental collaborations, Guide for SCOPUS/WOS/SCI Journals and Predatory Journals

Suggested Reading

- Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.

- Day, R.A., 1992. How to write and publish a Scientific paper, Cambridge University Press.
- Fink, A.,2009. Conducting Research Literature Reviews: From the internet to paper. Sage Publications.

PBT 529N   BIOSAFETY, IPR AND BIOETHICS   4+0

Unit-1
Introduction To Intellectual Property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, IP as a factor in R&D; IPs of relevance to biotechnology; introduction of GATT, WTO, WIPO, and TRIPS; plant variety protection and farmers rights act; concept of prior art': invention in the context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

Unit-2:
Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; the role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure /non-disclosure -patent application forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies; patent infringement.

Unit-3
Biosafety and Biosecurity; introduction to biological safety; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs LMOs; principles of safety assessment of transgenic plants. International Regulations –Cartagena Protocol, OECD consensus documents, and Codex Alimentarius; India Regulations –EPA act and rules, guidance documents, regulatory framework–RCGM, GEAC, IBSC, and other regulatory bodies.

Unit-4
Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, human and animal experimentation, animal rights/welfare, Genetically engineered food, environmental risk, labeling, and public opinion, biopiracy

Suggested Reading:
- Ganguli,P.(2001).Intellectual Property Rights: Unleashing The Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
- National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
- Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication.
- Kuhse, H. (2010). Bioethics: An Anthology. Malden, MA: Blackwell.
- Karen F.Greif and Jon F. Merz, Current Controversies in the Biological Sciences -Case Studies of Policy Challenge

PBT 530   Molecular Genetics   4+0
Unit 1
Molecular pathology of Chromosome anomalies: Numerical chromosomal disorders, Structural chromosomal disorders, Chromosome instability syndromes.
Unit 2

Inherited biochemical diseases: Enzyme defects- amino acid metabolism, Lipid metabolic disorders, Carbohydrate associated disorders: Complex genetic diseases – Hypertension, Diabetes mellitus, Mitochondrial diseases, Cancer as a genetic disease.

Unit 3

Low resolution mapping: Sub- chromosomal mapping, Chromosomal break points, FISH, cytogenetic methods, Somatic cell hybrid mapping, Radiation hybrid mapping.

Unit 4

High resolution mapping: DNA FIBRE FISH, Restriction mapping, VNTR microsatellite markers for mapping, EST mapping, STS mapping, SNP mapping, Conserved region mapping: IRE, CpG site mapping, Promoter site recognition

Suggested Readings:

8. Concepts of Genetics by Clugs, Cummings, Spencer etc
9. Molecular Biology of the Gene, 6th Ed., Watson et al, CSH Press,
10. Genes IX (VII, VIII), Benjamin Lewin, Jones and Bartlett
11. Genes and Genome, Singer & Berg, USB,
12. Genetic Analysis of Genes and Genomes, 6th Ed, Hartl & Jones, Jones and Bartlett,
13. Fundamental Bacterial Genetics, Trun & Trempy, Blackwell,
14. Genomes 3, TA Brown, Garland,

PBT 531N   Photochemistry and Pharmocognosy   4+0

Unit 1

Secondary metabolism; role of compartmentation and metabolite trafficking; Biosynthetic pathways for secondary metabolism; Biosynthesis of fatty acids and polyketides, phenols, flavonoids, tannins, lignans and lignins, alkaloids, terpenoids, steroids; turnover and degradation of secondary metabolism.

Unit 2

Classification, Phytochemical sources in plant kingdom, phytoconstituents and biological activities of secondary metabolites (Phenols and phenolic glycosides, sterols, steroidal alkaloids, stanols, miscellaneous isoprenoids, saponins, alkaloids, volatile oils, lipids and carbohydrates).
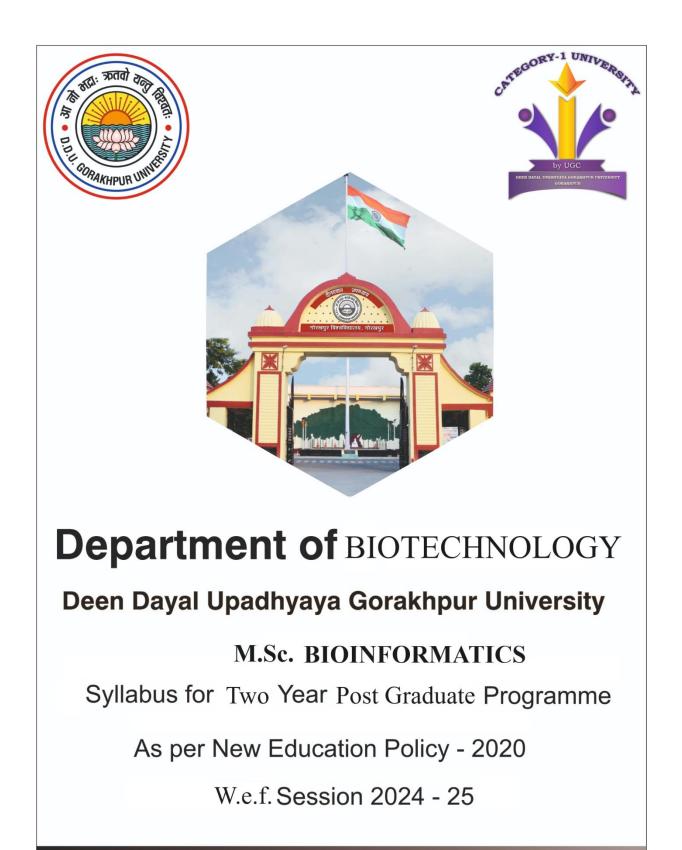
Unit 3

Antibiotics and their chemical nature, mode and mechanism of actions and bases of toxicity of antibiotics derived from amino acid metabolism, acetate metabolism and carbohydrate metabolism.

Unit 4

Methods for phytochemical analysis, tissue culture and biotechnology for the discovery and production of phyto – molecules; immunoassay; metabolomics: terms and definitions, different metabolomic technologies, merits and demerits, data acquisitions and applications; Ethnopharmacology: importance in drug developments

Suggested Reading

- Evans V.C., Trease and Evans Pharmacognosy, Harcourt Publishers Ltd., Sydney.
- Harbone J.B., Phytochemical Dictionary, Handbook of Bioactive Compounds from Plants, Taylor and Francis Ltd, Oxfordshire. 3. Wagner H., Plant Drug Analysis, Springer, Berlin.
- Zhang L., Demain A.L., Natural Products, Drug Discovery and Therapeutic Medicines, Human Press, New York.
- Kokate, C.K, Purohit A.P., Ghokhale S.B., Text book of Pharmacognosy, Nirali Prakashan, Pune.
- Rangari V.D., Text book of Pharmacognosy and Phytochemistry, Part I and II, Career Publication, Nasik.

PBT 532N   Project/Review   0+8

Each student must conduct a project/review/ industrial training in the fourth semester under the guidance of the allotted advisor/supervisor. The evaluation of the same will be done at the end of the fourth semester as per the guideline issued by the university authority.

Department of BIOTECHNOLOGY

Deen Dayal Upadhyaya Gorakhpur University

M.Sc. BIOINFORMATICS

Syllabus for Two Year Post Graduate Programme

As per New Education Policy - 2020

W.e.f. Session 2024 - 25

AFFILIATION

The proposed programme shall be governed by the Department of Biotechnology, Faculty of Science, D.D.U. Gorakhpur University, Gorakhpur– 273009.

PROGRAMME STRUCTURE

The M. Sc. Programme is divided into two Parts as under. Each part will consist of two Semesters as given below.

		Semester – Odd	**Semester – Even**
Part I	First Year	Semester – 1	Semester – 2
Part II	Second Year	Semester – 3	Semester – 4

For semester-1 and 2 would consist of four theory papers of 4 credits each, one laboratory course of 4 credits and Project/Review/Industrial Training of 4 credits. In Semester 1, there would be one open/minor elective course of 4 credit. Total credit in Semester 1 will be 20+4. Each student will carry research project/review/industrial training under the supervision of a faculty of the department. There may be a co-supervisor also from any industry/institute etc. The project/review/industrial training will be related to main subject. The students will submit the joint Research Project of Semester 1 and 2 at the end of 2nd Semester for evaluation. In semester 3, there would be two core courses of 4 credit each and two optional/elective courses having at least 3 options each. Semester 3 would also contain Laboratory course based on the theory papers of 4 credit. There would be a Project/review of 4 credit. In Semester 4, in addition to two core courses, there would be 2 optional courses having 3 options in each. At the end of 4th Semester, students will submit their research project/Review carried out in 3rd and 4th Semester for evaluation

MASTER OF SCIENCE
(BIOINFORMATICS)
TWO-YEAR FULL-TIME PROGRAMME

Curriculum Structure

Year	Course No.	Course Title	Credit	Type (Core/Elective)
		Semester 1		
	BI-501N	IT tools and applications	4+0	Core
	BI-502N	Molecular Biology	4+0	Core
	BI-503N	Biochemistry	4+0	Core
	BI-504N	Cell biology	4+0	Core
	BI-506N	Laboratory Course-I (based on core courses)	0+4	Core
			Total: 16+4	
		Semester 2		
	BI 508N	Computational Biology	4+0	Core
	BI 509N	Introduction R Programming	4+0	Core
	BI 510N	Probability and Information theory	4+0	Core
	BI 511N	Bio-analytical techniques	4+0	Core
	BI 512N	Laboratory Course-II (based on core courses)	0+4	Core
	BI-505N	Basic Bioinformatics	4+0	**Open elective**
			Total: 24	
		Semester 3		
	BI-514N	Database Management	4+0	Core
	BI-515N	Perl programming for bioinformatics	4+0	Core
	BI-516N BI-517N BI 518N	Optimization, machine learning and artificial intelligence Data structure and algorithms Bio-entrepreneurship	4+0	**Optional (only one)**
	BI 519N BI 520N BI 521N	Problem Solving Through C PYTHON programming for Bioinformatics Omics Technology	4+0	**Optional (only one)**
	BI 522N	Laboratory course-III (based on core and optional courses)	0+4	Core
	BI 523N	Project/review/ industrial training	0+4	Core
			Total:24	
		Semester 4		
	BI 524N	Molecular modeling and drug discovery	4+0	Core
	BI 525N	Human Genetics and Genome Project	4+0	Core
	BI 526N BI 527N BT 528N	NGS data Analysis Complex Algorithms in Bioinformatics Scientific Writing and communication	4+0	**Optional (only one)**
	BI 529N BI 530N BI 531N	Biosafety, IPR and Bioethics Statistical Methods In Bioinformatics Nano-biotechnology	4+0	**Optional (only one)**
	BI 532N	Project/review	0+4	Core
			Total: 20	

*Evaluation of the project will be in the second semester

(Year column: FIRST YEAR spans Semester 1 and Semester 2; SECOND YEAR spans Semester 3 and Semester 4)

BI 501N   IT Tools and application   4+0

Unit 1:
Computer Appreciation: Characteristics of Computers, Input, Output, Storage units, CPU, Computer System, Binary Number System Binary to Decimal Conversion, Decimal to Binary Conversion, Binary Coded Decimal (BCD) Code, ASCII Code.**Computer Organisation:** Central Processing Unit, Memory: Main Memory, Secondary Storage Devices. Input Devices, Output Devices, Multimedia, Computer Software**:** Relationship between Hardware and Software, system software, application software, compiler, names of some high level languages, free domain software.

Unit 2:
Operating Systems: Disk Operating System: Simple DOS Commands, Simple File Operations, Directory related Commands. **Microsoft Windows:** An overview of different versions of Windows, Basic Windows elements, Files management through Windows. Using essential accessories: Systems tools – Disk cleanup, Disk defragmenter, Notepad, Paint, wordpad. 1.3. **Linux:** An overview of Linux , Basic Linux elements: System Features, Software Features. File Structure, File handling in Linux, Installation of Linux: H/W, S/W requirements, Preliminary steps before installation, specifics on Hard drive repartitioning and booting a Linux System.

Unit 3:
Word Processing (Microsoft Word): Word Processing concepts: Saving, Closing, Opening an existing document, Selecting text, Editing text, Finding and replacing text, printing documents.

Spreedsheet Package (Microsoft Excel): Spreadsheet Concepts. Creating, Saving and Editing a workbook, Inserting, Deleting work Sheets, entering data in a cell/formula.

Unit 4:
Presentation Package (Microsoft Powerpoint): Creating, Opening and Saving Presentations, Creating the Look of Your Presentation, Working in Different Views, Working with Slides, Adding and Formatting Text.

Information Technology and Society: Application of Information Technology in Railways, Airlines, Banking, Insurance, Inventory Control, Financial Systems, Hotel Management, Education, Video Games, Telephone exchanges, Mobile Phones, Information Kiosks, Special effects in Movies.

Suggested Reading:

- Computer Fundamentals, First Edition (6th Edition) *P. K. Sinha and P. Sinha*, BPB Publication.
- IT Tools and Applications, *Ramesh Bangaria*, Laxmi Publications.

- Microsoft Office 2010 for Windows: Visual QuickStart Guide *Steven A. Schwartz* Pearson Education India

BI 502N   MOLECULAR BIOLOGY   4+0

Unit 1:
Prokaryotic and eukaryotic genome organization, structural elements of chromosome and construction of artificial chromosome. DNA replication: Enzymes, accessory proteins and mechanisms of prokaryotic and eukaryotic DNA replication.
Unit 2:
Fine structure of gene, molecular basis of spontaneous and induced mutations and their role in evolution; DNA damage and repair, DNA amplification and rearrangement. Anti-sense and Ribozyme Technology: Inhibition of splicing, polyadenylation and translation, disruption of RNA structure and capping, Biochemistry of ribozyme, hammerhead, hairpin and other ribozymes, applications of anti-sense and ribozyme technologies.
Unit 3:
Transcription: Organization of transcriptional units, mechanisms of transcription and its regulation in prokaryotes and eukaryotes, Operon concept, attenuation and antitermination controls, RNA processing (capping, polyadenylation, splicing), DNA methylation, heterochromatization, General and specific transcription factors, regulatory elements and mechanism of transcription regulation, transcriptional and post-transcriptional gene silencing, environmental regulation of gene expression.
Unit-4:
Translation: Genetic code, Prokaryotic and Eukaryotic translation, mechanisms for initiation, elongation and termination, regulation of translation, co-and post- translational modifications of proteins. Homologous Recombination and Site-specific recombination.

Suggested Reading:
:
- Molecular Biology of the Gene (4th Edition) *J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A. Steitz and A.M Weiner*, The Benjamin/ Cummings Publ. Co. Inc, California
- Molecular Biology of the cell (3rd Edition) by *Bruce Alberts, Dennis Bray, Julian Lewis, martin Raff, Keith Roberts and James D. Watson,* Garland Publishing, Inc, New York & London
- Gene Cloning and DNA Analysis (4th Edition) by *T.A Brown*, Blackwell Science
- Essential of Molecular Biology (3rd edition) by *G.M. Malacinski& D. Freifelder,* Jones & Bartlett Publisher

BI 503N   BIOCHEMISTRY   4+0

Unit 1
Amino acids and proteins: Classification, structure and properties of amino acids; primary, secondary, tertiary, quaternary and domain structure of proteins, forces stabilizing protein structure, Ramachandran plot, DNA-protein and protein-protein interactions, protein folding, protein misfolding and related diseases; protein sequencing.
Unit 2
Nucleic acids: Primary and secondary structure of nucleic acids, Watson-Crick model of DNA, structural polymorphism of DNA and RNA, the three-dimensional structure of RNA, biosynthesis of purines and pyrimidines.

Unit 3
Carbohydrates: Classification and structure of carbohydrates, polysaccharides, glycoproteins and peptidoglycans, glycolysis, TCA cycle, oxidative phosphorylation, glycogen synthesis and breakdown, gluconeogenesis, interconversion of pentoses and hexoses.
Unit 4
Lipids: Classification, structure and functions, biosynthesis of fatty acids, oxidation of lipids, triglycerides, phospholipids, sterols.

Suggested Reading:
- Biochemistry by Stryer, Freeman publisher
- Biochemistry, Vol I, II, III by GeofferyZubey, WCB press
- Fundamentals of Biochemistry by Voet, Voet& Pratt, John Wiley publisher
- Principles of biochemistry by Albert Lehninger, David L Nelson & Michael M Cox, Mac Milan worth publisher.

BI 504N   CELL BIOLOGY   4+0

Unit 1:
Cellular organelles: Cell types (prokaryotes/ eukaryotes), Plasma membrane, cell wall, cytoskeleton-their structural organization; Mitochondria; Chloroplast; Nucleus and other organelles and their organization and function, genetic constitution of mitochondria and chloroplast, artificial membrane Liposomes.
Unit 2:
Structure and organization of cell skeleton; Microfilaments and Microtubule-structure and assembly, actins, myosin muscle contraction, cilia, flagella-structure and function
Unit 3:
Biological membranes: Physicochemical properties of cell membranes and their structural constitution. Transport of nutrients across the membranes: simple, passive, facilitated diffusion, Protein targeting and sorting- Post transitional import of proteins to mitochondria lysosomes, nucleus, secretory vesicles, chloroplast and peroxisomes.
Unit 4:
Cell cycle: Mitosis, meiosis, the role of cyclins and cyclin-dependent kinases, regulation of Cdk-cyclin activity, Cdk inhibitors, induction of cancer with respect to cell cycle, molecular events and regulation in model systems, cell surface receptors, second messenger system, MAP kinase pathways, mechanism of signal transduction pathway. Molecular biology and biochemistry of cancer, oncogenes, tumour suppressor genes, chemical carcinogenesis

Suggested Reading:

- Essential Cell Biology by Bruce Alberts et.al., Garland Publisher.
- Cell and Molecular Biology by F. D P deRobertes, LW & W Publisher.
- Molecular Biology of the Cell by Alberts, Bray, Lewis, Raff, Roberts and Watson, Garland Publishers.
- Molecular Cell Biology by H. Lodish, D. Baltimore, A. Bark, S. L. Zipursky, P.Matsudaira and J. Darnell, Scientific American Books.

BI 506N   LABORATORY COURSE-I BASED ON CORE COURSES   0+4

The Laboratory course will based on the core courses

BI 508N   Computational Biology   4+0

UNIT-I
Introduction to computers and Bioinformatics. Types of hardware and software operating systems. Fundamentals of networking, operation of networks, telnet, ftp, www. Internet.

UNIT-2
Biological Research on the web:- Using search engines, finding scientific articles, public biological databases searching biological databases. Use of nucleic acid and protein data banks - NCBI, EMBL, DDBJ, SWISSPORT multiple sequence alignment.

UNIT-3
Sequence analysis, pair wise alignment and Database search. Phylogenetic analysis, profiles and motifs. Protein structures-visualizing, predicting and function from a sequence.

UNIT 4
Chemical composition - Bio-molecules. DNA, RNA. Structure of DNA, development of DNA sequence methods. Gene finder and feature detection in DNA. Gene finding, pairwise sequence comparision, sequence queries in Biological databases - drug designing

Suggested Reading
- Introduction to Bioinformatics by Stephen A Krawetz and David D. Womble, Humana Press. Bioinformatics: Sequence and Genome Analysis by David W. Mount, Cold Spring Harbor Laboratory Press
- Genomes by T.A. Brown, John Wiley & Sons Ltd, New York
- Genome analysis (Volume I, II, III and IV) a Laboratory Manual by Bruce Birren, Eric D.Green, Sue Klapholz, Richard M. Myers and Jane Roskams, Cold Spring Harbor Laboratory Press.

BI 509N   Introduction R programming   4+0

Introduction: Introducing to R, R Data Structures, Help functions in R, Vectors, Scalars, Declarations, recycling, Common Vector operations, Using all and any, Vectorized operations, NA and NULL values, Filtering, Vectorised if-then else, Vector Equality, Vector Element names.

Matrices, Arrays And Lists: Creating matrices, Matrix operations, Applying Functions to Matrix Rows and Columns, Adding and deleting rows and columns, Vector/Matrix Distinction, Avoiding Dimension Reduction, Higher Dimensional arrays, lists, Creating lists, General list operations,.

Unit 2
Data Frames: Creating Data Frames, Matrix-like operations in frames, Merging Data Frames, Applying functions to Data frames, Factors and Tables, factors and levels, Common functions used with factors, Working with tables, Other factors and table related functions - Control statements, , Tools for composing function code, Math and Simulations in R.

Unit 3
OOP: S3 Classes, S4 Classes, Managing your objects, Input/Output, accessing keyboard and monitor, reading and writing files, accessing the internet, String Manipulation, Graphics, Creating Graphs, Customizing Graphs, Saving graphs to files, Creating three-dimensional plots

Unit 4
Interfacing: Interfacing R to other languages, Parallel R, Basic Statistics, Linear Model, Generalized Linear models, Non-linear models, Time Series and Auto-correlation, Clustering
Aplication of R programing in Bioinformatics: Case studies.

Suggested Reading:
- A First Course in Statistical Programming with **R** by Braun & Murdoch.
- A Beginner´s Guide to **R**" by Zuur.
- Introduction to Scientific Programming and Simulation Using **R** by Chapman & Hall/CRC.
- **R** in a Nutshell by Adler.
- An Introduction to **R** by Venables & Smith

BI 510N   Data Structure and algorithms   4+0

Unit 1:

Introduction & computational complexity: Abstract data type and data structures, Classes and objects, Complexity of algorithms: worst case, average case and amortized complexity, notation for algorithm complexity, Algorithm analysis, Recurrence relations, Introduction to NP-completeness.
Unit 2:
Essential preliminaries: Overview of recursion, iteration, arrays, pointers, lists, stacks, queues. Dictionaries: Hash tables, Binary search trees, splay trees, Balanced Trees, AVL trees, 2-3 trees, B-Trees. Priority Queues : Heaps, binomial queues, Applications.
Unit 3:
Graphs: Shortest path algorithms (Dijkstra, Bellman-Ford, Floyd-Warshall), minimal spanning tree algorithms (Prim, Kruskall), depth-first, breadth-first search, and their applications.
Sorting: sorting methods and their analysis (shell sort, quicksort, merge sort, heap sort, radix sort), lower bound on complexity
Unit 4:
String matching: String matching algorithms (Rabin-Karp, Knuth-Morris-Pratt).
Algorithm design paradigms: Algorithm Design Paradigms: Greedy methods, divide and conquer, dynamic programming, backtracking, local search methods, branch and bound technique. Travelling salesman problem.

Suggested Reading:
- Lipshutz and Pai, 2010 Data Structure (Outline Schaum Series), McGraw Hill, Indian edition.
- Standish T. A., 1980 Data Structure Techniques, Addison-Wesley.

- Salzberg, B., 1988, File Structures, Prentice-Hall.
- Tharp, A.L., 1988, File Organization and Processing, John Wiley and Sons.
- Aho, A., Hopcroft, J. and Ullman, J., The Design and Analysis of Computer Algorithms, Addison Wesley.
- Goodman S.E. and Hedetniemi S.T., Introduction to the Design and Analysis of Algorithms. McGraw Hill.

BI 511N   Bio-analytical techniques   4+0

Unit I :
Microscopic techniques: Principles and application of light, phase contrast, fluorescence, confocal, scanning and transmission electron microscopy, cytophotometry and flow cytometry, fixation and staining, Fluorescence in-situ hybridization (FISH), GISH (Genomic in-situ hybridization).
Unit II
Chromatography & Spectroscopy: column chromatography (ion exchange, gel permeation, affinity), GLC and HPLC. Principles of colorimetry and UV-Vis spectrophotometry, Mass spectrometry, MALDI, X-Ray Crystallography
Unit III:
Electrophoresis and Radiation Biophysics: chromatography Agarose and polyacrylamide gel electrophoresis (native and denaturing), Immuno-electrophoresis, Isoelectric Focusing, Capillary electrophoresis. Principles of fluorescence, Tracer Technology, Dose-response relationship, Radioisotopes in Diagnostics and Biotechnology
Unit IV:
Gene Editing: History of its discovery, elucidation of the mechanism including an introduction to all the molecular players, development of applications for in vivo genome engineering for genetic studies, and promise of the technology as a next-generation therapeutic method.

Suggested Reading:
- Keith Wilson and John Walker. Principles and techniques of biochemistry and molecular biology.7th Edition,Cambridge University Press, Cambridge, UK.
- Donald Voet and Judith Voet. Biochemistry. John Wiley and Sons. New Jersey, USA
- Rodney F Boyer. Biochemistry laboratory: modern theory and techniques.2nd Edition, Pearson Prentice Hall, Boston,USA.
- R. Katoch. Analytical techniques in biochemistry and molecular biology,Springer, New York.
- D. L. Spector, R. D. Goldman. Basic methods in microscopy: protocols and concepts from cells: a laboratory manual. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.

BI 512N   Laboratory Course-III (based on core courses)   0+4

Laboratory course based on core courses

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BI 505N   Basic Bioinformatics   0+4

Unit 1:
Introduction to Genes and Proteins: Genome Sequences ORFs, Genes, Introns, Exons, Splice Variants DNA/RNA Secondary Structure Triplet Coding Protein Sequences Protein Structure: Secondary, Tertiary, Quaternary The notion of Homology.

Unit 2:
Introduction to Internet Use, Search Engines, and Sequence Information Sources**:** WWW, HTML, URLs Browsers: Netscape / Opera / Explorer Search Engines Google, PUBMED. EMBL GENBANK Entrez Unigene Understanding the structure of each source and using it on the web. PDB SwissProt TrEMBL Understanding the structure of each source and using it on the web.

Unit 3:
Introduction to Data Generating Techniques: Restriction Enzymes, Gel Electrophoresis, Chromatograms Blots, PCR, Microarrays, Mass Spectrometry What data each generates, and what bioinformatic problems they pose.

Unit 4:
Sequence and Phylogeny Analysis: Detecting Open Reading Frames, Outline of Sequence Assembly, Mutation Matrices, Pairwise Alignments, Introduction to BLAST, using it on the web, interpreting results, Multiple Sequence Alignment, Phylogenetic Analysis.

Suggested Reading:
- Bioinformatics: A practical guide to the analysis of genes and proteins (3rd Edition) D. Baxevanis and F. Oulette, Wiley Indian Edition.
- Bioinformatics Methods And Applications: Genomics Proteomics And Drug Discovery (3rd Edition) *Rastogi SC, Rastogi P, Mendiratta N.*. PHI Learning Pvt. Ltd.; 2008.
- Mount, D.W., Bioinformatics: 2001, Sequence and Genome Analysis. CSHL Press.
- Claverie, J.M. and Notredame C. 2003 Bioinformatics for Dummies. Wiley Editor.

BI 514N   Database Management   4+0

Unit 1:
Introduction to Databases: Why Database systems, Data abstraction and data models, Instances and schemas, Database Administrator, Data Definition and manipulation languages, brief introduction to network and hierarchical models.

Entitles Relationship model: Entity and entity sets, relationships and relationship sets,, E-R diagram, reducing E-R diagrams to Tables and trees.

Relational Algebra and Calculus: Relational algebraic operations such as select, project, union, set difference, Cartesian product,, intersections, natural join, division, generalized projection, outer join etc., tuple relational calculus, domain relational calculus.

Unit 2:
Issues in designing relational databases: Pitfalls in relational database design, decomposition, importance of normalization, functional dependencies, Boyce-Code Normal form, third normal form and fourth normal form.

Query language and query optimization: Domain types in SQL, Schema definition in SQL, Types of SQL commands, SQL operators, tables, views, indexes, aggregate functions, insert, delete and update operations, join, union, intersection, minus etc. in SQL, queries, sub-queries, equivalence of queries

Unit 3:
Database system architecture: Introduction to centralized system, client server system, parallel system and distributed system.

Introduction to ASN.1 and NCBI data model: Why specialized data model is required for biological sequences, different data types supported by ASN.1and how they are used for storage of different types of information reading of NCBI data using freely available NCBI toolbox.

Suggested Reading:
- Date, C.J. Introduction to Database Systems (Vol I & II), 2004, 8th Edition. AddisonWesley.
- Ullman, J.D. 1989, Principles of Database and knowledge base Systems (Vol I & II), Computer Science Press New York.
- Gio Wiederhold, 1997 Database Design, McGraw Hill.
- Elmasri R. and Navathe S.B., 2007 Fundamentals of Database Systems. Fifth Edition.Pearson.
- Singh S.K., 2011 Database Systems- Concepts, Designs and Application. 2nd Edition. Pearson

- Silberschatz A. Korth H. F. Sudarshan S., 2010 Database System Concepts. Sixth Edition. McGraw-Hill. Date K., Swamynathan S. 2012 An Introduction to Database Systems. Eight Edition. Pearson.

BI 515N   Perl programming and bioinformatics   4+0

Unit 1

Introduction: Introduction to Perl, Downloading and installation from Website, Writing and Running a Perl Program, Editing, Advantages.

Data Types: Scalar data and scalar variables: Number, String, Conversion between Numbers and Strings, Variable Interpolation, Arithmetic and Decimal Precision, Arrays: Initialization, Manipulation of Array elements;

Arithmetic and Logical Operators: Arithmetic Operators, Assignment Operators, Increment and Decrement Operators, String Concatenation and Repetition, Operators precedence and Associativity, Conditional Operators, Logical Operators, Operators for manipulating arrays, Operators for Manipulating hashes.

Unit 2

Conditionals and Loops: Conditional Statement; if, if…else, if and if-else, unless statement, Loops: while, for, until, do..while, do..until and foreach loop, last next, redo, continue and case switch statement. Input and Output file

Regular Expressions and Pattern Matching: Regular Expression, Pattern Matching, Meta Character, Simple Pattern, Matching Group of Characters, Matching multiple instances of Characters, Pattern Building

Unit 3

Function and Subroutines: Built-in Functions, Defining and calling subroutines, Returning Values from Subroutines, Using Local Variables in Subroutines, Passing Values into Subroutine, Perl References, Perl module and their uses.

Unit 4

Applications of Perl in Bioinformatics: Concatenating DNA Fragments, Transcription: DNA to RNA, Reading Protein Files, Finding Motifs, Simulating DNA, Generating Random DNA, Analysing DNA, Translating DNA to Proteins, Reading DNA from Files in FASTA format, Separating Sequence and Annotation, Parsing Annotation, Parsing PDB files, Parsing BLAST output, Bio-perl .

Suggested Reading:

- James Tisdall, "Beginning Perl for Bioinformatics", O'Reilly & Associates.
- James Tisdall, "Mastering Perl for Bioinformatics", O'Reilly.
- Cynthia Gibas & Per Jambeck, "Developing Bioinformatics Computer Skills", O'Reilly & Associates,
- Rex A. Dawyer, "Genomic Perl", Cambridge University Press
- Learning Perl, 3rd Edition , Author: Randal L. Schwartz and Tom Phoenix, O'Reilly

BI 516N   Optimization, machine learning and artificial intelligence   4+0

Unit 1:
Optimization techniques: Concepts of local and global optimum, constrained and unconstrained optimization, gradient, Hessian of a function, first order and second order necessary conditions for local minimizers, method of steepest descent, steepest descent for quadratic function, Newton's method, LevenbergMarquardt algorithm, and Lagrange multipliers methods.

Unit 2:
Genetic algorithms: Introduction to Genetic algorithms, exploitation and exploration, general structure of the basic genetic algorithm, different coding schemes, fitness function, chromosome, population, basic genetic operators, different selection mechanism, mutation, single point and multi-point crossover, termination criteria, elitist strategy.

Basic concepts of machine learning: Basic notions of learning,, introduction to learning algorithms, incremental learning, supervised learning, unsupervised learning, reinforcement learning, instance based learning and analytical learning.

Unit 3:
Clustering and classification: Introduction to clustering, maximum likelihood decomposition and its application to normal mixtures, k-means clustering algorithms, hierarchical clustering algorithms. Introduction to classifier design, linear discriminant analysis – two category and multi category cases, perceptron criterion and its minimization, decision trees (ID3, C4.5), impurity functions, pruning methods, rule extraction from decision trees, nearest neighbour classifier, k-nearest neighbour classifier, Bayes decision rule, lose function, minimum error rate classification, Bayes classifier with multivariate normal density.

Introduction to neural networks: Introduction to neural networks, introduction to biological neural network, motivation for artificial neural network (ANN), significance of massive parallelism and characteristics of (ANN), various types of architectures.

Unit 4:
Feed forward neural network: Layered networks, perceptron and motivation for multilayered perceptron (MLP), back-propagation learning , use of Levenberg-Marquardt method in training of MLP's, online vas batch learning, issues relating to initialization, termination, choice of architecture. Radial basis function networks and related training issues, properties of MLP and RBF.

Self-organizing maps and Recurrent neural networks: Self-organizing feature map, recurrent neural networks, Hopfield network and its applications, simulated annealing.

Suggested Reading:

- R. O. Duda, P. E. Hart and D. G. Stork, Pattern classification, John Wiley Sons, Second Edition,
- D. E. Goldberg, Genetic algorithms in search, optimization and machine learning, Pearson Education (Paper back)
- Christopher M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press,
- E. K. P. Chong and S. H. Zak, An introduction to optimization, John Wiley & Sons
- Tom Mitchell, Machine Learning, McGraw Hill, 1997

BI 571N   Probability and Information Theory   4+0

Unit 1
Probability Theory: Introduction, Random Experiment, Sample Space, Events, Complementary Events, Union and Intersection of Two Events, Difference Events, Exhaustive Events, Mutually Exclusive Events, Equally Likely Events, Independent Events, Mathematical & Statistical definition of Probability, Axiomatic definition of probability, Addition Theorem, Multiplication Theorem, Theorems of Probability, Conditional Probability, Inverse Probability.

Unit 2
Probability Distributions& Random Variables: Introduction, Probability mass/density function (PMF/PDF), discrete distributions, continuous distributions, mean and variance of common distributions, Properties, Cumulative Distribution function (CDF), properties, relation with PDF, functions of random variables, Characteristic function, special random variables, Chebychev and Markov Inequalities, Central limit theorem.

Unit 3:
Random Processes
Introduction, Random process, wide sense random process, strict sense and ergodic random process, Linear systems with random inputs.

Unit 4:
Information Theory: notion of information, concept of entropy, conditional and joint entropies, principle of maximum entropy, discrete memory less channel (DMC), Shannon's theorems and their applications, Variable length code, Huffman code, Shannon-Fano code.

Suggested Reading
- Henry Stark and John W.Woods, "Probability and Random Processes with Application to Signal Processing," 3rdEdition, Pearson Education, 2002.
- .George R. Cooper, Clave D. MC Gillem, "Probability Methods of Signal and System Analysis," 3rd Edition, Oxford, 1999.
- T. M. Cover and J. A. Thomas, Elements of Information Theory, Wiley,.
- El Gamal and Y.-H. Kim, Network Information Theory, Cambridge University Press,.

BI 518N   Bio-entrepreneurship   4+0

Unit-1:

Introduction to Bioentrepreneurship: concepts and overview of entrepreneurship, evolution and growth of entrepreneurship in India; Trends in entrepreneurship development, entrepreneurial potential and potential entrepreneur, finance management, Personal development and etiquette training.

Unit-2:
Human resource development, team building, and teamwork for entrepreneurship, small-scale set-up; Support mechanism for Biotechnology entrepreneurship in India, Preparation of proposal for funding

Unit-3:
Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies. Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP)

Unit-4:
Knowledge center and R&D: Knowledge centers like Universities and Research Institutions, Technology and upgradation, managing technology transfer, regulations for the transfer of foreign technologies, and Technology transfer agencies.

Suggested Reading
- The Business of Biotechnology: From the Bench of the Street: By Richard Dana Ono Published Butterworth- Heinemann, 1991.
- Entrepreneurship in Biotechnology: Managing for growth from start-up By Martin Gross Mann, 2003
- Innovation and entrepreneurship in biotechnology: Concepts, theories & cases by D. Hyne & John Kapeleris, 2006
- Dynamics of Entrepreneurial Development and Management by Vasant Desai, Himalaya Publishing House, 2005.
- Projects Planning Analysis, Selection, Implementation & Review by Prasannan. 6. Best Practices in Biotechnology Education: By Yali Friedman, Published by Logos Press, 2008.

BI 519N   Problem Solving Through C   4+0

Unit 1:
Introduction to Programming
The Basic Model of Computation, Algorithms, Flow-Charts, Programming Languages, Compilation, Linking and Loading, Testing and Debugging, Documentation.
Introduction to 'C' language: Character set, Variable and Identifiers, Built-in-Data Types, Variable Definition, Arithmetic operators and Expressions, Constants and Literals, Simple assignment statement, Basic input/output statement, Simple 'C' programs.
Unit 2:
Conditional Statements and Loops: Decision making within a program, Conditions, Relational Operators, Logical Connectives, if statement, if-else statement, Loops: while loop, do while, for loop, nested loops, infinite loops, switch statement, structured programming.
Arrays: One dimensional arrays: Array manipulation; Searching, Insertion, Deletion of an element from an array; Finding the largest /smallest element in an array; Two dimensional arrays, Addition/ Multiplication of two matrices, Transpose of a square matrix; Null terminated strings as array of characters, Representation sparse matrices
Unit 3:
Functions: Top down approach of problem solving, Modular programming and functions, Standard Library of C functions, Prototype of a function: Formal parameter list, Return Type,

Function call, Block structure, Passing arguments to a function: call by reference, call by value, Recursive Functions, arrays as function arguments.

Structures: Structure variables, initialization, structure assignment, nested structure, structures and functions, structures and arrays: arrays of structures, structures containing arrays, unions.

Pointers: Address operators, pointer type declaration, pointer assignment, pointer initialization, pointer arithmetic, functions and pointers, Arrays and Pointers, pointer arrays.

Unit 4:

Self Referential Structures and Linked Lists: Creation of a singly connected linked list, traversing a link list, Insertion into a linked list, Deletion from a linked list.

File Processing: Concepts of Files, File opening in various modes and closing of a file, Reading from a file, writing onto a file

Suggested Reading:
- "The C Programming Language" 2nd by Brian W Kernighan / Dennis M Ritchie, AT & T Bell Laboratories, Murrey Hill, Prentice Hall, Eaglewood Cliffs, New Jersey. 07632.
- " ANSI C Programming" by Yashavant Kanetkar.
- " Programming in C" by Reema Thareja.
- " Computer Basics and C Programming" by Rajaraman V.

BI 520N   Omics Technology   4+0

Unit I:
Introductory genomics Introduction to Genomics, Anatomy of prokaryotic and eukaryotic genome, the content of the genome, C-value paradox, CoT curve analysis, repetitive DNA, tools to study genome diversity.

Unit II:
Applied Genomics Strategies for major genome sequencing projects, approaches and assembly methods, NGS methods and advantages, gene analysis, and annotation.

Unit III:
Transcriptomics and expression profiling Genome expression analysis, RNA content and profiling, genetic mapping, Microarray (cDNA and protein microarray)

Unit IV:
Introductory proteomics Importance of proteomics, strategies in the analysis of proteome: 2-D PAGE, Mass spectrometry, Protein sequencing method (Edman degradation, MALDI TOF/TOF).

Suggested Reading
- Database Annotation in Molecular Biology: Principles and Practice, Arthur M. Lesk
- Bioinformatics : Sequence and genomic analysis by D. W. Mount, Cold Spring Harbour Laboratory Press.
- Recombinant DNA (Second Edition), James D. Watson and Mark Zoller
- Gene Cloning and DNA Analysis – An Introduction (Fourth Edition), T.A. Brown
- Protein array, Biochips and Proteomics by Smith and Albala (Eds), Marcel Dekkar, New York.
- Introduction to proteomics: Tools for new biology by Daniel C. Liebler, Humana Press

BI 521N   Python programming and bioinformatics   4+0

Unit 1

Introduction and Overview: A brief history of python – Unique features –Installation of Python and IDE - Lexical structure of python – Introduction of variables and data types with examples.

Unit 2
Statements and control structure: Introduction to python interpreter and interactive mode – Statement Read and Print commands – Evaluating expressions - Decision, Boolean Logic and Repetition structures syntax with examples in biological application.

Unit 3
Functions and Regular expressions: Defining and Calling a function - Fruitful functions (return value, parameters, local and global scope, function composition, recursion) – Examples in sequence analysis using function - Introduction to Modules. Regular Expression: Importance of patterns in biology – String manipulation using regular expressions (Extraction, splitting and matching).

UNIT 4
Tuples and Dictionaries: Introduction to Lists – List slicing – Finding items in Lists with operator – Copying and Processing Lists – List built-in methods – Two Dimensional lists. Tuples: Basic tuple operations – creation, concatenation, repetition, slicing, immutable and deletion. Dictionaries: creation, accessing and processing - Dictionary methods.

UNIT 5
Files and Exception Handling: File objects – File built-in methods and attributes - Reading and writing files - command line arguments. Exception Handling: Errors and exceptions, Detecting and Handling Exceptions.

Suggested Reading:
- Bioinformatics Programming Using Python (2009) by Mitchell L Model, O'Reilly Media, Inc.
- Python for Bioinformatics, by Bassi Sebastian, CRC Press, Taylor & Francis group
- Python Programming for Biology, (2015) by Tim J. Stevens, Wayne Boucher, Cambridge University Press.
- Bioinformatics Programming in Python: A Practical Course for Beginners (2008) Ruediger-Marcus Flaig, Wiley-Blackwell

BI 522N   **Laboratory Courses (based on core and optional courses)**   **0+4**

BI 523N   **Project/Review/Industrial training**   **-**

Each student must conduct project/review /industrial training in the third semester under the guidance of the allotted advisor/supervisor. The evaluation of the same will be done at the end of the fourth semester as per the guideline issued by the university authority.

BI 524N   Molecular modeling and drug discovery   4+0

Unit 1:
Introduction to drug designing: Different approaches to drug designing, Basic principle of similarity and complimentarily, High throughput vs rational drug designing, Use of computer modelling technique to drug designing.

Small molecular structures: Different coordinate systems and transformations amongst them, Basic Principle 2D and 3D Graphics and use of molecular graphics packages (e.g. RasMol, RasTop, Qmol, MolMol), Cambridge Structural Data base, Building small molecules using chemical information, Use of Builders and Sketchers (eq. ISIS Draw, HyperChem).

Unit 2:
Basic principles of target structure based (rational) drug designing: Target identification and validation, Active site analysis, Basic principle of Docking a ligand in active site of a target, Virtual Screeing, Different methods of scoring and Lead optimization.

Unit 3:

Basic concepts in quantitative structure activity relationship (QSAR): Objective of QSAR, Development of Hansch QSAR equation, QSAR Descriptors, Regression analysis.

Pharmacophore model building: Ligand-based pharmacophore modeling, Structure-based pharmacophore modeling.

Unit 4:
Forces stabilizing Protein & Nucleic Acid structures**,** Energy minimization and Molecular Dynamics methods**:** Theory, Application to Proteins, Applications to nucleic acids.

Suggested Reading:
- Molecular Modeling: Basic principles and applications. Holtje HD, sippl W, Rognan D and Folkers G. Wiley-VFH 2nd Edition.
- Quantum Biology: S. P. Gupta, New Age publishers
- olecular modelling and drug design. Andrew Vinter and Mark Gardner and Boca Raton, CRC Press.
- Molecular Similarity in drug design, Dean PM, Chapman and Hall.

BI 525N   Human Genetics and Genome Project   4+0

Unit 1

Genetic mapping of Mendelian characters: Recombinants, Non-recombinants, Genetic markers, Two point mapping, Multipoint mapping, Fine mapping using extended pedigrees and ancestral haplotypes. Identifying Human disease genes: Principles and strategies in identifying disease genes.

Unit 3

Mapping and identifying genes conferring susceptibility to complex diseases: Deciding whether a non-Mendelian character is genetic: the role of family, twin and adoption studies, Linkage analysis of complex characters, Examples that illustrate the varying success of genetic dissection of complex diseases.

Unit 4

Molecular Pathology: Rules for nomenclature of mutations & databases of mutations, Loss of function mutations, Gain of function mutations, Molecular pathology from gene to disease, Molecular pathology from disease to gene, Molecular pathology of chromosomal disorders.

Unit 5

Human Genome Project (HGP) – an overview of the project, goals of the project, major scientific strategies & approaches used in HGP, expected scientific & medical benefits of this project, about the organizations behind this project. How Human genome was mapped – physical mapping, genetic mapping, gene ontology, gene annotation.

Suggested Reading:
- The Human Genome, 3rd Edition,(2010) by Julia Richards R. Scott Hawley, Academic Press
- Human Genes and Genomes, (2013), by Leon Rosenberg, Dione Rosenber, Academic Press.
- Human Genome Project, (2013) by Kelly E. Happe, New York University Press.
- Genomics: The Science and Technology behind the Human Genome Project (1999), by Charles R. Cantor, Cassandra L. Smith, John Wiley & Sons, Inc.

Bi 526N   NGS data Analysis   4+0

Unit 1:
Introduction to NGS: Generation to DNA sequencing technologies, A Typical NGS Experimental Workflow, Different NGS Platforms – Illumina, Ion Torrent Semiconductor Sequencing, Pacific Biosciences SMRT, ONT Nanopore; Major Applications of NGS

Unit 2:
Base Calling, Quality Control & Read Mapping: Base Calling, FASTQ File Format, Base Quality Score, NGS Data Quality Control and Preprocessing; Reads Mapping – Mapping Approaches and Algorithms, Computing Power Required for NGS Data Analysis, Bioinformatics Skills & Software Required for NGS Data Analysis.

Unit 3:
Transcriptomics by RNA-Seq: Principle of RNA-Seq; Experimental Design: Factorial Design, Replication and Randomization, Sample Preparation, Sequencing Strategy; RNA-Seq Data Analysis: Data Quality Control and Reads Mapping, RNA-Seq Data Normalization, Identification of Differentially Expressed Genes, Differential Splicing Analysis, Visualization of RNA-Seq Data, Functional Analysis of Identified Small RNAs.

Unit 4:
Genotyping and Genomic Variation Discovery: Data Preprocessing, Mapping, Realignment, and Recalibration; Single Nucleotide Variant (SNV) and Indel Calling: SNV Calling, Identification of de novo Mutations, Indel Calling, Variant Calling from RNA-Seq Data, Variant Call Format (VCF) File, Annotation of Called Variants, Testing of Variant Association with Diseases or Traits.

Unit 6:
De novo Genome Assembly & ChIP-Seq Analysis: Genomic Factors and Sequencing Strategies for de novo Assembly, Genomic Factors That Affect de novo Assembly, Sequencing Strategies for de novo Assembly; Assembly of Contigs, Sequence Data Preprocessing, Error Correction, and Assessment of Genome Characteristics, Integrated ChIPSeq Data Analysis.

Suggested Reading

- Next-Generation Sequencing Data Analysis by Xinkun Wang, (2016) CRC Press, Inc. Subs. of Times Mirror 2000 Corporate Blvd. NW Boca Raton, FL United States.
- Statistical Analysis of Next Generation Sequencing Data (2014) Editors: **Datta**, Somnath, **Nettleton**, Dan (Eds.), Springer International Publications.
- Computational Methods for Next Generation Sequencing Data Analysis, Editor(s): Ion Măndoiu , Alexander Zelikovsky (2016), John Wiley & Sons.
- Next-generation sequencing data analysis (2016), Xinkun Wang, CRC Press, Boca Raton, Florida, Oxford publications.
- Big Data Analytics in Genomics, **Wong,** Ka-Chun (Ed.), Springer International Publications

BI 527N   **Complex Algorithms in Bioinformatics**   **4+0**

Unit 1
TSP; Weight matrices: Sequence weighting, pseudo count correction for low counts, Gibbs sampling, and Psi-Blast

Unit 2
Dynamic programming: Needleman-Wunsch, Smith-Waterman, and alignment heuristics; Data redundancy and homology reduction: Hobohm and other clustering algorithms

Unit 3
Hidden Markov Models: Model construction, Viterbi decoding, and posterior decoding, and Baum Welsh HMM learning

Unit 4
Artificial neural networks: Architectures and sequence encoding, feed-forward algorithm, and back propagation; BCO; ACO; Genetic Algorithm
Practical: Based on theory paper – BI-514

Recommended books:
- Bioinformatics: Problem Solving Paradigms, (2008),by Sperschneider, Volker, Springer International Publisher

- Bioinformatics Algorithms: Techniques and Applications, (2008) Ion Mandoiu, Alexander Zelikovsky, Wiley Science.
- Bioinformatics Algorithms, by Moguel Rocha, Pedro G. Ferreira, Academic Press Elsiever.

BI 528N   Scientific Writing and communication   4+0

Unit 1
Presentation techniques: structure of presentations, interacting with PowerPoint, slide design, body language and positioning, presentation of participants, feedback.
Unit 2
Scientific writing: academic language, structure of scientific documents, scientific sources, thesis writing, Selection of journal with appropriate Impact factor, Effective Literature Review, Inclusion and sequencing of authors based on their roles.
Unit 3
Preparation of title and abstract of manuscript, Preparation of Experimental Design, Discussion and conclusion, Graphical abstract/Image representation, obtaining permission for reproduction of data from other journals, Statistical tools in research.
Unit 4
Compilation of discussion and future directions in a review article, Respond to the reviewer's comments, Inter- and intra-departmental collaborations, Guide for SCOPUS/WOS/SCI Journals and Predatory Journals
Suggested Reading
- Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
- Day, R.A., 1992. How to write and publish a Scientific paper, Cambridge University Press.
- Fink, A.,2009. Conducting Research Literature Reviews: From the internet to paper. Sage Publications.

BI 529N   BIOSAFETY, IPR AND BIOETHICS   4+0

Unit-1

Introduction To Intellectual Property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, IP as a factor in R&D; IPs of relevance to biotechnology; introduction of GATT, WTO, WIPO, and TRIPS; plant variety protection and farmers rights act; concept of prior art': invention in the context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

Unit-2:

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; the role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure /non-disclosure -patent application forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies; patent infringement.

Unit-3

Biosafety and Biosecurity; introduction to biological safety; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs LMOs; principles of safety assessment of transgenic plants. International Regulations –Cartagena Protocol, OECD consensus documents, and Codex Alimentarius; India Regulations –EPA act and rules, guidance documents, regulatory framework–RCGM, GEAC, IBSC, and other regulatory bodies.

Unit-4

Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, human and animal experimentation, animal rights/welfare, Genetically engineered food, environmental risk, labeling, and public opinion, biopiracy

Suggested Reading:

- Ganguli,P.(2001).Intellectual Property Rights: Unleashing The Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
- National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
- Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication.
- Kuhse, H. (2010). Bioethics: An Anthology. Malden, MA: Blackwell.
- Karen F.Greif and Jon F. Merz, Current Controversies in the Biological Sciences -Case Studies of Policy Challenge

BI 530N **Statistical Methods in Bioinformatics** **4+0**

Unit 1:

Review: Mean, Median, Mode Standard Deviation, Variance and Correlation (Emphasis to be placed on hands on approach with real data sets) Probability limits and distribution theorems.

Sampling Distributions:Statistic Distribution of sample mean Sample variance – (application of Central limit theorem)

Estimation Theory: Biased and unbiased estimator Confidence interval: population mean, proportion Variance

Unit 2:

Maximum Likelihood Estimation: Discrete and Continuous distributions Likelihood function Log-likelihood functions (use of package recommended).

Inference – Test of hypotheses: Formulation of Hypothesis: Simple and Composite Type I and Type II errors Power of a test Significance of a test P-value, Testing, Chi-Square, t-test and F-test, Chi-Square goodness of fit, Test of diversity based on entropic method, Non-parametric: Mann-Whitney test.

Unit 3:

Simple Linear Regression and Correlation: Linear regression model Least squares methods Estimating model parameters Residual sum of squares.

Analysis of Variance: Single factor ANOVA Multi-comparison ANOVA

Unit 4:

Statistical Methods for Stochastic Processes: Testing of independence Testing of Markov property Association test.

Analysis of Stochastic process: Long Repeat Scan Statistics Analysis of Patterns.

Suggested Reading:

- Statistical methods in Bioinformatics, (2001), **Ewens**, Warren J., **Grant**, Gregory R., Springer International Publications.
- Statistical Methods in Bioinformatics, An Introduction, 2004, (second edition) Warren J. Ewens and Gregory R. Grant Springer, Heidelberg.

- Statistics For Bioinformatics (2016) by Julie Thompson , Elsevier Science
- Applied Bioinformatics: An Introduction (2008) by Selzer Paul Maria Et Al, Springer

BB 531N   NANOBIOTECHNOLOGY   4+0

Unit I
Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with examples for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.

Unit II
Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterization. Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in synthesis

Unit III
Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

Unit IV
Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli-responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

Suggested Reading
- Claudio Nicolini, Nanobiotechnology & Nanobiosciences Pan Stanford Publishing Pte. Ltd,.
- C.M. Niemeyer and C.A. Mirkin, Nanobiotechnology, Concepts, Applications and perspectives, WILEY-VCH, Verlag Gmb H&Co, .
- S. David Goodsell, Bionanotechnology, Lessons from Nature, Wiley-Liss, Inc, .
- Melgardt M.deVilliers, Pornanong Aramwit, Glen S.Kwon, Nanotechnology in Drug Delivery, Springer-American Association of Pharmaceutical Scientists Press
- Robert A. Freitas Jr. Nanomedicine, Volume I:Basic Capabilities, Landes Bioscience,

BI 532N   Project/Review   0+4

Each student must conduct project/review /industrial training in the first semester under the guidance of the allotted advisor/supervisor. The evaluation of the same will be done at the end of the second semester as per the guideline issued by the university authority.