SYLLABUS FOR B.SC. BIOTECHNOLOGY

HONOURS PROGRAMME UNDER NEP, 2020

DEPARTMENT OF BIOTECHNOLOGY -MANIPUR UNIVERSITY

OBJECTIVES OF THE PROGRAMME

The objectives of the B.Sc. Biotechnology programme is to empower the students from the basics of interdisciplinary life-sciences to the recent trends in Biotechnology and its applications for the benefit of the community. The course empowers the students with conceptual and practical skills of biotechnology and introduces the students to the latest developments in biotechnology. It is fast emerging as a top course providing distinct advantages to students as it finds applications in various aspects of life sciences. The curriculum for the Biotechnology Four-Year Undergraduate Program is based on the LOCF-CBCS system of the UGC with value addition courses which are envisaged in the NEP-2020. The learning outcomes-based curriculum framework for a degree in B.Sc. (Honours) Biotechnology is intended to provide a comprehensive foundation for the subject and to help students develop the ability to successfully continue with further studies and research in the subject while they are equipped with the required skills at various stages. This course serves a plethora of opportunities in different fields right from classical to applied aspects in Biotechnology.

OUTCOME OF THE PROGRAMME

By the end of the program the students will be able to:-

- *A detailed knowledge in the structure, function and applications of living organisms.*
- *Understand concepts in Biotechnology and demonstrate interdisciplinary skills acquired in cell biology, genetics, biochemistry, microbiology and molecular biology.*
- *Skill sets in handling microorganisms in the laboratory and their applications in academia and industry.*
- *Understanding and implementation of the applications of biotechnology in industry, health-care, environmental protection, food and agricultural research.*
- *Understanding the current trends in biotechnology and its applications.*
- *Demonstrating the ability to design, perform and interpret the experiments during the practical courses with an emphasis on technological aspects.*
- *Demonstrate comprehensive innovations and skills in the field of biomolecules, cell biology, molecular biology, bioprocess engineering and genetic engineering of plants, animals, microbes with respect to applications for human welfare.*
- *Apply knowledge and skills of immunology, bioinformatics in computational modelling of proteins, drug design and simulation to test the models and aid in drug discovery.*
- *Critically analyze, interpret data and apply tools of bioinformatics in various sectors of biotechnology including health and food.*
- *Demonstrate communication skills, scientific writing, data collection and interpretation abilities in all fields of Biotechnology.*
- *Learn and practice professional skills in handling microbes, animals, plants and demonstrate the ability to identify ethical issues related to recombinant DNA technology, genetic engineering, animal handling, intellectual property rights, biosafety, and biohazards.*
- *Gain through knowledge and apply good laboratory practice and good manufacturing practices in biotech industries.*
- *Understand and apply molecular biology techniques and principles in forensics and clinical biotechnology.*
- *Explore the biotechnological practices and demonstrate innovative thinking in addressing the current day and future challenges with respect to food, health, and environment.*

COURSE STRUCTURE OF B.SC. BIOTECHNOLOGY HONOURS PROGRAMME UNDER NEP, 2020

Semester	Core (Credit)	DSE (Credit)	GEC (Credit)	AECC (Credit)	SEC (Credit)	VAC (Credit)	Semester Credit)
I	BT5-11: FUNDAMENTALS OF CHEMISTRY AND BIOCHEMISTRY (6)			AECC-1 English/MIL (4)	SEC-1 (Any one of the following) BT5-13A: Mushroom cultivation Or BT5-13B: Biofertilizer Production Or BT51-3C: Fermentation Technology (4)	VAC-1 (2)	24
	BT5-12 Cell biology (6)					VAC-2 (2)	
II	BT5-14: FUNDAMENTALS OF BIOTECHNOLOGY (6)			AECC-2 Environmental Sciences (4)	SEC-2 (any one of the following) BT5-16A Ornamental/Medicinal Plant Micropropagation or BT5-16B Food Biotechnology (4)	VAC-3 (2)	24
	BT5-15 BIOPHYSICS AND BIOINSTRUMENTATION (6)					VAC-4 (2)	
Exit option with Bachelor's Certificate in a Discipline on completion of courses equal to a minimum of 46 Credits							
III	BT6-11 MICROBIOLOGY (6) BT6-12 GENETIC (6) BT6-13 PLANT AND ANIMAL PHYSIOLOGY (6)		GEC-1 (6)			VAC-5(2)	26
IV	BT6-14 ENZYMOLOGY (6) BT6-15 IMMUNOLOGY (6) BT6-16 MOLECULAR BIOLOGY (6)		GEC-2 (6)			VAC-6 (2)	26
Exit option with Bachelor's Diploma in a Discipline on completion of courses equal to a minimum of 96 Credits							

V	BT7-11 GENETIC ENGINEERING (6) BT7-12 BIOSTATISTICS (6)	BT7-15: NANOBIOTECHNOLOGY (6)	GEC-3 (6)			VAC-7 (2)	26
VI	BT7-13 PLANT BIOTECHNOLOGY (6) BT7-14 ANIMAL BIOTECHNOLOGY (6)	BT7-16: MEDICAL BIOTECHNOLOGY (6)	GEC-4 (6)			VAC-8 (2)	26
Exit option with Bachelor's Degree in a Discipline on completion of courses equal to a minimum of 140 Credits							
VII	BT8-11 BIOINFORMATICS (6) BT8-12 BIOPROCESS TECHNOLOGY (6)	BT8-15: BIOSAFETY AND BIOETHICS (6)	GEC-5 (6)				24
VIII	BT8-13 ENVIRONMENTAL BIOTECHNOLOGY (6) BT8-14 INTELLECTUAL PROPERTY RIGHTS (6)	BT8-16: Dissertation/ Project Work/ Internship	GEC-6(6)				24
Award of Bachelor's Degree with Honours in a Discipline on completion of course equal to a minimum of 182 Credits							

PROPOSED SYLLABUS FOR B.Sc. BIOTECHNOLOGY HONOURS PROGRAMME UNDER NEP, 2022
Manipur University

FIRST SEMESTER

BT5-11 FUNDAMENTAL OF CHEMISTRY AND BIOCHEMISTRY 4 Credits

UNIT I: Ionic equilibrium and electrochemistry: Concepts of acids and bases, ionization constants of weak acids and bases, ionic product of water, hydrogen ion concentration (pH), buffer solution, common buffer solutions used in biological experiments, salt hydrolysis, solubility and solubility products. Chemical bonding and Stereochemistry: Concept of chemical bonding – ionic, covalent and metallic bond, their general characteristics, valence bond approach, valence shell electron pair repulsion theory (VSEPR theory), shape of simple molecules like BeF2, BF3, NH3, H20, PCl5, SF6 etc., molecular orbital theory, hybridization, intermolecular forces and hydrogen bonding, Atomic chemistry-electromagnetism, Basics of stereochemistry, optical Isomerism - optical isomers, isomeric number and tetrahedral carbon atom, enantiomers, diastereomers, racemic modification; geometrical isomerism, condition of geometric isomer, cis-trans and E-Z nomenclature, R-S nomenclature.

UNIT II: Basics in organic chemistry: Nomenclature, hydrocarbons – aliphatic and cycloalkanes, alcohols, carboxylic acid, ethers, alkyl halides, amine, nitrile, isocyanide, acid derivatives, nitro and diazonium salt, oxidations, reductions, eliminations, nucleophilic and electrophilic substitution reactions, addition reactions, synthesis of small molecules, Quantitative structure-activity relationships (QSAR)

UNIT III: Carbohydrates: Structure, Function and properties of Monosaccharides, Disaccharides and Polysaccharides. Homo & Hetero Polysaccharides, Mucopolysaccharides, Bacterial cell wall polysaccharides, Glycoprotein's and their biological functions.
Lipids: Structure and functions –Classification, nomenclature and properties of fatty acids, essential fatty acids. Phospholipids, sphingolipids, glycolipids, cerebrosides, gangliosides, Prostaglandins, Cholesterol. Amino acids & Proteins: Structure & Function. Structure and properties of Amino acids, Types of proteins and their classification, Forces stabilizing protein structure and shape. Different Level of structural organization of protein. Nucleic acids: Structure and functions: Physical & chemical properties of Nucleic acids, Nucleosides & Nucleotides, purines & pyrimidines.

UNIT IV: Carbohydrates Metabolism: Reactions, energetics and regulation. Glycolysis: Fate of pyruvate under aerobic and anaerobic conditions. Pentose phosphate pathway and its significance, Gluconeogenesis, Glycogenolysis and glycogen synthesis. TCA cycle, Electron Transport Chain, Oxidative phosphorylation. ß-oxidation of fatty acids.

PRACTICALS: **2 Credits**

1. Principles of Colorimetry: (i) Verification of Beer's law, estimation of protein. (ii) To study the relation between absorbance and % transmission.
2. Preparation of buffers.
3. Separation of Amino acids by paper chromatography.
4. Qualitative tests for Carbohydrates, lipids and proteins

SUGGESTED READING: *(All the books should be of the latest edition/version)*

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. Biochemistry. VI Edition. W.H Freeman and Co.
2. Buchanan, B., Gruissem, W. and Jones, R. Biochemistry and Molecular Biology of Plants.American Society of Plant Biologists.
3. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company, New York, USA.
4. Hopkins, W.G. and Huner, P.A. Introduction to Plant Physiology. John Wiley and Sons.
5. Salisbury, F.B. and Ross, C.W. Plant Physiology, Wadsworth Publishing Co. Ltd.
6. Physical chemistry - P.W. Atkins, ELBS. 6. Physical Chemistry – G.M. Barron – Mc Grow Hill.
7. Essentials of Physical Chemistry – Bahl and Tuli
8. Organic Chemistry by Marrison and Boyd, Prentice Hall of India Pvt. Ltd, New Delhi
9. Guide book to Mechanism in Organic Chemistry by Peper Sykes, Orient Longman
10. Organic Chemistry by I.L. Finar, Volume-II
11. An introduction to Electrochemistry by Samuel Glasstene

BT5-12 CELL BIOLOGY **4 Credits**

UNIT I: Cell: Introduction and classification of organisms by cell structure, cytosol, compartmentalization of eukaryotic cells, cell fractionation. Cell membrane and permeability: Chemical components of biological membranes, organization and fluid mosaic model, membrane as a dynamic entity, cell recognition and membrane transport.

UNIT II: Cytoskeleton and cell motility: structure and function of microtubules, Microfilaments, Intermediate filaments. Endoplasmic reticulum: Structure, function including roles in protein segregation. Golgi complex: structure, biogenesis and functions including roles in protein secretion.

UNIT III: Lysosomes: vacuoles and microbodies: structure and functions; Ribosomes: structures and functions including roles in protein synthesis. Mitochondria: structure and function, Genomes, biogenesis. chloroplasts: structure and function, genomes, biogenesis nucleus: structure and function, chromosomes and their structure.

UNIT IV: Extracellular Matrix: Composition, molecules that mediate cell adhesion, membrane receptors for extracellular matrix, macromolecules, regulation of

receptor expression and function. Signal transduction. Cell Cycle, Cell Division, Cell senescence, Apoptosis.

PRACTICALS **2 Credits**

1. Study the effect of temperature and organic solvents on semi-permeable membrane.
2. Demonstration of dialysis.
3. Study of plasmolysis and de-plasmolysis.
4. Cell fractionation and determination of enzyme activity in organelles using sprouted seedor any other suitable source.
5. Study of the structure of any Prokaryotic and Eukaryotic cell.
6. Microtomy: Fixation, block making, section cutting, double staining of animal tissueslike liver, oesophagus, stomach, pancreas, intestine, kidney, ovary, testes.
7. Cell division in onion root tip/ insect gonads.
8. Preparation of Nuclear, Mitochondrial & cytoplasmic fractions.

SUGGESTED READING: *(All the books should be of the latest edition/version)*

1. Karp, G. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. JohnWiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. Cell and Molecular Biology. 8thedition.Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E.The Cell: A Molecular Approach. 5th edition.ASMPress & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P.The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

BT5-13A: Mushroom Cultivation **4 credits**

UNIT I Introduction, history of mushroom cultivation and its present status in India, record of cultivated edible fungi, definition of mushroom cultivation, importance of mushroom.

UNIT II Identification and classification of mushroom, life cycle, food values and composition, medicinal values, general morphology features, important characters for identification of mushroom, edible and poisonous mushroom.

UNIT III Selection of mushroom to be cultivated, definition of spawn and their types, characteristics of good spawn, storage, types of substrate, substrate preparation and its sterilization, spawning or inoculation, post spawning, incubation, cropping and harvesting

UNIT IV Factor affecting mushroom cultivation, major pest, diseases and contamination, control measure, packing, economic importance, preservation and processing, advantages of cultivation of Pleurotus sps.

SUGGESTED READING: *(All the books should be of the latest edition/version)*

1. Handbook of Mushroom Poisoning, Diagnosis & Treatment by David G, Spoerke and Barry Rumack
2. Mushroom Production & Processing Technology by Pathak Yadav Gour
3. A Handook of Mushroom Cultivation by RP. Pandey & S.K Ghosh
4. Modern Mushroom Cultivation by Ruti Singh & UC. Singh

BT5-13B: BIO-FERTILIZER PRODUCTION 4 Credits

UNIT I: Introduction, History and concept of Biofertilizers, status scope and importance of Biofertilizers, Classification of Biofertilizers. Nitrogen fixation.

UNIT II: Structure and characteristic features of bacterial Biofertilizers- Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium and Frankia; Cyanobacterial biofertilizers- Anabaena, Nostoc, Hapalosiphon and fungal biofertilizers- AM mycorrhiza and ectomycorrhiza.

UNIT III: Production technology: Strain selection, sterilization, growth and fermentation, equipment, mass production of carrier-based and liquid biofertilizers. FCO specifications and quality control of biofertilizers.

UNIT IV: Application technology for seeds, seedlings, tubers, sets etc. Biofertilizers - Storage, shelf life, quality control and marketing. Factors influencing the efficacy of biofertilizers.

SUGGESTED READING: *(All the books should be of the latest edition/version)*

1. General Microbiology- Dubey and Maheswari
2. Motsora,M.R.,P.Bhattacharya and Beena Srivastava. Biofertilizer Technology, Marketing and Usage-A Source Bookcum-Glossary.
3. Subbarao, N.S. 1993. Biofertilizers in Agriculture and Forestry (Oxford and IBH Pub. Co., New Delhi)
4. Mahendra K. Rai. Hand book of Microbial biofertilizers, The Haworth Press, Inc. New York.
5. Kannaiyan S. Bioetchnology of Biofertilizers, CHIPS, Texas

BT5-13C: FERMENTATION TECHNOLOGY 4 Credits

UNIT I: Fermentation as an ancient tradition, development of fermentation microbiology: historical background. Fermentor: Main components and its uses, peripheral parts and accessories. Control systems and sensors. Fermentor preparation and use: disassembly and cleaning of vessel, autoclaving, inoculation of fermentor vessel, sampling from fermentor vessel and routine maintenance of a fermentor. Specialized bioreactors (pulsed, fluidized bed, airlift bioreactor).

UNIT II: Medium formulation, energy source, carbon sources, nitrogen sources, minerals, growth factors, buffers, inhibitors and precursors, antifoaming agents. Air and medium sterilization. Inoculum preparation and scale up of fermentations.

UNIT III: Batch, fed batch and continuous fermentations. Multiple fermentation and solid substrate fermentations. Microbial growth cycle, diauxic growth, growth yields. Kinetics of microbial growth and death. Framework for kinetic models-stoichiometry, reaction rates, yield coefficients and linear rate equation. Isolation, preservation and improvement of industrially important microorganism ,Isolation of industrially important microorganisms.

UNIT IV: Primary and secondary screening. Preservation of industrially important microorganisms. Strain improvement by genetic recombination approaches and directed screening for mutants with altered metabolism. Removal of microbial cells and solid matter, foam separation, cell disruption, precipitation, filtration, centrifugation, liquid-liquid extraction, chromatography, membrane process, drying and crystallization. Physical, chemical and biological assays for detection of fermentation products

SUGGESTED READING: *(All the books should be of the latest edition/version)*

1. Bioprocess Engineering by Michael L.Schuler and F.Kargi .Prentice Hall of India
2. Biochemcal Engineering Fundamentals. J.E. Bailey and D.F. Ollis Mcgraw Hill International Editions
3. Process Biotehnology Fundamentals by S.N. Mukhopadhyaya. Vivi Books Pvt. Ltd.
4. Principles of Fermentation Technology by P.F. Stanbury,A. Whittaker & Hall Pergaman. McNeul & Harvey Publications.

SECOND SEMESTER

BT5-14 FUNDAMENTALS OF BIOTECHNOLOGY 4 Credits

UNIT I: Introduction to biotechnology: Origin and definitions, history of biotechnology-ancient, classical and modern, major scientific discoveries in biotechnology, an interdisciplinary activity-strain choice, mass culture, optimization of cell responses, process of operations, product recovery. Scope and importance, commercial potential. Biotechnology in India and its global trends, Major biotechnology institutes and companies in India.

UNIT II: DNA fingerprinting, cloning (DNA cloning, animal cloning), Transgenic plants and animals, in vitro fertilization, artificial insemination, artificial insemination, stem cell technology.

UNIT III: Biotechnology and its application: Applications of biotechnology in Agriculture, medicine, environment, veterinary sciences, food industry, chemical industry, pharmaceutical industry forensic science; Bioremediation and waste treatment biotechnology

UNIT IV: Emerging fields of biotechnology: nanobiotechnology, bioinformatics, pharmacogenomics,

regenerative medicine, therapeutic proteins, bio-robotics, biosensors; Brief account of safety guidelines and risk assessment in biotechnology; Ethical issues related to biotechnology.

PRACTICALS **2 Credits**

1. Basic operations in laboratory
2. Documentation: The Lab Notebook & Lab Report
3. Biotechnology Laboratory Security & Safety
4. Lab Equipment & Reagent Orientation
5. Math Skills for the Laboratory
6. Basic tools in the biotechnology laboratory
7. Calibrating Lab Instruments
8. Preparing solutions

SUGGESTED READING: *(All the books should be of the latest edition/version)*

1. *Mathuriya A S. General introduction to biotechnology Industrial Biotechnology (New Delhi: Ane Books Pvt) p 2*
2. Biotechnology: Progress and Application by Saif Hameed
3. Hulse JH. Biotechnologies: Past history, present state and future prospects. Trends Food Sci Technol
4. Wohlgemuth R. Industrial biotechnology – past, present and future. New Biotechnology
5. Biotechnology Fundamentals and Application by S. S. Purohit Ex-Head, P.G. Department of Botany Dungar College, Bikaner.
6. Seidman & Moore, Basic Laboratory Methods for Biotechnology: Textbook & Laboratory Reference,
7. Laboratory security: http://ehs.uky.edu/ohs/labsecurity.html
8. Molecular Biology Problem Solver edited by Alan S. Gerstein
9. Basic Laboratory Methods for Biotechnology, by Lisa A. Seidman & Cynthia J. Moore. Prentice Hall

BT5-15 BIOPHYSICS AND BIOINSTRUMENTATION **4 Credits**

UNIT I: Energetic of a living body: Sources of heat limits to temperature, heat dissipation and conservation, Lambert-Beer law, spectrophotometer and colorimetry, primary events in photosynthesis, strategies of light reception in microbes, plants and animals, correction of vision faults, electrical properties of biological compartments, electricity as a potential signal, generation and reception of sonic vibrations, hearing aids, intra- and intermolecular interactions in biological systems, spatial and charge compatibility as determinant of such interactions.

UNIT II: Physical methods applied to find out molecular structure by general spectroscopy: UV-Vis, fluorescence, atomic absorption, IR, Raman spectra, atomic absorption spectrophotometer (AAS) and atomic emissions (AES), ESR/EPR and circular dichroism analysis using light scattering and NMR. Biosafety Cabinets. Physical methods of imaging intact biological structures; ultrasound, optical filters, X-ray, CAT scan, **ECG**, EEG and MRI. X-rays and lasers-X-ray crystallography, X-ray diffractometer and X-ray fluorescence Spectrometer (XRF).

UNIT III: Isotopes and radiation-radioactivity, isotopes, measurement of radioactivity, monitoring accumulation of isotopes with Geiger counter, Scintillation counter, autoradiography. Separation techniques; chromatography - TLC,

Column chromatography, gas chromatography, HPLC, ion-exchange, mass-spectrometer, electrophoresis, centrifugation, - ultracentrifugation, density gradient, lyophilization. Vacuum drying. Tools using light- colorimeter, types of photometer, fluorimetry, Gel-Doc, PCR.

UNIT IV: Microscopes-light: phase-contrast dark field microscope, electron microscope (SEM & TEM), scanning probe microscope (SPM), atomic force microscope (AFM) and scanning tunneling microscope (STM) (For topography, gene mapping, DNA analysis). Interactions of laser beam with tissues, Isotope separation by laser beam with tissues. Flow cytometry and immunofluorescence microscopy, detection of molecules in living cells.

PRACTICALS: **2 Credits**

1. Determination of "g" by bar pendulum.
2. Determination of viscosity of liquid.
3. Determination of surface tension by capillary rise method.
4. Determination of focal lengths of convex lenses.
5. Determination of horizontal component of Earth's magnetic field.
6. Determination of radius of curvature of a convex lens by Newton's ring method.
7. Demonstration of the following instrumentations/methods:
8. Chromatography, Centrifugation, Fluorescence, Biosafety Cabinets, PCR Handling Basics.
9. Paper chromatography of amino acids, sugars, and purine and pyrimidine bases.
10. Colorimetric determination of any one amino acids.
11. Separation of pigments by adsorption chromatography.
12. Thin Layer chromatography separation - sugars & lipids.

Suggested Reading Materials: *(All the books should be of the latest edition/version)*

1. Perspectives of modern physics – Arthur Beiser (Mc Graw Hill)
2. Nuclear physics an introduction – S.B. Patel (New Age International)
3. Introduction to atomic spectra – H.E. White (Mc Graw Hill)
4. Textbook of optics and atomic physics – P.P. Khandelwal (Himlaya Publishing House)
5. Molecular cell biology – Ladish, Berk, Matsudara, Kaiser, Krieger, Zipursky, Darnell (W.H.Freeman and Co.)
6. Biophysics - Cotrell (Eastern Economy Edition)
7. Clinical Biophysics –Principles and Techniques- P. Narayanan (Bhalani Pub., Mumbai)
8. Biophysics – Pattabhi and Gautham (Narosa Publishing House)
9. Instrumentation measurements and analysis – Nakara, Choudhari (Tata Mc Graw Hill)
10. Handbook of analytical instruments – R.S. Khandpur (Tata Mc Graw Hill)
11. Biophysical Chemistry- Upadhyay, Upadhyay and Nath – (Himalaya Pub. House, Delhi)
12. Principles and Techniques of Practical Biochemistry, Keith Wilson (Editor) and JohnWalker (Editor): Cambridge University Press
13. Principles of Physical Biochemistry, K. E. Van Holde, *et al*.: Prentice Hall
14. Principles of Instrumental Analysis, Douglas A. Skoog, et al: Harcourt College Publishers

15. Quantitative Chemical Analysis, Daniel C. Harris: W. H. Freeman & Co. Bk & cdr edition
16. Spectrophotometry and Spectrofluorimetry: A Practical Approach, Michael G. Gore(Editor): Oxford Univ Press,
17. Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry,Irwin H. Segel: John Wiley & Sons

BT5-16A ORNAMENTAL/MEDICINAL PLANT MICROPROPAGATION 4 Credits

UNIT I Definition of ornamental/medicinal plants, different types, usefulness and applications, different vegetative propagation methods, advantages and limitations of natural propagation.

UNIT II Propagation of plants through plant tissue culture, Historical background, Laboratory organization, culture facilities, general equipments and glasswares, different sterilization methods, dry and wet, flame sterilization. Laboratory contaminants- different control measures.

UNIT III Culture media preparation, media constituents, role of micro and macro nutrients, vitamins, carbon source in culture media, solidifying agent, pH and temperature adjustment in media preparation, preparation of different media like MS, B5, Mitra etc. Plant growth hormones, different types, role and uses in tissue culture, preparation of stock solutions, explants selection, different sterilization methods and explant inoculation.

UNIT IV Micropropagation, different stages, micropropagation of ornamental/medicinal plants, proliferation of axillary buds, Somaclonal variation, somatic embryogenesis, production of protocorms/protocorm like bodies, adventitious buds, shoot and root induction, seedling developments, acclimatization and hardening process. Limitation and advantages of micropropagation.

Suggested Reading Materials: *(All the books should be of the latest edition/version)*

1. Plant Cell, Tissue and organ culture, by O.L. Gamborg and GC, Phillips
2. Plant Biotechnology, by A. Slater, N. Scott and M. Flower
3. Plant Tissue Culture: Theory and Practice, by S.S. Bhojwani and M.K. Razdan
4. Introduction to Plant Biotechnology, by H.C. Chawla 5. Plant Cell and Tissue Culture, by I.K Basil and T.A. Thorpe

BT5-16B FOOD BIOTECHNOLOGY 4 Credits

UNIT I Principles of food biotechnology: Basic principles and application of biotechnology in food industries with regard to production, processing regulatory aspect of modern biotechnology application in food industry in the context of environment protection of human and animals.

UNIT II Fermentation technology: natural and synthetic media. Fermenters types and cell bioreactors, Process development: shake flask fermentation, upstream

processing, Disintegration of cells, separation, extraction, concentration and purification of products.

UNIT III Lactic acid bacteria-put a dash distribution, classification and physiology; antimutagenic, antimicrobial and health-promoting effects; malo-lactic. Protective factors of lactic bacteria in food preservations. Yeasts and moulds associated fermented food. Technology for the production of Sauerkraut, Kimchi, Bamboo shoot, rice beer, idli, dosa, yogurt, dahi, kefir, cheese, miso, tempeh and salami, traditional fermented food of India, nutritional changes.

UNIT IV Microbes in food technology: microbial starters for industrial production; sources, propagation, preservation, and use of starters. Improvement of starters by classical and molecular biological techniques. Microbial protein as food and feed: SCP and economics of SCP and microbially derived additive flavours and odors, Pathogenic microbes – infections; bacterial toxins and mycotoxins sources, physiological effects; methods of prevention and control in foods and feeds.

Suggested Reading Materials: *(All the books should be of the latest edition/version)*

1. Food biotechnology Ed .dietrich knorr, Marcell dekker inc.
2. Handbook of food analysis (vol I & vol II) Leo M Nollet, Marcel Dekker
3. Food microbiology _ W.C Frazier; Mc Graw Hill Book Co.
4. Modern food microbiology J. M. Jay, D. Van; Nostrand co.
5. Fermented food (7)-Ed. by A.H Rose; Academics Press
6. Microbial food poisoning _Ed.A.R. Elev. Chapmam & Hall
7. Principles of enzymology for food science – whittaker ,J.R Marcle Dekker
8. Introduction to fermentation technology –Whittaker
9. Biochemical Reactors _JM Lee; Prentice Hall Inc,USA
10. Bioprocess technology: Fundamentals and application, KTH, Stocholm.

THIRD SEMESTER

BT6-11 MICROBIOLOGY 4 Credits

UNIT I: Fundamentals, History and Evolution of Microbiology. Classification of microorganisms: Microbial taxonomy, criteria used-including molecular approaches, Classification of bacteria.
Microbial Diversity: Distribution and characterization Prokaryotic and Eukaryotic cells, Morphology and cell structure of major groups of microorganisms eg. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses.

UNIT II: Cultivation and Maintenance of microorganisms: Nutritional requirements and nutritional types of micro-organisms, methods of isolation, Purification and preservation.
Microbial growth: Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria.
Bacterial Reproduction: Transformation, Transduction and Conjugation. Endospores and sporulation in bacteria.

UNIT III: Control of Microorganisms: Concept of sterilization. Sterilization by physical, chemical and chemotherapeutic Agents

Water Microbiology: Bacterial pollutants of water, coliforms and non coliforms. Sewage composition and its disposal.

Food Microbiology: Important microorganism in food Microbiology: Moulds, Yeasts, bacteria. Major food born infections and intoxications, Preservation of various types of foods. Fermented Foods.

UNIT IV: Diseases caused by gram negative and gram positive bacteria:

B.anthracis, C.tetani, C.botulinum, C.diphtheriae M.tuberculosis, M. leprae etc E.coli, N. gonorrhoea, N. meningitidis, S. typhi, S. dysenteriae, Y. pestis, H. influenzae, V. cholerae, M. pneumoniae etc

Diseases caused by viruses:Pox virus, Herpes virus, Papova virus, Retro viruses (including HIV/AIDS) and Hepatitis viruses; SARS

Fungal and Protozoan infections. Dermatophytoses, Subcutaneous infection, systemic infection and opportunistic fungal infections, Gastrointestinal infections, Blood-borne infections.

PRACTICALS: **2 Credits**

1. Preparation of media & sterilization methods.
2. Isolation and enumeration of the number of bacteria from soil, air and water
3. Staining methods: simple staining, Gram staining, spore staining, negative staining, hanging drop.
4. Culture techniques – Streak plate, pour plate and spread plate.
5. Determination of bacterial cell size by micrometry.
6. To perform antibacterial testing by Kirby-Bauer method.
7. To prepare temporary mounts of Aspergillus and Candida by appropriate staining.

SUGGESTED READINGS: *(All the books should be of the latest edition/version)*

1. Alexopoulos CJ, Mims CW, and Blackwell M. Introductory Mycology.John and Sons, Inc.
2. Jay JM, Loessner MJ and Golden DA. *Modern Food Microbiology*. 7thedition, CBS Publishers and Distributors, Delhi, India.
3. Kumar HD.Introductory Phycology. 2nd edition. Affiliated East Western Press.
4. Madigan MT, Martinko JM and Parker J. Brock Biology of Microorganisms. Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. Microbiology. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR.General Microbiology. 5thedition. McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction.Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ. Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

BT6-12 GENETICS **4 Credits**

UNIT I: Mendelian genetics : Mendel's experimental design, monohybrid, di-hybrid and tri hybrid crosses, Law of segregation & Principle of independent assortment. Verification of segregates by t-test and back crosses, Chromosomal theory of inheritance, Allelic interactions: Concept of dominance, recessiveness, incomplete dominance, co-dominance, semi-dominance, pleiotropy, multiple allele, pseudo-allele, essential and lethal genes, penetrance and expressivity. Non allelic interactions: Interaction producing new phenotype complementary genes, epistasis (dominant & recessive), duplicate genes and inhibitory genes.

UNIT II: Chromosome and genomic organization: Eukaryotic nuclear genome nucleotide sequence composition –unique & repetitive DNA, satellite DNA. Centromere and telomere DNA sequences, middle repetitive sequences- VNTRs & dinucleotide repeats, repetitive transposed sequences- SINEs & LINEs, middle repetitive multiple copy genes, noncoding DNA.
Genetic organization of prokaryotic and viral genome.
Structure and characteristics of bacterial and eukaryotic chromosome, chromosome morphology, concept of euchromatin and heterochromatin. packaging of DNA molecule into chromosomes, chromosome banding pattern, karyotype, giant chromosomes, one gene one polypeptide hypothesis, concept of cistron, exons, introns, genetic code, gene function.

UNIT III: Chromosome and gene mutations: Definition and types of mutations, causes of mutations, Ames test for mutagenic agents, screening procedures for isolation of mutants and uses of mutants, variations in chromosomes structure - deletion, duplication, inversion and translocation (reciprocal and Robertsonian), position effects of gene expression, chromosomal aberrations in human beings, abonormalities– Aneuploidy and Euploidy.
Sex determination and sex linkage: Mechanisms of sex determination, Environmental factors and sex determination, sex differentiation, Barr bodies, dosage compensation, genetic balance theory, Fragile-X-syndrome and chromosome, sex influenced dominance, sex limited gene expression, sex-linked inheritance.

UNIT IV: Genetic linkage, crossing over and chromosome mapping: Linkage and Recombination of genes in a chromosome crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Crossing over at four strand stage, Multiple crossing overs Genetic mapping. Extra chromosomal inheritance: Rules of extra nuclear inheritance, maternal effects, maternal inheritance, cytoplasmic inheritance, organelle heredity, genomic imprinting. Evolution and population genetics: In breeding and out breeding, Hardy Weinberg law (prediction, derivation), allelic and genotype frequencies, changes in allelic frequencies, systems of mating, evolutionary genetics, natural selection.

PRACTICALS: **2 Credits**

1. Permanent and temporary mount of mitosis.
2. Permanent and temporary mount of meiosis.
3. Mendelian deviations in dihybrid crosses
4. Demonstration of - Barr Body -*Rhoeo* translocation.
5. Karyotyping with the help of photographs

6. Pedigree charts of some common characters like blood group, color blindness andPTC tasting.
7. Study of polyploidy in onion root tip by colchicine treatment.

SUGGESTED READING: *(All the books should be of the latest edition/version)*

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. Principles of Genetics. JohnWiley & Sons.
2. Snustad, D.P., Simmons, M.J.Principles of Genetics. V Edition. John Wiley and SonsInc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. Concepts of Genetics.Benjamin Cummings.
4. Russell, P. J. Genetics- A Molecular Approach. Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. Introduction to Genetic Analysis, W. H. Freeman & Co.

BT6-13 PLANT AND ANIMAL PHYSIOLOGY 4 Credits

UNIT I: The shoot and root apical meristem and its histological organization, simple & complex permanent tissues, primary structure of shoot & root, secondary growth, growth rings, leaf anatomy (dorsi-ventral and isobilateral leaf). Photosynthesis- Photosynthesis pigments, concept of two photo systems, photphosphorylation, calvin cycle, CAM plants, photorespiration, compensation point. Nitrogen metabolism- inorganic & molecular nitrogen fixation, nitrate reduction and ammoniumassimilation in plants.

UNIT II: Plant water relations: Importance of water to plant life, diffusion, osmosis, plasmolysis,imbibition, guttation, transpiration, stomata & their mechanism of opening & closing. Micro & macro nutrients: criteria for identification of essentiality of nutrients, roles and deficiency systems of nutrients, mechanism of uptake of nutrients, mechanism of food transport. Growth and development: Definitions, phases of growth, growth curve, growth hormones (auxins, gibberlins, cytokinins, abscisic acid, ethylene).
Physiological role and mode of action, seed dormancy and seed germination, concept of photo-periodism and vernalization.

UNIT III: Digestion: Mechanism of digestion & absorption of carbohydrates, Proteins, Lipids and nucleicacids. Composition of bile, Saliva, Pancreatic, gastric and intestinal juice.
Respiration: Exchange of gases, Transport of O_2 and CO_2, Oxygen dissociation curve, Chlorideshift.
Composition of blood, Plasma proteins & their role, blood cells, Haemopoisis, Mechanism ofcoagulation of blood.
Mechanism of working of heart: Cardiac output, cardiac cycle, Origin & conduction of heartbeat.

UNIT IV: Structure of cardiac, smooth & skeletal muscle, threshold stimulus, All or None rule, singlemuscle twitch, muscle tone, isotonic and isometric contraction, Physical, chemical & electricalevents of mechanism of muscle contraction.
Excretion: modes of excretion, Ornithine cycle, Mechanism of urine formation.
Mechanism of generation & propagation of nerve impulse, structure of synapse, synapticconduction, saltatory conduction, Neurotransmitters

Mechanism of action of hormones (insulin and steroids).
Different endocrine glands– Hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid and adrenals, hypo & hyper-secretions.

PRACTICALS **2 Credits**

1. Preparation of stained mounts of anatomy of monocot and dicot's root, stem & leaf.
2. Demonstration of opening & closing of stomata
3. Separation of photosynthetic pigments by paper chromatography.
4. Demonstration of aerobic respiration.
5. Preparation of root nodules from a leguminous plant.
6. Finding blood coagulation time
7. Determination of blood groups
8. Counting of mammalian RBCs
9. Determination of Haemoglobin

SUGGESTED READING: *(All the books should be of the latest edition/version)*

1. Dickinson, W.C.Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Hopkins, W.G. and Huner, P.AIntroduction to Plant Physiology. John Wiley and Sons.
3. Mauseth, J.D. Plant Anatomy. The Benjammin/Cummings Publisher, USA.
4. Nelson, D.L., Cox, M.M. Lehninger Principles of Biochemistry, W.H. Freeman and Company, New York, USA.
5. Salisbury, F.B. and Ross, C.W. Plant Physiology, Wadsworth Publishing Co. Ltd.
6. Taiz, L. and Zeiger, E.Plant Physiology, Sinauer Associates Inc .MA, USA
7. Guyton, A.C. & Hall, J.E. Textbook of Medical Physiology. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
8. Tortora, G.J. & Grabowski, S. Principles of Anatomy & Physiology. John wiley & sons,Inc.

FOURTH SEMESTER

BT6-14 ENZYMOLOGY **4 Credits**

UNIT I: Enzyme classification (rationale, overview and specific examples); Isolation, crystallization and purification of enzymes, test of homogeneity of enzyme preparation, methods of enzyme analysis. Zymogens and their activation (Proteases and Prothrombin). Enzyme substrate complex: concept of E-S complex, binding sites, active site, specificity, Kinetics of enzyme activity, Michaelis-Menten equation and its derivation, Different plots for the determination of Km and Vmax and their physiological significance, factors affecting initial rate, E, S, temp. & pH. Collision and transition state theories, Significance of activation energy and free energy.

UNIT II: Two substrate reactions (Random, ordered and ping-pong mechanism) Enzyme inhibition types of inhibition, determination of Ki, suicide inhibitor. Mechanism of enzyme action: General mechanistic principle, factors associated with catalytic efficiency: proximity, orientation, distortion of strain, acid-base, nucleophilic and covalent catalysis. Techniques for studying mechanisms of action, chemical

modification of active site groups, specific examples-: chymotrypsin, Iysozyme, GPDH, aldolase, RNase, Carboxypeptidaseand alcohol dehydrogenase.

UNIT III : Enzyme regulation: Product inhibition, feed backcontrol, covalent modification. Enzyme - Enzyme interaction, Protein ligand binding,measurements analysis of binding isotherm, cooperativity, Hill and scatchard plots, kinetics of allosteric enzymes.

UNIT IV: Allosteric enzymes with special reference to aspartate transcarbomylase and phosphofructokinase. Qualitative description of concerted and sequential models. Negative co- operativity and half site reactivity. Isoenzymes– multiple forms of enzymes with special reference to lactate dehydrogenase. Multienzyme complexes. Ribozymes. Multifunctional enzyme-eg Fatty Acid synthase.

PRACTICALS **2 Credits**

1. Quantitative estimation of proteins by Bradford/Lowry's method.
2. Calculation of kinetic parameters such as Km, Vmax, Kcat
3. Assay of enzymes (any two) - Amylase, Protease, Catalase, Urease,Galactosidase, Alcohol dehydrogenase, Cellulase & Glucose oxidase.
4. Molecular weight determination of enzymes / proteins by Gel filtration, SDS-PAGE.

SUGGESTED READING: *(All the books should be of the latest edition/version)*

1. Biochemistry, Lubert Stryer, WH Freeman
2. Harper's Illustrated Biochemistry by Robert K. Murray, David A Bender, KathleenM.Botham, Peter J. Kennelly, Victor W. Rodwell, P. Anthony Weil, McGrawHill,
3. Biochemistry, Donald Voet and Judith Voet, Publisher: John Wiley and Sons
4. Biochemistry by Mary K.Campbell & Shawn O.Farrell, Cenage Learning
5. Fundamentals of Enzymology Nicholas Price and Lewis Stevens Oxford University Press
6. Fundamentals of Enzyme Kinetics Athel Cornish-Bowden Portland Press
7. Practical Enzymology Hans Bisswanger Wiley–VCH
8. The Organic Chemistry of Enzyme-catalyzed Reactions Richard B. Silverman Academic Press

BT6-15 IMMUNOLOGY **4 Credits**

UNIT I: Immune Response - An overview, components of mammalian immune system, molecular structure of Immuno-globulins or Antibodies, Humoral & Cellular immune responses, T- lymphocytes & immune response (cytotoxic T-cell, helper T-cell, suppressor T-cells), T-cell receptors, genome rearrangements during B-lymphocyte differentiation, Antibody affinity maturation class switching, assembly of T-cell receptor genes by somatic recombination, Antigens.

UNIT II: Regulation of immunoglobulin gene expression – clonal selection theory, allotypes & idiotypes, allelic exclusion, immunologic memory, heavy chain gene transcription, genetic basis of antibody diversity, hypotheses (germ line & somatic mutation), antibody diversity, Monoclonal Antibodies

UNIT III: Major Histocompatibility complexes – class I & class II MHC antigens, antigen processing. Immunity to infection – immunity to different organisms, pathogen defense strategies, avoidance of recognition. Complement system, Autoimmune diseases, Immunodeficiency-AIDS, Hypersensitivity reactions

UNIT IV: Vaccines & Vaccination – adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, passive & active immunization. Introduction to immunodiagnostics – RIA, ELISA.

PRACTICALS **2 Credits**

1. Differential leucocytes count
2. Total leucocytes count
3. Total RBC count
4. Haemagglutination assay
5. Haemagglutination inhibition assay
6. Separation of serum from blood
7. Double immunodiffusion test using specific antibody and antigen.
8. ELISA Demonstration

SUGGESTED READING: *(All the books should be of the latest edition/version)*

1. Abbas AK, Lichtman AH, Pillai S. Cellular and Molecular Immunology. Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. Roitt's Essential Immunology.Wiley-Blackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA.Kuby's Immunology. W.H.Freeman and Company, New York.
4. Murphy K, Travers P, Walport M. Janeway's Immunobiology. Garland Science Publishers, New York.
5. Peakman M, and Vergani D. Basic and Clinical Immunology.Churchill Livingstone Publishers, Edinberg.
6. Richard C and Geiffrey S. Immunology. Wiley Blackwell Publication.

BT6-16 MOLECULAR BIOLOGY **4 Credits**

Unit 1 Molecular basis of life – DNA and RNA as genetic material, nucleic acids, structure and functions of DNA and RNA, Watson and Crick model of DNA and other forms for DNA (A and Z) Functions of DNA and RNA including ribozymes.

Unit 2 DNA replication prokaryotic and eukaryotic – Enzymes and proteins involved in replication,theta model and rolling circle model. DNA repair and mechanism-photo reactivation, excision repair, mismatch repair, SOS repair recombination in prokaryotes transformation, conjunction and transduction.

Unit 3 Structure of prokaryotic and eukaryotic gene- genetic code, properties and Wobble hypothesis. Transcription in prokaryotes and eukaryotes mechanism, promoters and RNA polymerase, transcription factors, post transcriptional modifications of eukaryotic mRNA. Translation mechanism of translation in prokaryotes and eukaryotes, post translational modifications of proteins.

Unit 4 Regulation of gene expression, regulation of gene expression in prokaryotes – operon concept (Lac and Tryp), regulation of gene expression in eukaryotes - transcriptional activation, galactose metabolism in yeast. Coding and Non-coding genes. Gene organization and expression in mitochondria and choloroplasts. Insertional elements and transposons. Transposable elements in maize and drosophila.

PRACTICALS **2 Credits**

1. Preparation of solutions for molecular biology experiments.
2. Isolation of chromosomal DNA from bacterial cells.
3. Isolation of Plasmid DNA by alkaline lysis method
4. Agarose gel electrophoresis of genomic DNA or plasmid DNA

SUGGESTED READING: *(All the books should be of the latest edition/version)*

1. Karp, G. Cell and Molecular Biology: Concepts and Experiments. JohnWiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. Cell and Molecular Biology. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. The World of the Cell. Pearson Benjamin Cummings Publishing, San Francisco.
4. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., Molecular Biology of the Gene .Cold Spring Harbour Lab. Press, Pearson Pub.