NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

Honors in

BIOTECHNOLOGY

SCHEME OF INSTRUCTION AND SYLLABI

(for students of B.Tech., Biotechnology)

(Effective from 2021-22)

DEPARTMENT OF BIOTECHNOLOGY

SCHEME OF INSTRUCTION

Honors Program – Biotechnology

S. No.	Course Code	Course Name	L	T	P	Credits	Sem.
1	BT5113 BT5114	Protein Engineering / Nutrigenomics	3	0	0	3	V
2	BT5153	Advanced Recombinant DNA Technology	3	0	0	3	VI
3	BT5163 BT5164	Molecular Pathogenesis / Agriculture Biotechnology	3	0	0	3	VI
4	BT5104	Advanced Stem Cell and Tissue Engineering	3	0	0	3	VII
5	BT5112 BT5118	Molecular Virology / Infection and Immunity	3	0	0	3	VII
6	BT5167	Bioeconomy and Biorefineries	3	0	0	3	VIII
			18	0	0	18	

Course Code: BT5113	PROTEIN ENGINEERING	Credits 3-0-0: 3

Pre-Requisites: BT203, BT255

Course Outcomes: At the end of the course, the student will be able to

CO1	Relate Protein structure to protein function.
CO2	Comprehend protein-folding pathways.
CO3	Select appropriate techniques for protein engineering.
CO4	Understand the protein characterization techniques.

Syllabus:

The Relationship between Protein Structure and Function: Protein synthesis, protein structure, families of protein structures: alpha, alpha/beta, beta, etc., protein function and structure-function relationships. Ramachandran plot; Motifs of protein structures and their packing. Protein folding pathways in prokaryotes and eukaryotes; Structure of chaperones and role of chaperones in protein folding; Folding of single domain and multi-domain proteins; Inclusion bodies and recovery of active proteins.

Methods in Protein Engineering: Strategies for protein engineering; Protein Engineering with Random Mutation, Protein Engineering with site-specific mutation, PCR based methods for engineering proteins, Role of low-fidelity enzymes in protein engineering; Gene shuffling and Directed evolution of proteins; Antibody engineering.

Structural Analysis of Proteins: Similar structure and function of homologous proteins; Role of multiple alignment; Homology and ab- initio method for protein structure prediction; Phage display systems; Rational protein design, different databases and their uses.

Proteome Analysis: Introduction to the concept of proteome, components of proteomics, proteomic analysis, importance of proteomics in biological functions, protein identification, protein arrays, protein chips and applications, cross linking methods, affinity methods, yeast hybrid systems, isotope labeling, protein identification with two-dimensional gel electrophoresis data and mass spectrometry data. Functional proteomics tools.

Learning Resources:

Text Books:

1. Protein Engineering and Design, Anton Torres, Syrawood Publishing House, 2017.
2. Protein Engineering: Design, Selection & Applications (Protein Biochemistry, Synthesis, Structure and Cellular Functions), Mallorie N Sheehan, Nova Science Publishers Inc; UK, 2011.

Reference Books:

1. Protein engineering in Industrial biotechnology, Ed. Lilia Alberghina, Harwood Academic Publishers, 2002.
2. Proteomics: Protein Sequence to Function, Pennington, S.R and M.J. Dunn, Viva Books, 2002.

Online Resources:

1. https://www.springer.com/gp/book/9783030568979
2. https://www.science.gov/topicpages/p/protein+engineering+study.html

Course Code: BT5114	NUTRIGENOMICS	Credits 3-0-0: 3

Pre-Requisites: BT255

Course Outcomes: At the end of the course, the student will be able to

CO1	Demonstrate the concepts of Nutrition and Genomics.
CO2	Explain the role of differential gene expressions in diseases.
CO3	Analyze nutritional genomics in association with human metabolism and diseases.
CO4	Evaluate the nutritional data using computational tools.

Syllabus:

Introduction to Nutrigenomics: Genome, genomics, nutrigenetics, nutrigenomics: A brief introduction, primer on genomics and beyond, Genome-wide association studies. Nutrigenomics: measuring nutrition-responsive genome activity, Transcriptomics, Proteomics, and Metabolomics. Nutrigenetics: measuring interindividual response to nutrients, Genetic responses to individual nutrients.

Expression of Nutrigenomics: Nutrient–Gene Interactions: Lunasin Structure and Function, Lunasin Treatment of Prostate Cancer and Gene Expression Profiling, Lunasin-Induced Gene Expression Profiles, Genes Involved in Suppression of Cell Proliferation, Genes Involved in Protein Degradation, Modulation of Gene Expression by Dietary Iron, Zinc, Selenium.

Nutritional Metabolic Responses: Nutrigenomic approaches to understand the transcriptional and metabolic responses, obesity, anti-obesity action of Luteolin, Inflammation, and Cardiometabolic syndrome. Applications of genomics and bioinformatics in nutrition. Nutritional genomics: cellular signaling and molecular targets, Vitamin-D on cardiovascular disease.

Advances in Nutrigenomics: Personalization the norm of Nutrigenomics, Public Health and Nutrigenomics, Public Health Applications of Nutrigenomics, Implementation and Evaluation. Bio-computation and analysis of complex datasets in Nutritional Genomics: Nutritional Genomics: Part of High-Throughput Biology, Proteomics and Metabolomics Data, Sources of Complexity in Nutritional Genomics, Data Sets in Nutritional Genomics, Level of Complexity in Gene Expression Experiments.

Learning Resources:

Text Books:

1. Nutritional Genomics, Jim Kaput Raymond L. Rodriguez, John Wiley & Sons, Inc, 2019.
2. Nutritional genomics, Wiyane R Bildak, Raymond L Rodriguez, CRC Press, Taylor & Francis Group, 2012.

Reference Books:

1. Nutrition and Genomics Issues of Ethics, Law, Regulation and Communication, David Castle, Nola M, Academic Press, Elsevier, 2014.
2. Nutrigenomics, Gerald Rimbach, Jurgen Fuchs, Lester Packer, CRC Press, Taylor & Francis Group, 2018.

Course Code: BT5153	ADVANCED RECOMBINANT DNA TECHNOLOGY	Credits 3-0-0: 3

Pre-Requisites: BT303

Course Outcomes: At the end of the course, the student will be able to

CO1	Design suitable cloning strategies for bacteria, plant and animal cells.
CO2	Apply appropriate mutagenesis approach to generate desired genetic combination.
CO3	Design cloning strategies for heterologous gene expression in bacteria and yeast.
CO4	Apply appropriate gene transfer techniques for animals and plants.
CO5	Develop transgenic organisms for the benefit of society.

Syllabus:

Molecular Cloning and Advanced Vectors: Plasmids and Phage Vectors, Cosmids, phagemid and other advanced vectors: phage-derived PACs, BACs, YACs and gateway cloning vectors—cloning strategies.

Mutagenesis Strategies: Changing genes – site directed mutagenesis, reverse mutagenesis, cassette mutagenesis. Gene knockout, RNA interference, CRISPR-Cas9, transposon mutagenesis.

Cloning Strategies in Bacteria other than *E. coli* and Yeasts: Cloning in gram negative and gram- positive bacteria—Different vectors and suitable cloning strategies. Integrative vectors for fungi, Yeast promoter systems for over expression of genes, multipurpose vectors.

Gene Transfer Strategies: Gene transfer strategies and generation of transgenic plants and animals—Transfection techniques and use of suitable selectable markers, over expression of transgenes, *Agrobacterium* mediated transformation, Direct DNA transfer method and use of viral vectors for plants and animals, Advance transgenic technologies.

Learning Resources:

Text Books:

1. Principles of gene manipulation and Genomics, Old RW and Primrose SB, Blackwell Scientific Publications, 2006, 7th Edition.
2. Advanced Bacterial Genetics: Use of Transposons and Phage for Genomic Engineering. Kelly T. Hughes and Stanley R. Maloy, Methods in Enzymology, Vol. 421, Academic Press, 2007.

Reference Books:

1. Gene Cloning and DNA Analysis: An Introduction, Brown TA. Blackwell Publishing, 2016, 7th Edition.
2. Molecular Cloning: A Laboratory Manual. (3 volume set). Green, M. R. and Sambrook, J.Cold Spring Harbor Lab Press, 2012, 4th Edition.

Online Resources:

1. https://nptel.ac.in/courses/102/103/102103013/

Course Code: BT5163	MOLECULAR PATHOGENESIS	Credits 3-0-0: 3

Pre-Requisites: BT253, BT254, BT304

Course Outcomes: At the end of the course, the student will be able to

CO1	Analyze human-pathogen interactions using modern understanding of Koch's postulates.
CO2	Understand the molecular basis of evolution of pathogens.
CO3	Select appropriate model to analyze specific interaction of host-pathogen.
CO4	Use suitable molecular technique to assess pathogenicity.
CO5	Relate the roles and regulations of virulence factors in pathogenicity.

Syllabus:

Human Microbiota and Disease: Normal microbiota of human body and their interaction with host system. Characterization of human microbiota. Establishing connection between microbes and diseases—Koch's Postulates and its limitations. Modern alternatives to Koch's postulates, Concept of disease and virulence.

Molecular Evolution of Pathogens: Mechanisms of genetic variations, Different forms of mutations, chromosomal rearrangements, Horizontal gene transfer methods, Pathogenicity islands and pathogen evolution.

Molecular Techniques and Use of Different Models: Different animal and tissue culture models to measure pathogenicity—Experimental methods—LD_{50} and ID_{50} values estimation, competition assay, gentamicin protection and plaque assay, fluorescence microscopy methods. Different molecular approaches to identify pathogenic and host factors for establishing diseases.

Molecular Mechanisms of Pathogenicity: Strategies to evade host defense mechanisms—pre-infection, colonization and evading host immunity. Production, secretion and delivery of different toxins and virulence factors. Different regulatory mechanisms for virulence genes, Quorum sensing.

Learning Resources:

Text Books:

1. Bacterial Pathogenesis: A Molecular Approach, Wilson, B. A., Salyers, A. A., Whitt, D. D. and Winkler, M. E. ASM Press, 2011, 3rd Edition.

Reference Books:

1. Molecular Pathology: The molecular basis of human disease, Wiliamcoleman& Gregory Tsongalis, Academic Press, 2017, 2nd Edition.
2. Methods in Microbiology: Bacterial Pathogenesis, Vol. 27, Williams, P. Ketky, J and SalmondG, Academic Press, 1998.

Course Code: BT5164	AGRICULTURAL BIOTECHNOLOGY	Credits 3-0-0: 3

Pre-Requisites: BT353

Course Outcomes: At the end of the course, the student will be able to

CO1	Apply plant tissue culture techniques in agriculture and horticulture.
CO2	Understand the utility of mycorrhiza as biofertilizers in agriculture.
CO3	Apply biotechnology techniques in the field of agriculture.
CO4	Comprehend biosafety regulations for genetically modified crops.
CO5	Understand quality improvement techniques used for commercial crop varieties.

Syllabus:

Introduction to Agriculture: An introduction, Impact of Biotechnology on Agro-biodiversity; Biotechnology for Agriculture; Micropropagation Technology and its use in Agriculture. Role of biofertilizers and bio-pesticides in sustainable agriculture. Mass cultivation of microbial inoculants, plant growth promoting rhizobacteria diazotrophic microorganism, Free living and symbiotic nitrogen fixing microbes, Molecular basis of legume rhizobium symbiosis.

Biofertilizer in Agriculture: Mechanism of biological nitrogen fixation process. Study of nitrogen fixation, rhizobial nodulation gene and hydrogen uptake genes in nitrogen fixation process. Production of biofertilizers and applications of rhizobium, azotobacter, azolla and, 7ycorrhiza: Applications in agriculture and forestry. Plant growth regulators in agriculture and horticulture.

Molecular Application in Agriculture: Molecular aspects of biotic and abiotic stress responses and genetic engineering for drought, salinity and Temperature. Insect resistance – BT gene applications. Virus resistance – coat protein mediated, nucleocapsid gene and RNAi approach. Fungal resistance – PR proteins chitinase, beta glucanases. Nematode resistance – Nematode infestation and engineering for nematode resistance. Long shelf-life of fruits and flowers: use of ACC synthase, polygalacturanase, ACC oxidase. Male sterile lines: barstar and barnase systems. Genetic improvement of nutritional quality of oils.

Quality Improvement using Agricultural Biotechnology: Improvement of qualitative characters – Nutritional value of storage products – elite strains rich in iron, protein and amino acids, golden rice and its color – anthocyanines, betalaines, crocin and crocetins. Flavors – capsaicin, vanillin, stevioside thaumatin, The recent trends in agriculture.

Learning Resources:

Text Books:

1. Agricultural Biotechnology, Arie Altman, Marcel Dekker, Inc. 2012.
2. Biotechnology in Agriculture and Forestry, Bajaj YPS, Vol.22. Springer-Verlag, 2010.

Reference Books:

1. Agricultural Biotechnology at a Glance Dr. K.H. Singh Dr. Ajay Kumar Thakur, Dr. Nehanjali, Parmar science technology publisher; 2019,1st Edition.
2. Agricultural Biotechnology, H.D Kumar, Daya Publishing House, 2005.

Course Code: BT5104	ADVANCED STEM CELL AND TISSUE ENGINEERING	Credits 3-0-0: 3

Pre-Requisites: BT253, BT254

Course Outcomes: At the end of the course, the student will be able to

CO1	Classify different stem cells.
CO2	Explain the construction of connective tissues.
CO3	Select the procedure for isolation and identification of stem cells.
CO4	Construct scaffolds for tissue engineering
CO5	Identify regulatory considerations for biomaterials used in tissue engineering.

Syllabus:

Cell Culture Medium: Introduction to the balanced salt solutions and growth medium, Chemical, physical and metabolic functions of different constituents of culture medium, role of carbon-di- oxide and role of serum and its supplements in maintaining cells in culture medium, serum and protein free defined media and their application.

Maintenance of Cells: Biology and characterization of cultured cells, Maintenance and management of cell lines, Scale-up of animal cells in culture, Scale-up of anchorage dependent cells and suspension cultures: Cell isolation and selection; cell preservation.

Stem Cells: Definition, classification and sources, Properties and application of embryonic stem cells, Cell adhesion – Extracellular matrix, In vitro cell proliferation, Induced pluripotent stem cells.

Tissue Engineering: Elements of biomaterials, Mechanical concepts in biomaterials, Characterization of biomaterials, Methods for the determination of biocompatibility, Basic techniques to manufacture scaffolds, Bioreactor for tissue engineering –Design and scale up, Hollow fiber systems, Micro carrier-based systems.

Learning Resources:

Text Books:

1. Essentials of Stem Cell Biology, Robert Lanza, Anthony Atala, 2013, 3rd Edition.
2. Stem Cell Biology, David Gottlieb, Cold Spring Harbor, 2002.

Reference Books:

1. Tissue Engineering, Clemens van Blitterswijk, Academic Press, 2008.
2. Principles of Tissue Engineering, Robert Lanza, Academic Press Inc, 2020, 5thEdition.

Online Resources:

1. https://www.sciencedirect.com/science/article/pii/S1672022915000029
2. https://www.nibib.nih.gov/science-education/science-topics/tissue-engineering-and-regenerative-medicine

Course Code: BT5112	MOLECULAR VIROLOGY	Credits 3-0-0: 3

Pre-Requisites: BT202, BT253, BT254, BT304

Course Outcomes: At the end of the course, the student will be able to

CO1	Illustrate the Structure and Replication of viruses.
CO2	Understand and explain the complexity of Viral Genomes.
CO3	Outline the molecular mechanisms used by viruses to exploit their hosts.
CO4	Study the mechanisms of pathogenesis, epidemiology and control.

Syllabus:

Introduction to Virology, Classification, Structure and Replication: Basic characteristics and classification of viruses, virion structure (non-enveloped viruses, enveloped viruses), viral replication: overview, recognition & attachment to host cell, penetration.

Structure and Complexity of Viral Genomes: Introduction to viral genomes, virus mutants, suppression, genetic interactions between viruses, non-genetic interactions between viruses, large' DNA genomes, small' DNA genomes, positive-strand RNA viruses, negative-strand RNA viruses, segmented and multipartite virus genomes, reverse transcription and transposition.

Mechanisms of Viral Pathogenesis and Control: Acquisition & infection of target tissue, cytopathogenesis (lytic & nonlytic infections, oncogenic viruses), human host defenses against viral infection, immunopathology, epidemiology of viral diseases, control of viral spread.

Learning Resources:

Text Books:

1. Principles of Virology, Volume 1: Molecular Biology, S.J. Flint, V.R. Racaniello, G. F. Rall and A.M. Skalka, ASM Press, 2015.

Reference Books:

1. Principles of Molecular Virology, Alan J. Cann, Elsevier Academic Press, 2015, 6th Edition.
2. Introduction to Modern Virology, Nigel Dimmock, Andrew Easton and Keith Leppard, Wiley-Blackwell, 2016, 7th Edition.

Course Code: BT5118	INFECTION AND IMMUNITY	Credits 3-0-0: 3

Pre-Requisites: BT202, BT253, BT254, BT304

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand basic concepts of the immune system.
CO2	Identify the cellular and molecular basis of immune responsiveness.
CO3	Describe the roles of the immune system in both maintaining health and contributing to disease.
CO4	Apply knowledge of immune responses to various pathogens by integrating genomics and proteomics with bioinformatics strategies.
CO5	Design the vaccine using bioinformatics tools.

Syllabus:

Introduction to Immune System: Innate and Adaptive Immunity, Cells and Organs of the Immune system, Structure, Function and Classification of Immunoglobulins, Monoclonal and Polyclonal antibodies, Antibody Diversity, Basis of antigen-antibody interactions, B-cell and T-cell maturation, MHC: Antigen processing and presentation, B-cell and T-cell activation.

Immunodeficiency Disorders: Immune response to infectious diseases – viral, bacterial, parasitic infections; Immuno-diagnosis of infectious diseases, Immune response in Autoimmune disease and Cancer, AIDS and other immunodeficiencies, Immune system aging – Cardinal features, Age-related changes in B- cell and T-cell functional responses, Age-associated changes in lymphoid organs and soluble immunological mediators, Mechanisms and therapeutic targets.

Immunological Databases: SYFPEITHI-MHC-presented epitopes, IMGT, the international ImMunoGeneTics information system, IMGT ontology, IMGT Choreography, T-cell and B-cell epitope databases, Peptide and Allergen databases, Features of ADB, Allergome, SDAP, IEDB analysis, MHCBN-comprehensive database of MHC binding and non-binding peptides.

From Immunome to Vaccine: Principles and strategy for developing vaccines, Prediction of immunogenicity, Vaccine design tools, Reverse Vaccinology, Immunomics-based vaccinology, Peptides with Antimicrobial Activity or Antibiotic Peptides, Future of Computational Modelling and Prediction Systems in Clinical Immunology.

Learning Resources:

Text Books:

1. Kuby Immunology, Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen, 2018, 8th Edition.
2. Immunoinformatics: Bioinformatic Strategies for Better Understanding of Immune Function, Gregory R Bock, Jamie A Goode, Wiley, 2003.

Reference Books:

1. Roitt's EssentialImmunology, Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt, 2017, 13th Edition.

2. Immunoinformatics (Immunomics Reviews), Christian Schonbach, Shoba Ranganathan, Vladimir Brusic, USA: Humana Press, 2010.

Online Resources:

1. https://www.nature.com/nri/
2. https://www.frontiersin.org/journals/immunology
3. https://www.journals.elsevier.com/immunoinformatics

Course Code: BT5167	BIOECONOMY AND BIOREFINERIES	Credits 3-0-0: 3

Pre-Requisites: BT203, BT301

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand biofuel policies, law, demand and supply barriers.
CO2	Analyze biomass composition and structure.
CO3	Apply concept of biorefinery to substitute oil dependent economy.
CO4	Utilize synthetic biology and metabolic engineering principles for biofuels production.
CO5	Evaluate the standards and life cycle assessment of biofuels.

Syllabus:

Introduction to Biofuels: Oil economy Vs Bio economy, working principle of IC engines, Biofuels in the global energy scene, National biofuel policy and law. Biofuel Feedstocks.

Biomass Conversion and Bioprocess Technologies: Classification of biofuels, Biomass composition and analysis. Biomass conversion technologies. First, second, third and advanced biofuels production technologies/process and challenges. Consolidated bioprocess engineering (CBP) for biofuels. Concept of Bio refinery: Biomass to value added compounds, Bioelectricity.

Synthetic Biology and Metabolic Engineering for Biofuels: Biomass converting enzymes and manipulations, Synthetic biology and metabolic engineering approaches (case studies) for biofuels production.

Analysis and Assessment of Biofuels: Life Cycle assessment of biomass and biofuels, Standards of biofuels, Exergy analysis of biofuels.

Learning Resources:

Text Books:

1. Biofuels Engineering Process Technology, Caye M. Drapcho; NhuậnPhúNghiêm; Terry H. Walker, McGraw Hill: New York, 2020, 2nd Edition.
2. Bioenergy Biomass to Biofuels and Waste to Energy, Anju Dahiya, Academic Press, 2020, 2nd Edition.

Reference Books:

1. Bioenergy Research: Advances and Applications, Vijai K. Gupta, Elsevier B.V. Netherlands, 2014, 1st Edition.
2. Efficiency of Biomass Energy: An Exergy Approach to Biofuels, Power, and Biorefineries, Krzysztof J Ptasinski, John Wiley & Sons, 2015, 1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/102/104/102104057/