MASTER OF SCIENCE (M.Sc.)
IN
PLANT BIOTECHNOLOGY

PROGRAM STRUCTURE AND SYLLABUS
2019-20 ADMISSIONS ONWARDS

(UNDER MAHATMA GANDHI UNIVERSITY PGCSS REGULATIONS 2019)

EXPERT COMMITTEE OF BIOSCIENCE (PG)
MAHATMA GANDHI UNIVERSITY

2019

EXPERT COMMITTEE OF BIOSCIENCE (PG)

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Assistant Professor and Head, Department of Biotechnology
Sahodaran Ayyappan Smaraka SNDP Yogam College, Konni.

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Assistant Professor and Head, School of Biosciences, MACFAST, Thiruvalla

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SCMS School of Technology and Management (SSTM), South Kalamassery, Cochin

8. **Dr. Salini Bhasker**
Senior Scientist, Division of Molecular Biology
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9. **Dr. Thakur Das Saha (External expert)**
Former Head, Molecular Biology & Genomics Lab, RRI, Kottayam

Table of Contents

M.Sc. Plant Biotechnology

(Mahatma Gandhi University Regulations PGCSS2019 from 2019-20 Academic Year)

1. **Aim of the Program**

The aim of the programme is to highlight the role played by Biotechnology in modern society and its relevance to sustainable development. It seeks to provide the following: to advance education and research in Plant Biotechnology and explore sustainable solutions for agriculture, environment and energy sectors.

2. **Eligibility for Admission**

B Sc Botany, Biochemistry, Biotechnology, Microbiology, Agricultural Science, Environmental Science under Part III Core Group (Core + Complementary + Open Courses) with not less than CGPA of 2.00 out of 4.

3. **Medium of Instruction and Assessment**

Course of study will be over a period of two academic year under semester system

a. Scheme of examination

The examinations for the award of degree consist of theory and practical papers, dissertation and comprehensive viva-voce. There will be examinations at end of each semester for theory and practical courses. Each semester consists of four theory papers and one practical examination for the first three semesters. The fourth semester has project presentation and evaluation and comprehensive viva-voce in addition to one practical examination and three theory papers which are exclusively based on elective courses.

b. Dissertation

Each candidate should submit a dissertation in four copies of the research project undertaken by him/her at the end of fourth semester for evaluation.

c. Comprehensive viva-voce

A comprehensive viva-voce will be held at the end of the fourth semester covering all the courses of the programme taught in the entire four semesters.

4. **Faculty under which the Degree is Awarded**

M.Sc. Plant Biotechnology

5. **Specializations offered, if any**

Nil

6. Note on compliance with the UGC Minimum Standards for the conduct and award of Post Graduate Degrees

7. PROGRAMME STRUCTURE

Course Code	Title of the Course	Type of the Course	Hours per week	Credits	Total Credits
FIRST SEMESTER					
BS010101	Biochemistry and Cell Biology	Core	4	4	19
BS010102	Microbiology and Immunology	Core	4	4	
BS010103	Genetics and Molecular Biology	Core	4	4	
BS010104	Bioanalytical Techniques and Bioinformatics	Core	3	3	
BS010105	Laboratory course I	Core	10	4	
SECOND SEMESTER					
BS010201	Plant Cell Tissue and Organ Culture	Core	4	4	19
BS010202	Genetic Engineering	Core	4	4	
BS010203	Metabolism and Metabolic Engineering	Core	4	4	
BS010204	Biomass and Bioenergy	Core	3	3	
BS010205	Laboratory course II	Core	10	4	
THIRD SEMESTER					
BS010301	Plant Stress Biology	Core	4	4	19
BS010302	IPR and Translational Research	Core	4	4	
BS010303	Genomics and Proteomics	Core	4	4	
BS010304	Bioprocess Technology and Engineering	Core	3	3	
BS010305	Laboratory course III	Core	10	4	

Course Code	Title of the Course		Type of the Course	Hours per week	Credits	Total Credits
FOURTH SEMESTER						
BS800401	Electives Group A	Research Methodology and Science communication	Elective	5	4	23
BS800402		Molecular Techniques for Crop Improvement	Elective	5	4	
BS800403		Introduction to Nanotechnology	Elective	5	4	
BS810401	Electives Group B	Plant Developmental Biology	Elective	5	4	
BS810402		Systematic Botany, Biodiversity and Economic Botany	Elective	5	4	
BS810403		Ecology and Ecoinformatics	Elective	5	4	
BS820401	Electives Group C	Green House Management and Plant Protection	Elective	5	4	
BS820402		Business Management and Entrepreneurship	Elective	5	4	
BS820403		Marine Biotechnology	Elective	5	4	
BS010401	Laboratory course IV		Core	10	4	
BS010402	Research Project & dissertation		Core		5	
BS010403	Comprehensive Viva-Voce		Core		2	
			TOTAL		**80**	

8. SYLLABUS

8.1. FIRST SEMESTER COURSES

BS010101	Biochemistry and Cell Biology
BS010102	Microbiology and Immunology
BS010103	Genetics and Molecular Biology
BS010104	Bioanalytical Techniques and Bioinformatics
BS010105	Laboratory course I

BS010101 Biochemistry and Cell Biology

Total Credits: 4

Total Hours: 72

1. Objective of the Course

The course is designed to give a basic understanding of the chemical makeup of the cell and the different mechanisms in a cell which makes life possible.

2. Course Content

Unit 1: Genetic Foundations

Structure of nucleic acids (DNA, RNA); Structure and different forms of DNA; Chromosomal DNA and its packaging, global structure of chromosomes; Current understanding of central dogma of molecular biology; Brief overview of gene expression and control; Introduction to noncoding RNA (8 h)

Unit 2: Chemical Foundation

Functional groups in biomolecules; Proteins: Structure of amino acids. Peptide bonds. Primary structure of proteins. Three dimensional structures of proteins: secondary structures, motifs, domains, Ramachandran plot; tertiary structure; quaternary structure, multimeric proteins and holoenzymes. Protein-protein interactions. Protein denaturation and folding. Proteins as enzymes, Enzyme nomenclature and classification, Enzyme catalysis, DNA binding proteins – overview of structure, interactions and functions. DNA-binding motifs in gene regulatory proteins; Lipids: Structure and function. Phytosterols; Carbohydrates as biomolecules: structure and function, significance of glycoproteins and proteoglycans. Sugar code; Introduction to hormones, vitamins and pigments in plants. (24 h)

Unit 3: Cellular Foundations

Domains of life; General methods in cell biology; Structure of typical eukaryotic cell – plant cell; Cell membrane- Current understanding of membrane structure, composition of cell membrane – membrane lipids and membrane proteins: types, structure and functions; Membrane transport in plants – Mechanisms and molecules involved in active and passive transport. Proteins as molecular motors; Extra cellular matrix, cytoskeleton; Secretory pathway and organelles involved, protein trafficking, exocytosis, endocytic pathways, cell junctions in plants; Chloroplast – ultra structure and function; Mitochondria- structure, function. Mitochondria and male sterility. Chloroplast mitochondrial interaction; Nucleus – Structure and components; Peroxisomes, glyoxysomes. Plant vacuoles. (20 h)

Unit 4: The Dynamic Cell

General principles of cell signaling. Membrane proteins as cell surface receptors for signaling, Signaling via G-Protein-linked cell-surface receptors and enzyme-linked cell-surface

receptors. Second messengers. HRE binding proteins; Cell signaling in plants; Cell cycle and cell cycle regulation in animals and plants. Apoptosis in plant and animal cell. (12 h)

Unit 5: Evolutionary Foundations

Evolution of the Cell: From molecules to the first cell. RNA world. From prokaryotes to eukaryotes. From single cells to multicellular organisms. Endosymbiotic theory; Phylogenetic trees, Homology, Orthology, Paralogy, Xenology; Plant and animal divergence. (8 h)

3. Recommended Text books:

- Berg, J. M., Tymoczko, J. L., Gatto G. J. and Stryer, L. Biochemistry. W H Freeman, New York, 2012.
- Karp, G. Cell and Molecular Biology: Concepts and Experiments Biology. John Wiley & Sons, 2009
- Lodish et al. Molecular Cell Biology. W H Freeman, New York, 2016.

4. Recommended References:

- Adams, R.L.P, Knowler, J.T. and Leader, D.P. The Biochemistry of Nucleic Acid. Springer Science+Business Media, B.V., 1992.
- Alberts, B. et al. Molecular Biology of the Cell. Garland Science, 2013
- Hardin, J. and Bertoni, G.P. Becker's World of the Cell, Pearson, 2016.
- Muray K.R. et al. Harper's Illustrated Biochemistry. McGraw Hill Professional, 2009.
- Nelson, D.M. and Cox, M.M. Lehninger Principles of Biochemistry. W H Freeman, New York, 2013
- Voet, D. and Voet, J.G. Biochemistry 4e. W. Ross MacDonald School Resource Services Library, 2010

BS010102 Microbiology and Immunology

Total Credits: 4

Total Hours: 72

1. Objective of the Course

The course is designed to introduce the students to different groups of microorganisms, their structure, important chemical constituents, life cycle and significance of their interaction with environment, and various microbial culture methods. Finally the course aims to provide understanding in the basics of immunology, molecules involved, mechanisms and methods.

2. Course Content

Unit 1: Introduction to microorganisms

History and Scope of Microbiology; Classification of microorganisms - Bacteria, Fungi, Virus, Algae, Protozoa; Sterilization techniques, disinfectant and antiseptic agents. (10 h)

Unit 2: Bacteria and their ecological significances

Bacterial cell- structure and functions of cellular components-cell wall composition of Gram positive and Gram negative bacteria, sub-cellular organizations, flagella, capsule and spores; Bacterial Staining; antimicrobial agents-antibiotics, and antibacterial agents and their mode of action; antibiotic resistance; Agricultural and Environmental Microbiology: Microbial flora of soil - influence of environmental factors viz. pH, light, organic matter, moisture and temperature. Nitrogen cycle, Carbon cycle and Phosphorous cycle - Interaction of microbes - Nitrogen fixing organisms; Biology of archaebacteria. (16 h)

Unit 3: Virus and Fungi

Classification, morphology and characteristics of Virus, and Fungi - structure of DNA, RNA viruses, replication of animal viruses, bacteriophages- Lysogeny and Lytic cycle; virus like agents- satellites, viroids and prions; mode of action of antiviral and antifungal drugs. (14 h)

Unit 4: Microbial culture methods

Microbial culture –continuous culture and synchronous culture; composition of culture media -solid and liquid media, chemically defined media, complex and differential media; Microbial growth, effect of pH, temperature and radiation on microbial growth. (8 h)

Unit 5: Immunology

Innate and acquired immunity. Structure and functions of primary and secondary lymphoid organs- Lymphoid cells (B-lymphocytes, T-lymphocytes and Null cells), mononuclear cells (phagocytic cells and their killing mechanisms), granulocytic cells (neutrophils, eosinophils and basophiles), mast cells and dendritic cell. Epitopes, haptens, adjutants and mitogens. Classification, fine structure and functions of immunoglobulins – Clonal selection - concept of antigen specific receptor– Agglutination, precipitation and opsonization, gel diffusion (Ouchterlony double immunodiffusion and Mancini's Radial immunodiffusion),

immunoblotting, RIA, ELISA and ELISPOT, hypersensitivity (Types I, II, III, IV). Autoimmunity, immunodeficiencies. (24 h)

3. Recommended Text books:

- Janeway, C.A. et al., Immunobiology 5e. Garland Science, New York, 2001.
- Prescott, Harley and Klein. Microbiology 5e. McGraw Hill Science, 2002
- Punt, Stranford, Jones and Owen. Kuby Immunology 8e, W H Freeman, 2018.

4. Recommended References:

- Bauman, R.W. Microbiology Brief edition. Pearson Benjamin Cummings, 2004.
- Black, J.G. Microbiology-Principles and explorations 6 e. John Wiley & Sons, 2004.
- Delves, P.J., Martin, S.J., Burton, D.R. and Roitt, I.M. Roitt's Essential Immunology 13e. Wiley Blackwell, 2017.
- Engleberg, N.C., DiRita, V. and Dermody, T. Schaechter's Mechanisms of Microbial Disease. Lippincott Williams and Wilkins, 2013.
- Harvey A.R., Cornelissen, C.N. and Fisher, B.D. Lippincott’s Illustrated Reviews: Microbiology, Lippincott Williams & Wilkins, 2013.
- Murray, P.R. et al. Medical Microbiology. Elsevier, 2016.
- Tizard, I.R. Immunology: An Introduction, Saunders College Pub., 1995
- Tortora, G.J. Funke, B.R. and Case, C.L. Microbiology: An Introduction. 8e. Benjamin Cummings, 2004
- Willey, J.M., Sandman and Wood. Prescott's Microbiology 11e, McGraw Hill Higher Education, 2019.

BS010103 Genetics and Molecular Biology

Total Credits: 4

Total Hours: 72

1. Objective of the Course

Course is designed to make the student understand the fundamentals of Mendelian and post Mendelian Genetics apart from population and developmental genetics. Also the course aims to impart an understanding in replication, transcription and translation with special emphasis on RNA biology.

2. Course Content

Unit 1: Fundamentals of Genetics

Fundamentals of Mendelian Genetics; Molecular basis of codomianance, incomplete dominance, epistasis; Chromosomal basis of inheritance. Works of Bateson, Morgan, Sturtevant; Chromosome characteristics: Chromosomes as units of inheritance, euchromatin and heterochromatin, Coding and non-coding sequences, transposons. Genetic recombination in eukaryotes. Linkage and crossing over; Chromosome mapping, Tetrad analysis; Chromosomal aberrations and their significance in evolution and plant breeding. (10 h)

Unit 2: Population and Developmental Genetics

Environment and gene expression. Twin studies, genetic environment, non-genetic environment, phenocopies, penetrance and expressivity; Quantitative inheritance; Organelle genetics and cytoplasmic inheritance; Hardy Weinberg principle, natural selection, genetic drift, Genetic variation, Allele frequencies and its change; Developmental genetics: Model system - *Drosophila*, pattern formation, Maternal effect, Homoetic transformations; Differentiation in plants, floral development - apetalous, pistillate, agamous interactions. (10 h)

Unit 3: DNA replication and transcription

DNA Replication: Models of DNA Replication. Steps in replication – prokaryotes and eukaryotes. DNA polymerases and other enzymatic factors involved - in eukaryotes and prokaryotes, end problem of replication. Inhibition of replication; Proof reading and Repair mechanisms and their significance in cell cycle control; Significance of telomeres.

Process of transcription, RNA polymerases in prokaryotes and eukaryotes, Mechanism of transcription – prokaryotes and eukaryotes. Operon models. Transcription factors in eukaryotes, CpG islands, Post transcriptional modifications, catalytic RNA, Significance of alternate splicing. RNA editing. Transcription and processing of rRNA and tRNA. Inhibitors of transcription. Fundamentals of epigenetics. Histone acetylation and deacetylases, methylation and demethylation, chromosome remodeling complex. Genetic switches. Molecular and genetic mechanisms that create specialized cell types. (26 h)

Unit 4: RNA Biology

Types and functions of RNA – coding, non-coding, regulatory, catalytic and parasitic; Secondary structure of RNA: non-standard Watson-Crick base pairing, secondary structure diagrams, Structure of ribozymes; Small RNAs: RNA interference, siRNA, miRNA, piwiRNA; RNA interactions: RNA aptamers, RNP world - RNA binding domains; RNA-protein interactions in regulation of gene expression. UTRs of mRNA. ENCODE project. Role of RNAs in translational regulation. Non-coding RNAs in gene dosage regulation; Parasitic RNAs: Group I and II self splicing introns, retrotransposons and viral RNA. Telomerase, pseudogenes, retrosequences and retrogenome. (12 h)

Unit 5: Translation and Protein synthesis

Genetic code, properties, wobble hypothesis, Codon usage biasness, Process of translation - eukaryotes and prokaryotes, inhibition of translation. Post translational modifications, cell organelles involved. (14 h)

3. Recommended Text books:

- Griffiths A.J.F., Gelbart, W.M., Miller, J.H. and Lewontin, R.C. Modern Genetic Analysis. W. H. Freeman, New York, 1999.
- Karp, G. Cell and Molecular Biology: Concepts and Experiments Biology. John Wiley & Sons, 2009
- Krebs, J.E.; Goldstein, E.S. and Kilpatrick, S.T. Lewin's genes XII. Jones & Bartlett Learning, Burlington, MA, 2018.

4. Recommended References:

- Alberts, B. et al. Molecular Biology of the Cell. Garland Science, New York and London, 2013
- Brown, T. A. Genomes 2e. Oxford: Wiley-Liss, 2002.
- Clark, D. P. and Pazdernik, N.J. Molecular Biology. Elsevier, 2012.
- Kurien, J. Konforti, B. and Wemmer, D. Molecules of Life: Physical and chemical properties. Garland Science, New York and London, 2013
- Lodish et al. Molecular Cell Biology. W H Freeman, New York, 2016.
- Malthus, T. An Essay on the Principle of Population. 1798
- REA's Problem Solvers in Genetics, Research Education Association, New Jersey, 1993
- Watson et al. Molecular Biology of the Gene. Pearson, 2014

BS010104 Bioanalytical Techniques and Bioinformatics

Total Credits: 3

Total Hours: 54

1. Objective of the Course

The course aims to introduce the student to various analytical instruments used in biological and related experiments and to make her/him understand the basic principles of these techniques. Additionally the course introduces the student into the fundamentals of bioinformatics, its applications and basic tools.

2. Course Content

Unit 1: Spectroscopy and Microscopy

Spectroscopy - Concepts of spectroscopy, Laws of photometry. Beer-Lambert's law, Principles and applications of colorimetry; Visible and UV spectroscopy, ORD, CD, Xray diffraction, X-ray absorption, MALDI, ESR, and NMR.

Microscopy: Principles and applications of various types of Light and Electron microscopy; Dark field, Bright Field, Phase contrast, confocal, fluorescence, scanning & transmission electron microscopy, Cryo-electron microscopy, Atomic Force Microscopy; Tissue Processing for Light and Electron Microscopy, Micrometry. (12 h)

Unit 2: Chromoatography, Electrophoresis and Centrifugation

Chromatography – Principles and applications of paper, thin layer, ion exchange, affinity, gel permeation, adsorption and partition chromatography. HPLC and FPLC. HPTLC and GC.

Electrophoretic techniques – Principles of electrophoretic separation. Types of electrophoresis including paper, cellulose, acetate/nitrate and gel. Electroporation, Pulse field gel electrophoresis. 2D electrophoresis. Isoelectric focusing (IEF).

Centrifugation – Principle of centrifugation, concepts of RCF, different types of instruments and rotors, preparative, differential and density gradient centrifugation, analytical ultra-centrifugation, determination of molecular weights and other applications, subcellular fractionation. (14 h)

Unit 3: PCR

PCR – Principle of thermal cycler. Steps in amplification by traditional PCR. types of PCR based on its applications; Digital PCR, applications. Portable PCR; Real time PCR. TaqMan probe- and SYBR Green–based detection. Absolute and relative quantitation. Applications; Microarray – construction, types and applications. (6 h)

Unit 4: Introduction to Bioinformatics

Introduction to Bioinformatics, Online databases and search tools, data organization, Biological data bases, structural data bases, DNA and RNA sequence data bases, genomic

sequences, protein seq data bases, Distance matrix methods and parsimony. Multiple sequence alignments-tree alignments, star alignments, pattern in pair wise alignment, genetic algorithm.

(12 h)

Unit 5: Bioinformatic tools and applications

Sequence analysis softwares, SS search, BLAST, FASTA, CLUSTAL, Phylogenetic analysis, construction of phylogenetic tree, evolutionary changes in nucleotide and protein sequences, structure prediction, structural alignment tools, homology modeling, drug design. Applications of Bioinformatics: pharmaceutical industry, immunology, agriculture, forestry, basic research, chemiinformatics in biology, geoinformatics, legal ethical and commercial considerations. (10 h)

3. Recommended Text books:

- Ghosal, S and Sabaria. K. Fundamentals of Bioanalytical Techniques and Instrumentation. PHI, 2010
- Lesk, A.M. Introduction to Bioinformatics. Oxford University Press, 2002.
- Wilson, K. and Walker, J. Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 2010.

4. Recommended References:

- Attwood T.K. and Parry-Smith, D.J. Introduction to Bioinformatics. Pearson. Education 2003
- Hammes G.D. Spectroscopy for the Biological Sciences; Wiley Interscience, USA, 2005.
- Higgs, P. G., Attwood, T. K. Bionformatics and Molecular evolution. by Blackwell Publishing Ltd., 2005.
- Mount, D. Bioinformatics: Sequence and Genome analysis. Cold Spring Harbour Lab Press, New York, 2001.
- Srivastava, M. Bioanalytical Techniques. Alpha Science International Ltd., 2007 .
- Vo-Dinh (Ed.) Bioanalysis Advanced Materials, Methods, and Devices, Springer, 2013.

BS010105 Laboratory Course I

Total Credits: 4

Total Hours: 10 hours/ week

1. Objective of the Course

The course aims to provide the student basic practical experience in analysis and estimation of different macromolecules, solution preparation, in culture, isolation and identification of microbes, in immunology and enzymology and in basic bioinformatics tools.

2. Course content

Unit 1: Biochemical techniques, analysis, and enzymology

1.1. Identification of carbohydrates, lipids & proteins.

1.2. Mixture analysis.

1.3. Estimation of sugar, proteins and amino acids.

1.4. Spectrophotometry.

1.5. Preparation of acetate and phosphate buffers of different strength and pH

1.6. Paper chromatography and TLC

1.7. Estimation of enzyme activity ALP/ SGOT/ SGPT

1.8. Determination of Km and Vmax

1.9. Effect of pH, Effect of temperature on enzyme activity

Unit 2: Fundamental microbial techniques

2.1. Techniques of isolation of microbes, spare count using haemocytometer

2.1. Motility of microbes - Hanging drop

2.3. Bacterial staining- Gram staining and spore staining, flagella staining.

2.4. Detection of *E. coli* in water

2.5. Antibiotic sensitivity tests

Unit 3: Immunological assays

3.1. Immunodiffusion in gel

3.2. Serological tests for the diagnosis of microbial infections

3.3. ELISA

Unit 4: Nucleic acid isolation and *in silico* analysis

4.1. Extraction and purification of nucleic acids- DNA and RNA from plant materials.

4.2. Sequence Similarity Searching (NCBI BLAST, FASTA)

4.3. Multiple sequence Alignment (Clustal W/Clustal X)

4.4. ORF Prediction (Using ORF Finder)

4.5. Molecular Phylogeny (PHYLIP, MEGA)

3. Recommended Text books:

- Bujnicki, J.M. Practical Bioinformatics. Springer, 2006.
- Jain, M. and Agarwal, J. and Venkatesh, V. Microbiology Practical Manual. Elsevier India, 2018
- Plummer, D. An Introduction to Practical Biochemistry 3e, McGraw Hill Education, 2017
- Sawhney, S.K. and Singh, R. (Eds). Introductory Practical Biochemistry. Narosa Publications. New Delhi, 1999.
- van Emon, J.M. Immunoassay and other Bioanalytical Techniques. CRC Press, 2016

4. Recommended References:

- Lesk, A.M. Introduction to Bioinformatics. Oxford University Press, 2002.
- Mackie and Mccartney. Practical Medical Microbiology, Elsevier, 1996.
- Wilson, K. and Walker, J. Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 2010.

8.2. SECOND SEMESTER COURSES

BS010201	Plant Cell Tissue and Organ Culture
BS010202	Genetic Engineering
BS010203	Metabolism and Metabolic Engineering
BS010204	Biomass and Bioenergy
BS010205	Laboratory course II

BS010201 Plant Cell Tissue and Organ Culture

Total Credits: 4

Total Hours: 72

1. Objective of the Course

The course is designed to give the student an overview of plant tissue culture which will make her/him appreciate the different techniques involved in the process and finally the applications of plant tissue culture for the greater goal of crop improvement.

2. Course content

Unit 1: Basics of Plant tissue culture

History of Tissue Culture technique. Requirements for a plant tissue culture lab - Laminar air flow device, Sterilisation scheme for culture chamber; Totipotency of plant cells- dedifferentiation and redifferentiation; Nutrient media: Composition of commonly used nutrient culture media with respect to their contents like inorganic chemicals, organic constituents, vitamins, amino acids etc.; Sterilisation of the media and appliances by autoclaving. (12 h)

Unit 2: Methods in Plant tissue culture

Culture of plant materials - explants selection and technique of culturing the same; Growth conditions; Methods of sub culturing and transfer of regenerated plants to the field; Micro propagation: Proliferation of axillary buds, induction of adventitious buds and bulbs, callus regeneration, somatic embryogenesis; Continuous culture, immobilized cultures, estimation of growth and artificial seeds; Biochemical and molecular basis of differentiation in plant tissue culture. (12 h)

Unit 3: Cloning and storage methods

Cloning: Isolation of single cells, culturing of single cell- different methods, culture cell viability test; Cryopreservation and slow growth cultures, Freezing and storage, thawing, reculture. (4 h)

Unit 4: Applications in Crop improvement I

Basics of plant breeding. Scope and application of plant tissue culture in agriculture; Crop improvement by induced *in vitro* mutations. physical and chemical mutagents. Advantages and limitations; Methods for production of haploids and development of homozygous lines, Gametoclonal variations, analytical breeding; Protoplast culture and regeneration of plants, isolation, merits and demerits. Somaclonal variations, isolation of somaclonal variants. Molecular basis of somaclonal variation; Seaweed tissue culture - callus induction and plantlet regeneration, protoplast culture and somatic hybridisation. (24 h)

Unit 5: Applications in Crop improvement II

In vitro breeding: Overcoming pre-fertilisation and post-fertilisation crossing barriers in plant breeding . In vitro pollination, mentor pollen technique, Endosperm culture for polyploidy breeding, Embryo rescue. Advantages and limitations; Production of virus free plants- shoot meristem culture. Thermotherapy, cryotherapy and chemotherapy. Virus indexing. Maintenance of virus free stocks. Applications and limitations. Significance of *in vitro* propagation techniques in developing transgenic crops. (20 h)

3. Recommended Text books

- Hartmann, H.T., Kester, D.E., Davies, F.T. and Geneve, R.L. Hartmann & Kester's Plant Propagation: Principles and Practices, Pearson, 2010.
- Razdan, M. K. Introduction to Plant Tissue Culture. Oxford & IBH, 2005.
- Gamborg, O. and Gregory, P. (Eds.) Plant Cell, Tissue and Organ Culture: Fundamental Methods, Springer, 1995.

4. Recommended References:

- Chopra, V. L., Sharma, R. P. and Swaminathan, M. S. Agricultural Biotechnology: 2nd Asia Pacific Conference, Science Pub Inc., 1996
- Kalyan Kumar, D. An Introduction to Plant Tissue Culture. New Central Book Agency, New Delhi, 1997.
- Guptha, P.K. Elements of Biotechnology. Rastogi Publications, 2016
- Slater, A., Scott, N. and Fowler, M. Plant Biotechnology: The Genetic Manipulation of Plants, Oxford, 2008.
- Kung, De S., and Wu, R. Transgenic Plants: Engineering and Utilization, Academic Press, 2012
- Collin, H. A. and Edwards, S. Plant Cell Culture. BIOS Scientific Publishers, 1998
- Gresshoff , P.M. Plant Molecular Biology. CRC Press, 1994
- Jogdand, S.N. Advances in Biotechnology. Himalaya Publishing House, 2007.

BS010202 Genetic Engineering

Total Credits: 4

Total Hours: 72

1. Objective of the Course

The course is designed to give the student a basic understanding of genetic engineering, various tools and approaches employed and their applications.

2. Course content

Unit 1: Introduction to genetic engineering

Enzymes used in genetic engineering: Restriction endonucleases, DNA polymerase, Reverse transcriptase, Polynucleotide kinase, DNA ligase, Terminal deoxynucleotidyl transferase, Alkaline phosphatase; Homopolymer tailing, Linkers, Adaptors. Application of PCR in rDNA technology; Ligation of DNA fragments with vectors. Primers with restriction sites; Characteristics of *E. coli* as host for cloning; Vectors for cloning - Plasmids, Bacteriophage and Filamentous phage vectors, cosmids, BAC and YAC vectors. Applications, T/A vectors, TOPO cloning, GATEWAY cloning; Expression vectors – features and significance. Prokaryotic expression systems- Gene expression based in bacteriophage T7 RNA polymerase. (16 h)

Unit 2: Eukaryotic host systems

Properties of yeast as host for cloning, Types of vectors designed for cloning in yeast. Shuttle vectors; Vectors for cloning in animal cells– SV 40, Adenovirus, Baculovirus, Retrovirus vectors. DNA viruses that infect plants – Caulimoviruses vectors, Geminiviruses vectors, Types of vectors used in higher plants- Tumour-inducing (Ti) plasmids, binary and cointegrate vectors. (10 h)

Unit 3: Strategies of gene transfer and DNA libraries

Introducing genes into prokaryotes - Natural gene transfer methods, Calcium chloride mediated transformation, Transfection with phage vectors, Methods of introduction of foreign DNA in animal system- DNA/calcium phosphate co precipitate method, Phospholipids as gene-delivery vehicles. Electroporation, Microinjection, Triparental mating; Cloning strategies- Construction of genomic and cDNA libraries, Shot gun cloning, Chromosome walking; Selection and screening of recombinant clones, Methods based on nucleic acid hybridization, finding specific clones by functional complementation. Reporter genes. (16 h)

Unit 4: RNA interference and gene editing

Studying of gene function through protein interactions-Two hybrid screening, Phage display libraries; Applications of RNA interference in genetic engineering. Concept of gene knock out technique; Mutagenesis and gene editing: Site directed mutagenesis, Transposon mutagenesis, CRISPR/ CAS system and its applications. Ethical aspects and safety of genome editing. (14 h)

Unit 5: Blotting and Sequencing Techniques

Blotting techniques –Southern, Northern, Western. Applications and current scenario; Fluorescence in-situ hybridization, Electrophoretic mobility shift assay, ChIP assay; Principles and methods for DNA sequencing: Sanger's method, automated Sanger's sequencing. Next generation sequencing techniques: Sequencing by synthesis, Pyro sequencing, Ion torrent

sequencing, Nanopore Sequencing, Single molecule real time DNA sequencing. NGS data formats, indexing, maping reads. Basics of assembly of NGS data. Applications of NGS; Molecular pharming. (16 h)

3. Recommended Text books

- Brown, T. A. Gene Cloning and DNA Analysis. Wiley-Blackwell, 2016.
- Old, R.W. and Primrose, S.B. Principles of Gene Manipulation. Blackwell Publishing, MA, 2001.

4. Recommended References:

- Dale, J.W., von Schantz, M. and Plant, N. From Genes to Genomes: Concepts and Applications of DNA Technology. Wiley, 2011
- Desmond S. T. Nicholl. An Introduction to Genetic Engineering. Cambridge University Press, 2002
- Glick, B.R. and Pasternak, J.J. Molecular Biotechnology: Principles and Applications of Recombinant DNA ASM Press, 2003
- Henry, R. J. Plant Genotyping: The DNA fingerprinting of plants. CABI, New Delhi, 2001.
- Primrose, S.B, Twyman, R.M and Old, R.W. Principles of Genetic Manipulation and Genomics. Science Ltd, MA, 2006
- Wilson, K. and Walker, J. Principles and Techniques of Biochemistry and Molecular Biology. CPL Scientific Publishing Services Limited, 2005
- Wink, M. (Ed). An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology. Wiley, 2016

BS010203 Metabolism and Metabolic Engineering

Total Credits: 4

Total Hours: 72

1. Objective of the Course

The course is envisaged to impart in students an understanding of the basic metabolic processes involving major biomolecules in a cell with emphasis on plant cell and how these processes can be manipulated in a suitable living system for meeting the demands of various related industries.

2. Course content

Unit 1 Bioenergetics

Concept of free energy, standard free energy, determination of ΔG for a reaction. Relationship between equilibrium constant and standard free energy change, biological standard state & standard free energy change in coupled reactions. Biological oxidation-reduction reactions, redox potentials, relation between standard reduction potentials and free energy change (derivations and numerical included). High energy phosphate compounds – introduction, phosphate group transfer, free energy of hydrolysis of ATP and sugar phosphates along with reasons for high ΔG. Energy charge. (14 h)

Unit 2 Basics of metabolism

Fundamentals of carbohydrate metabolism, amino acid metabolism, lipid metabolism (18 h)

Unit 3 Introduction to Plant cells and metabolism

Photosynthesis: Photosynthetic pigments and light harvesting complexes, Photo inhibition of photosynthesis, Photosynthetic carbon reduction (PCR) cycle, C4 syndrome and Crassulacean acid metabolism; Aerobic respiration and pathways involved, Alternate electron pathways and Respiration rate; Photo-morphogenesis : Phytochromes, Crypto chromes, photo-morphogenesis

Nitrogen metabolism: Physical and biological nitrogen fixation, Ammonification, Nitrification, Denitrification, Biochemistry and Genetics of nitrogen fixation and Ammonium assimilation.

Plant Hormones: Biosynthesis, Physiological effects and mechanism of action of Auxins, Gibberellic acids, Cytokinins, Abscisic acid, Ethylene, Brassinosteroids , Polyamines and Strigolactones. (16 h)

Unit 4 Plant Secondary Metabolism

Plant secondary products of industrial importance, alkaloids, Non-protein amino acids, Amines, Cyanogenic glucosides, glucosinolates, Terpenoids, Phenolics, ; Biochemistry of major secondary metabolic pathways; *In vitro* production of secondary metabolites: Plant growth regulators and elicitors; Cell suspension culture development: methodology, kinetics of growth and production formation, optimization of culture; Hairy root cultures and their cultivation; Biotransformation. (12 h)

Unit 5 Metabolic engineering

Regulation of metabolic pathways, compartmentalization. Feed-back inhibition, Metabolon. Rate limiting step, pathway engineering and flux analysis. Metabolic engineering for enhancing nutritional quality, enhancing photosynthesis efficiency. Case studies of engineered strategies. (12 h)

3. Recommended Text books

- Dharmapalan, B. Plant Biochemistry: An Introduction. Alpha Science, 2016
- Hopkins, W. G and Huner, N. P. A. Introduction to Plant Physiology. John Wiley & Sons, New York, 2004.
- Nelson, D.M. and Cox, M.M. Lehninger Principles of Biochemistry. W H Freeman, New York, 2013

4. Recommended References:

- Christina Smolke. The Metabolic Pathway Engineering Handbook: Tools and Applications. CRC Press, 2017.
- Gregory N. Stephanopoulos et al. Metabolic Engineering: Principles and Methodologies. Elsevier, 2006
- Mukherji, S and Gosh A. K. Plant Physiology. 2nd ed. New Central Book Agency, Kolkata, 2005.
- Slater A, NW Scott, MR Fowler. Plant biotechnology, 2nd ed. Oxford University Press, 2008.

BS010204 Biomass and Bioenergy

Total Credits: 3

Total Hours: 54

1. Objective of the Course

The course is designed to make the student appreciate biomass as an energy source and the different energy products obtained from various sources of biomass and their utility.

2. Course content

Unit 1: Introduction to Bioenergy

Energy sources - General account-Nuclear energy and Fossil fuel energy, Non – Nuclear and Non – Fossil fuel energy; Bioenergy-energy plantations, social forestry and Silvi culture energy farms. (10 h)

Unit 2: Biomass and source of energy I

Composition of biomass, aquatic and terrestrial biomass production of algal and fungal biomass, Organic wastes as a renewable source of energy, sources of wastes and composition of wastes. (10 h)

Unit 3: Biomass and source of energy II

Bioenergy sources: Petrolieum plants(petro plants)- hydrocarbons for higher plants like *Hevea* and *Euphorbia.* Algal hydrocarbons; Alcohols: Alcohols as a liquid fuel-Hydrolisis of lignocellulosic materials, Ethanol production, fermentation and recovery of ethanol. (12 h)

Unit 4: Bioenergy production I

Biomass conversion: Non biological process- Direct combustion (hog fuel), pyrolysis, Gasification and Liquification; Biological process: Enzymatic digestion, aerobic and anaerobic digestion. (8 h)

Unit 5: Bioenergy production II

Gaseous fuels: Biogas and hydrogen: Biogas technology benefits from biogas plants; Biogas production: aerobic digestion solubilization, acidogenesis, methanogenesis; Biogas production from different feed stocks like *Salvinia* and *Eichornia;* Hydrogen as a fuel: Photobiological process of hydrogen production. Hydrogenese and hydrogen production. Halo bacteria; An overview of global bioenergy research. Thrust areas and vision of Bioenergy programme of Department of Biotechnology, Govt. of India. (14 h)

3. Recommended Text books:

- Mckinney, M. L. and Schoch, R.M. Environmental science-systems and solutions. Jones and Bartlett Publishers, 2007

4. Recommended References:

- Malik, V.S. and Sridahar, P. Industrial biotechnology. Science Pub Inc, 1992
- Turner, R.K. Sustainable Environmental Management: Principles and Practice. Belhaven Press, 1988
- International Encyclopedia of Ecology and Environment Vol.1-30. Indian Institute of Ecology & Environment Publ.

BS010205 Laboratory Course II

Total Credits: 4

Total Hours: 10 hours/ week

1. Objective of the Course

The course is designed to provide the students practical knowledge regarding methods in plant tissue culture and biomass conversion

2. Course content

Unit 1: Plant Cell and Tissue Culture

1.1. Formulation of tissue culture media-different types

1.2. Collection of explants material

1.3. Surface sterilization of explants materials

1.4. Preparation of explants and inoculation

1.5. Sub- culture of callus; Regeneration of plants from callus.

1.6. Hardening techniques of tissue culture plantlets.

1.7. Techniques for axillary bud proliferation.

1.8. Preparation of artificial seeds.

1.9. Culture of single cells.

1.10. Technique of cryopreservation.

Unit 2: Biomass and Bioenergy

2.1. Biogas production

3. Recommended Text books

- Razdan, M. K. Introduction to Plant Tissue Culture. Science Publishers, 2003

4. Recommended References:

- Bhojwani. S.S and Razdan. M.K. Plant tissue culture. Science Publishers, 2004.
- Dixon, R.A. and Gonzales, R.A (Eds.). Plant Cell Culture: A Practical approach.
- Phytochemical Methods A Guide to Modern Techniques of Plant Analysis By JB Harborne. Springer, 1998.

8.3. THIRD SEMESTER COURSES

BS010301	Plant Stress Biology
BS010302	IPR and Translational Research
BS010303	Genomics and Proteomics
BS010304	Bioprocess Technology and Engineering
BS010305	Laboratory course III

BS010301 Plant Stress Biology

Total Credits: 4

Total Hours: 72

1. Objective of the Course

The course is designed to introduce the student to the field of stress biology in plants. The course aims to cover the basics of pathogenesis from the view point of both the host and invading organisms and then the biotic and abiotic stress physiology including the effect of environment on disease development.

2. Course content

Unit 1: Plant pathology

Plant pathology; its scope and relationships to other sciences. Concept of plant diseases; saprophytes and parasitism (heterotrophic organisms and mode of nutrition), pathogenicity. Classification of plant diseases, plant diseases control - Principles and methods. Legislative methods, cultural methods, soil and sand treatment, biological, control, chemical control, Control through resistant varieties, quarantine. Plant disease forecasting. (14 h)

Unit 2: Pathogenesis

Pathogenesis penetration and entry, colonization of the host, factors affecting infection, enzymes in plant diseases – cell wall degrading enzyme. Toxins in relation to plant diseases: a general account, mode of action and types. (12 h)

Unit 3: Defense mechanism against pests and pathogens

Genetics of plant-pathogen interaction. Zig-zag model of plant-pathogen interaction. Hypersensisitve response (HR), Systemic Acquired Resistance (SAR), PR-proteins. Pathways and networks involved in plant defense, role of salicylic acid, jasmonic acid and ethylene in plant defense; Plant defense against microbial pathogens (bacteria, virus, fungus, nematodes); Plant defense against insect pests; Plant responses to post infectional agents; alteration in growth, photosynthesis, respiration, nitrogen metabolism, aromatic compounds, and growth regulators-vascular transport. (20 h)

Unit 4 Abiotic Stress physiology

Plant responses to abiotic stress - Water deficit and drought resistance, Flooding, Temperature stress, Salt stress, ion toxicity, Pollution stress and potential biotic stress. Role of small molecules (osmolytes, biogenic amines and hormones), transcription factors and heat shock proteins and protein kinases in plant abiotic stress tolerance. (16 h)

Unit 5 Environment and Disease development

Effect of environment on diseases development. Plant diseases, epidemiology, forms of epidemics and conditions governing some of the important crop diseases. (10 h)

3. Recommended Text books

- Agrios, G. Plant Pathology. Academic Press, Londo, 1988
- Bilgrani, K.G. and Dubey, H.C. A Text Book of Modern Plant Pathology, 1980

- Manners, J.G. Principles of Plant Pathology, Cambridge University Press, Cambridge, 1982.

4. Recommended References:

- Anega, KG, , Experiments in microbiology, plant pathology, and tissue culture, Wishwz prakasam (Willey Eastern Limited). 1993
- Boicer, F. and Cook , R.J. Biological control of plant pathogens, San Francisco, 1974
- Braual, N.K. et al., Text book of plant pathology. Oxford publishing company, New Delhi. 1980
- Butler, E.J. Jones Plant pathology periodical book agency, Delhi, 1986
- Ganulco, H.C. and Kar, A.K. College Botany volume11. central book depot, Calcutta, 1986
- Holliday, P. Fungal diseases of tropical crops. Cambridge University, 1980
- Mehrotra, R.S. Plant pathology 2nd Edition. Tata McGraw hill Publi. New Delhi, 1979
- Singh, R.S. Introduction to Principles of Plant Pathology. Oxford &IBH Pub. Co. Pvt. Ltd., New Delhi, 1984.

BS010302 IPR and Translational Research

Total Credits: 4

Total Hours: 72

1. Objective of the Course

Research and need for improvisations necessitates the need for development of new technologies, products and processes. The course is designed to make the student aware of legal and other issues involved in their pursuit of academic goals in terms of intellectual property rights, patents, and related acts and laws, and bioethics. Also the course has a unit on translational research which aims to impart in the student the idea that the research ultimately has to reach the masses through innovations in fields of medicine and agriculture.

2. Course Content

Unit 1: IPR

Intellectual Property Right (IPR) and Protection (IPP): About Intellectual Property and Intellectual Property Right, their scope and duration of protection, choice of intellectual property protection, IPR and Plant Genetic Resources (PGR), GATT and TRIPs. (14 h)

Unit 2: Patents

Patents in biotechnology: Patentable subject matter, procedure of patenting, products and processes, novelty, non-obviousness, utility, enablement, disclosure, prior approval before applying for IPR. Patenting of biological material- worldwide and Indian context, International conventions, patent applications, implication of patenting of higher plants, patenting transgenic organisms, genes and DNA sequences, IPR in agriculture: Plant variety protection, plant patents and utility patents, Plant breeders right (PBRs) and Farmers Rights. Environmental laws of India and Biological Diversity Act. (16 h)

Unit 3: **Biotechnology and Society**

Perceptions of the consumers, government, industry and civil society. Biotechnology and globalization, role of international economic and regulatory regimes.

Bioethics: Codes of ethics in history, UN Declaration on bioethics and human rights, implications; Research and regulatory ethics: Responsible Conduct of Research, misconduct, Falsification, fabrication, plagiarism, conflict of interest, regulatory misconduct, implications for public trust in biotechnology. (16 h)

Unit 4: Biosafety

Biosafety: Concepts, biosafety in the laboratory, institution and outside, regulatory regime through institutional, state and national biosafety bodies, biosafety in rDNA work, hospitals, fields etc. International biosafety dimensions: Cartagena Protocol, biological warfare and bioterrorism. Food safety and environmental safety evaluation of genetically modified microbes, crops, animals. (14 h)

Unit 5: Translational research

Significance of plant translational research- significance, avenues, case studies. Challenges and future prospects; Product development and Entrepreneurship programmes –

process, possibilities, schemes and legalities involved; Strategies and case studies in herbal drug development. (12 h)

3. Recommended Text books

- Cornish, W. R. Intellectual property: Patents, Copyright, Trade marks, and Allied rights. Sweet & Maxwell, 1999

4. Recommended References:.

- Ahuja, V.K. Law Relating to Intellectual Property Rights. Lexis Nexis, 2017.
- Ashok Soni. Complete reference of Intellectual property rights laws- 2 vols.
- Mittal, D.P. Indian Patents Law. Taxmann, 1999
- TIFAC New Delhi : Intellectual Property Rights Bulletin.

BS010303 Genomics and Proteomics

Total Credits: 4

Total Hours: 72

1. Objective of the Course

Deciphering the genetic makeup and protein population in an organism are among the elementary approaches in biological sciences. The course is envisaged to provide the student an understanding in genomics and proteomics and, the different approaches and techniques employed in these fundamental fields of study.

2. Course content

Unit 1: Structural Genomics

Strategies for genome sequencing, Sequence assembly: Clone contig and shotgun approaches. Organization of genomes: main features of bacterial and eukaryotic genome organization. Plant genome project and its applications. Locating the genes: ORF scanning, homology searches. (12 h)

Unit 2: Functional Genomics

Determination of the functions of genes: gene inactivation (knock-out, anti-sense and RNA interference) and gene over expression. Approaches to analyze global gene expression: transcriptome, Serial Analysis of Gene Expression (SAGE), Expressed Sequence Tags (ESTs), Massively Parallel Signature Sequencing (MPSS), microarray and its applications, gene tagging, Metagenomics: Prospecting for novel genes from metagenomes and their biotechnological applications. (14 h)

Unit 3: Introduction to Proteomics

Human genome - Genomes to Proteomes - HUPO –Branches of proteomics - Protein extraction Methods: Subcellular fractionation, Density gradients: Ultrafiltration, - Protein fractionation - Affinity purification –Combined Fractional Diagonal: Chromatography (COFRADIC) - Removal of interfering compounds, salts, DNA, lipids, Protein solubilization methods, chaotropes, detergents, etc - Preparation of Sample - Sample handling and storage - Protein detection and quantification methods – Stable Isotope Labeling with Aminoacids in Culture (SILAC) - Chemical tagging, fluorescence, negative staining, radiolabeling –Chemical modifications. (18 h)

Unit 4: Proteomic Techniques for Analysis

2-D gel electrophoresis – Mass Spectrometry –Principles -MALDITOF - RP chromatography /Tandem mass spectrometry - Protein sequence analysis -N-terminal determination methods- Protein modification – Protein microarrays – Tissue microarray – Infra red Protein array with Quantitative Readout (IPAQ)- X-ray crystallography - Nuclear Magnetic Resonance - X-ray Tomography -Data Analysis algorithms – Sequence Analysis algorithms.

(16 h)

Unit 5 Proteomic approach for Clinical studies

Protein Biomarker Discovery and Validation – Body fluid profiles, blood disease profiles, diabetes profiles, infectious diseases, stroke and myocardial infarction, nervous system, Alzheimer, low abundance and hydrophobic proteins. High throughput techniques to identify protein molecules in sample - Emerging technologies: Proteomics in Biotechnology - Microfluidics. (12 h)

3. Recommended Text books

- Twyman, R.M. Principles of Proteomics. BIOS Scientific Publisher, New York. 2004.
- Singer M and Berg P Genes and Genomes: A Changing Perspective; University Science Books, CA, USA, 1991.

4. Recommended References:

- Liebler, D.C. Introduction to Proteomics: Tools for the New Biology. Human Press, Totowa NJ. 2002.
- Buchanan B, Gruissem G, and Jones R Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA, 2000.
- Hammes GD. Spectroscopy for the Biological Sciences; Wiley Interscience, USA, 2005.
- Harlow and Lane D (Eds.). Antibodies – A Laboratory Manual; Cold Spring Harbor Laboratory, USA, 1988.
- Lieber DC. Introduction to Proteomics: Tools for New Biology; Humana Press, NJ., 2006
- Pennington SR, Dunn MJ (Eds.). Proteomics: From Protein Sequence to Function, BIOS Scientific Publishers, 2002
- Westermeier, R and T. Naven. Proteomics in Practice: A Laboratory Manual of Proteome Analysis. Weinheim: Wiley-VCH, 2002.

BS010304 Bioprocess Technology and Engineering

Total Credits: 3

Total Hours: 54

1. Objective of the Course

Fermentation process is being widely tailored made and used in industries for production of an array of economically important compounds. An understanding of the process as performed in laboratories and industries, techniques, design and instrumentation involved, is required for the student and the course aims to cater to this requirement.

2. Course Content

Unit 1: Introduction to fermentation processes

Range of fermentation process, microbial biomass, microbial enzyme, microbial metabolites, and transformation processes; Microbial growth kinetics- Batch culture, continuous culture, industrial applications of continuous culture processes, fed-batch culture; The isolation, preservation and improvement of industrially important and useful microorganisms. (10 h)

Unit 2: Media and Sterilization techniques

Media for industrial fermentation- typical media, media formulation, water, energy and carbon sources, nitrogen sources, minerals, vitamin sources, nutrient recycle, buffers, precursors and metabolic regulators, oxygen requirement.

Sterilization of air and media- Media sterilization, batch and continuous media sterilization processes, sterilization of fermenter, sterilization of the feeds, sterilization of air, theory of fibrous filters, filter design. (14 h)

Unit 3: Development of inoccula for industrial fermentation

Development of inocula for yeast, bacteria, fungal and actinomycetes processes, the inoculation of fermenters. (8 h)

Unit 4: Design of Fermenter

Basic functions of a fermenter, construction, aeration and agitation, baffles, the achievement and maintenance of aseptic conditions, valves, other fermentation vessels. Aeration and agitation- The oxygen requirements of industrial fermentation processes, determination of KLa, factors affecting KLa, fluid rheology. (12 h)

Unit 5: Instrumentation and control

Control systems, manual, automatic, methods of Measurements of process variables, flow, temperature, pressure, agitator shaft power, foam sensing and control, measurement and control of dissolved oxygen, on-line analysis of process parameters, computer control of fermenters. (10 h)

3. Recommended Text books:

- Moser, A. Bioprocess Technology: Kinetics and Reactors. Springer-Verlag, 1988.
- Niazi,S.K. and Brown, J.L..Fundamentals of Modern Bioprocessing. CRC Press, 2017.

4. Recommended References:

- Doran, P.M. Bioprocess Engineering Principles. Elsevier, 2013.
- Flickinger, M.C. and Drew, S.W. (Eds). Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis and Bioseparation, 5 Volume Set, Wiley_Interscience, 1999
- Henry C. Vogel (Ed.). Fermentation and Biochemical Engineering Handbook: Principles, Process Design and Equipment, Noyes Publications, 2007.
- Lee, S.Y. and Papoutsakis (Eds). Metabolic Engineering (Biotechnology and Bioprocessing).
- Shuler, M.L. Bioprocess Engineering: Basic Concepts. Prentice Hall, 2001.

BS010305 Laboratory course III

Total Credits: 4

Total Hours: 10 hours/ week

1. Objective of the Course

The laboratory course aims to provide the student practical experience in the basic techniques in genetic engineering experiments, plant transformation and formulation and practices in countering pathogen/ pest attack

2. Course content

Unit 1: Techniques in Genetic Engineering

1.1. Preparation of genomic and plasmid DNA from *E.coli* cells.

1.2. Agarose gel electrophoresis of plasmid and chromosomal DNA.

1.3. Restriction endonuclease digestion of DNA

1.4. DNA ligation methods.

1.5. Construction of recombinant DNA.

1.6. Transformation of competent *E. coli* cells

1.7. Selection and screening of transformed cells (100 h)

Unit 2: Plant transformation and validation

2.1. *Agrobacterium*-mediated plant transformation and marker gene assay

2.2. Southern blotting. (60 h)

Unit 3: Stress Biology of Plants

3.1. Rhizosphere and rhizoplane studies.

3.2. Analysis of exudates Effect of chemicals in control of diseases. Laboratory testing of the efficacy of common fungicides.

3.3. Biological control - methods like Tobacco leaf extracts, turmeric, neem oil, pungam oil etc. (20 h)

3. Recommended Text books.

- Frederick. M.A., Roger. B.R., David. D. M., Seidman. J. G., John A. S., Kevin. S. Current Protocols in Molecular Biology. John Wiley and Son, Inc., 2003.

4. Recommended References:

- Sambrook, J., Russell, D. W., & Russell, D. W. Molecular Cloning: A Laboratory Manual (3-volume set). CSLP, 2001.

8.4. FOURTH SEMESTER COURSES

BS800401	Electives Group A	Research Methodology and Science communication
BS800402		Molecular Techniques for Crop Improvement
BS800403		Introduction to Nanotechnology
BS810401	Electives Group B	Plant Developmental Biology
BS810402		Systematic Botany, Biodiversity and Economic Botany
BS810403		Ecology and Ecoinformatics
BS820401	Electives Pool C	Green House Management and Plant Protection
BS820402		Business Management and Entrepreneurship
BS820403		Marine Biotechnology
BS010401	Laboratory course IV	
BS010402	Research Project & Dissertation	
BS010403	Comprehensive Viva-Voce	

ELECTIVES

GROUP A

BS800401 Research Methodology and Science Communication

Total Credits: 4

Total Hours: 90

1. Objective of the Course

Post graduate courses in general are designed to encourage the students to further their knowledge through research activities. The course aims to introduce the student to the philosophy in research and accepted methodologies followed in due course and importance and methods of communicating science effectively. Also a basic understanding regarding biostatistics is also included.

2. Course content

Unit 1: Creativity, thinking skills and outlooks on research

Various views on creativity. Critical thinking. Problem solving strategies. Logical thinking – common logical fallacies; Types of research – pure and applied, incremental and innovative, qualitative and quantitative. Philosophy of science: the scientific method, Research process. The raw data- experimental designs, measurement and recording. Collection, analysis and interpretation of data. Ethics in scientific research and academics. (14 h)

Unit 2: Research papers

Format of a science research paper. Reference citing styles. Literature collection and report writing. Proof reading and editing. Publication process. Peer review – single/ double blind and open. Plagiarism. Open Access Publications; Google scholar and Scopus. Bibliometrics and Webometrics – impact factors, h-, h b-, g- indices, Drawbacks in interpreting impact. Reference management tools. Current awareness: RSS feed, TOC alerts, DB alerts. (18 h)

Unit 3: Biostatistics

The mean, the range, the standard deviation, standard error, student t-test, student t-distribution, chi-square test, correlation. Basic statistics-averages statistics of dispersion, coefficient of variation and analysis of variance. R software for statistical computing and graphics: (20 h)

Unit 4: Science Communication

Fundamentals of Science communication. History of Science communication, Science communication in India. Entrepreneurship in Science communication. Science communication in the information age. (20 h)

Unit 5: Practicing Science Communication

Effective science communication. – speaking and writing skills. Communication skills for scientists. Different modes of science communication and popularisation. Visualizing science

for communication.. Making effective multi-media and poster presentations. Science diplomacy and public understanding of science (18 h)

3. Recommended Text books:

- Antonisamy, B. et al. Principles and Practice of Biostatistics. Elsevier India, 2017.
- Biju Dharmapalan. Scientific Research Methodology. Alpha Science Int. Ltd., 2012.
- Holliman, R. et al. Practising Science Communication in the Information Age: Theorizing Professional Practice, Oxford University Press, 2009
- Kothari C. R. and Gaurav G. Research Methodology: Methods and Techniques. New Age Publishers, 2019.
- Wilson, A. (Ed). Handbook of Science Communication. Routledge, 1998.

4. Recommended References:

- Bagla, P. and Binoy, V. V. (Eds.) Bridging the Communication Gap in Science and Technology Lessons from India, Springer, 2017.
- Bassham, G., Irwin, W., Nardone, H. and Wallace, J.: Critical Thinking: A Students Introduction, Tata McGraw Hill, 2008
- Bennett, D.J. et al. Successful Science Communication. Cambridge University Press, 2012.
- Charles Pavitt. The Philosophy of Science and Communication. Nova Science Publications, 2001.
- Davies, S. R., Maja, H. Science Communication Culture, Identity and Citizenship. Palgrave Macmillan, 2016
- Day, R.A. How to Write and Publish a Scientific Paper. Greenwood Press, 2011
- Holliman, R., et al. Investigating Science Communication in the Information Age: Implications for Public Engagement and Popular Media. Oxford, 2009.
- Martin W. Bauer Journalism, Science and Society: Science Communication Between News and Public Relations. Routlledge, 2007
- Olson, R. Don't Be Such a Scientist: Talking Substance in an Age of Style. Island Press, 2010
- Pagano, M. and Gauvreau, K. Principles of Biostatistics. Chapman and Hall, 2018.
- Patairiya, M. Science Journalism in India. Pantaneto Press, UK. http://pantaneto.co.uk/science-journalism-in-india-manoj-patairiya/
- Rowena Murray. How to Write a Thesis, Tata McGraw Hill, 2010.

BS800402 Molecular Techniques for Crop Improvement

Total Credits: 4

Total Hours: 90

1. Objective of the Course

The course aims to impart in the students an understanding of various molecular approaches followed in crop improvement programmes. The students will be introduced largely to the various marker technologies and their applications like in mapping and selection apart from genetic engineering involving nuclear and other organellar genomes, and different traits that are being introduced/ augmented in the process which helps in crop improvement

2. Course content

Unit 1: Nuclear and organellar genome engineering

Genetic engineering through *Agrobacterium tumefaciens*: Ti plasmids, Structure of TDNA. Suitability of Ti plasmid as cloning vector. T-DNA integration into chromosomal DNA. Genetic engineering through disarmed Ti plasmids. Regeneration of plantlets; Chloroplast and mitochondrial engineering, Engineering of chloroplast genome in *Chlamydomonas* and in higher plants. (16 h)

Unit 2: Molecular markers

Fundamentals of genetic maps, different types of markers used for maping, molecular markers. Molecular marker types (including RFLP, SSR, RAPD, ISSR, SNP) – merits and demerits

(16 h)

Unit 3: Markers in crop improvement programme

Estimating genetic diversity and distances. Linkage maps. QTL detection (Quantitative Trait Loci) - Biparental crosses, Association genetics, Multiparental populations. QTL validation - Advanced backcrosses, Near isogenic lines. Fine mapping and positional cloning. Principles of marker-assisted selection. Introduction to genome-wide association; Molecular markers for plant genotyping and germplasm analysis – applications. DNA bar coding for plants. Crop improvement and gene tagging; Physical maps using in- situ hybridisation (ISH). (22 h)

Unit 4: Transgenic plants and Crop improvement

Herbicide resistant, Virus resistant, Insect resistant, Fungi and Bacterial resistant, plants, Transgenic plants with improved storage proteins, Stress- cold –drought tolerant plants, Fertility restoration strategies, barnase/ barstar system in mustard. Transgenic plants as bioreactors. A concise glimpse of current Indian and world-wide scenario in Agriculture Biotechnology. Genetic engineering of seaweeds. (18 h)

Unit 5: Gene banks and biosafety

Importance of gene banks, Establishment of gene banks using plasmids and phages. Risk factors involved in the release of Genetically Engineered Organism: Possible dangers of GEO's, biohazards of rDNA technology, risk evaluation and release of GEO's. GRAS. Bio safety handling of hazardous chemicals and radioisotopes.

Biological containment –EL-1, EK-2 and EK-3. Physical laboratory containments- P1, P2, P3 and P4. (18 h)

3. Recommended Text books:

- Acquaah, G. Principles of Plant Genetics and Breeding. Wiley-Blackwell, 2012.
- Chawla, H.S. Introduction to Plant Biotechnology. CRC Press, 2009.
- Trevan M. D, Boffey S, Goulding K. H, Stanbury P. Biotechnology- The Biological Principles. Tata McGRaw Hill, 1995.

4. Recommended References:

- Abdin, M.Z. et al. Plant Biotechnology: Principles and Applications. Springer, 2017.
- Krebs, J.E.; Goldstein, E.S. and Kilpatrick, S.T. Lewin's Genes XII. Jones & Bartlett Learning, Burlington, MA, 2018
- Old, R.W. and Primrose, S. B. Principles of Gene Manipulation. Blackwell Publishing, MA, 2001.
- Sleper, D.A. and Poehlman, J.M. Breeding Field Crops. Wiley-Blackwell, 2006
- Tzfira, T. and Citovsky, V. (Eds). *Agrobacterium*: From Biology to Biotechnology. Springer, 2008.
- Watson et al. Molecular Biology of the Gene. Pearson, 2014.
- Xu, Y. Molecular Plant Breeding. CABI, 2010

BS800403 Introduction to Nanotechnology

Total Credits: 4

Total Hours: 90

1. Objective of the Course

The course aims to introduce the field of nanotechnology

Unit -1: Basics of Nanotechnology

Definitions and Scales, Origins of Nanotechnology Beyond Moore's Law, Current State of Nanotechnology, Future of Nanotechnology, Nanotechnology in Nature and Applications Tools of trade - Seeing the nano Scale, Nature of Light, Electron Microscope, Scanning Probe Microscope, Basic governing Theories – Quantum Mechanics, Chemical Bonds, Crystal Structure Negative Differential Resistance (NDR). (18 h)

Unit -2: Nanomaterials

Molecular building blocks for nanostructure systems, Nanomaterials - Formation of Materials, Carbon Nanomaterials, Buckyball, Carbon Nano Tubes, Inorganic Nano Materials, Zero Dimensional Nano-Structures, One Dimensional Structures, Two Dimensional Structures.

(16 h)

Unit -3: Electrical Resistance - an Atomistic View

Energy Band Diagram: Energy level diagram, Fermi function, n - type operation, p - type operation, Negative differential resistance - thermo electric effect - Nano transistors – in elastic spectroscopy - NEGF formalism - input parameters - derivation of NEGF equations - Inflow / Outflow, quantum of conductance, Potential profile, Iterative procedure for self - consistent solution, Quantum capacitance. (20 h)

Unit -4: Nanoscale Device Modeling

Model Hamiltonian, SAM - Signals used to control and probe molecules, Synthesis; Fabrication and overview of Nano tube devices - their properties, Inadequacy of macroscopic models, Equilibrium, Non - Equilibrium, Density Matrix and current operator; NEGF Formalism – Broadening (18 h)

Unit-5: Ethical Social Implications and Applications

Environment - Society, Technology, and the Environment, Environmental Risks of Nanotechnology, Nanotechnology Solutions to Environmental Problems, Overall Risk and Precaution Application : Water Purification, Solar Energy, Human Implants, RF - ID Chipped Identification, Military – Nano Enabled Military, Nano enabled Defense System. (18 h)

3. Recommended Text books:

- Reed, M.A. and Lee, T. Molecular Nano electronics. American Scientific Publishers, 2003.

- Horst - Gunter Rubahn, Basics of Nano Technology, Wiley - VCH Verlag Gmbh & Co, 2008.
- Chris Binns, Introduction to Nanoscience and Nanotechnology, John Wiley and Sons, 2010.

4. Recommended References:

- Fritz Allhoff, Patrick Lin, and Daniel Moore. What Is Nanotechnology and Why Does It Matter. Wiley Blackwell A John Wiley & Sons, Ltd., 2010
- Suprio Dutta Tutorial on, "Electrical Resistance - an atomistic view", Purdue University.

ELECTIVES
GROUP B

BS810401 Plant Developmental Biology

Total Credits: 4

Total Hours: 90

1. Objective of the Course

The course is designed as to provide an elementary understanding of various stages of plant development including embryogenesis, shoot, root and floral development.

2. Course content

Unit 1: Model plants for developmental biology

Introduction of model plants used for development studies in plant system, advantages of each system with special emphasis on model plant Arabidopsis Reproduction: Male and female gametophyte development, genetic and hormonal regulation of reproduction, pollination and fertilization (18 h)

Unit 2: Embryogenesis

Basic lay out of dicot and monocot embryos, stages of embryo development, embryonic axis, cell division and pattern formation in embryo, genetic and hormonal regulation of embryo development, cell polarity in embryo Seed formation and germination

Seed formation, cotyledon, endosperm and seed coat: development. Seed dormancy and germination, seedling development, genetic regulation of vernalization (18 h)

Unit 3: Shoot development

Structure and function of shoot apical meristem (SAM), initiation and maintenance of SAM, regulation of meristem size, antagonism between SAM and lateral organs, genetic regulations, axial bud formation, shoot branching Leaf development: Emergence of leaf primordium from SAM, abaxial and adaxial identity of leaf cells, leaf margin, trichome, epidermis and stomata development, vascular differentiation (22 h)

Unit 4: Root development

Root apical meristem structure and function, lateral root development, lateral and adventitious root development, root hair development, hormonal regulations in root development (14 h)

Unit 5: Flower development

Transition from vegetative to reproductive stage, inflorescence meristem, floral whorls specification, ABC model and beyond, whorl boundary specification, asymmetric flower development, structure and development of monocot flowers. (18 h)

3. Recommended Text books

- Buchanan, Grussem and Jones (Ed.) Biochemistry and Molecular Biology of plants, ASPB publication.
- Plant Physiology by Taiz and Zeiger, Sinauer Associate Inc. Publishers

4. Recommended References:

- The Arabidopsis Book, ASPB publication (available at www.aspb.org)

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BS810402 Systematic Botany, Biodiversity and Economic Botany

Total Credits: 4

Total Hours: 90

1. Objective of the Course

The course is designed to provide the student an understanding of three related fields, viz., plant taxonomy, biodiversity and economic botany. The student after completing the course will be familiar with various concepts and methods of these fields of study.

2. Course content

Unit 1: Taxonomy and systematics

Concepts and taxonomic characters: taxa and taxonomic hierarchy; Systems of classification: artificial, natural and phylogenetic systems; Classification systems of Bentham and Hooker, Engler and Prantle, Hutchinson, and Bessey; Taxonomic evidence: morphology, anatomy, embryology, palynology, cytology and micromorphology; Chemotaxonomy; Variation and speciation; Phylogeny of angiosperms, phylogenetic reconstruction (20 h)

Unit 2: Organizations for systematic studies and taxonomic literature

Botanical specimen collection, herbarium preparation; Important herbaria and botanical gardens; Botanical Survey of India; Floras, monographs, revisions, keys, indices, and glossaries (16 h)

Unit 3: Plant nomenclature

Binomial system; Need for scientific names; Principles of ICBN; Type method; Publication of names: conservation, retention and rejection of names, Principle of Priority (12 h)

Unit 4: Biodiversity

Biodiversity concepts and definitions; Genetic diversity, species diversity and ecosystem diversity; Agro biodiversity and cultivated taxa; Loss of biodiversity, factors causing biodiversity loss; Red Data book and Red Lists; Conservation of biodiversity: in situ conservation, protected areas-biosphere reserves and national parks, homestead gardens and sacred groves; ex situ conservation, botanic gardens seed banks, field gene banks; in vitro conservation methods; Biodiversity legislation and conventions, international biodiversity laws, Convention on Biological Diversity, Agenda 21, national legislation, Biodiversity Act; Economic value of biodiversity; Trade restrictions; Economic, legal and ethical issues of biodiversity (22 h)

Unit 5: Economic Botany

Plant products and their importance to mankind; Origin and distribution of food plants; Cereals, legumes and nuts, vegetables, fruit plants; Spices and condiments; Fatty oils and waxes; Essential oils; Forest products: timber, Non-wood forest products- gums, resins; honey, dyes and pigments, etc. (20 h)

3. Recommended Text books

- Davis, P.H. and Heywood, V.H. Principles of Angiosperm Taxonomy. Oliver and Boyd, Edinburgh, 1963.
- Krishnamurthy, K.V. An Advanced Text Book of Biodiversity: Principles and Practice. Oxford IBH Pub. Pvt. Ltd., New Delhi, 2003
- Quickie, D.I.J. Principles and Techniques of Contemporary Taxonomy. Blackie Academic and Professional, London, 1993.

4. Recommended References:

- Briggs, D. and Walters, S.M. Plant Variation and Evolution, 3rd ed., Cambridge University Press, Cambridge, 1997.
- Jones, P.G and Sutton, J.M. Plant Molecular Biology: Essential techniques. John Wiley & Sons, New York., 1997.
- Melchias, G. Biodiversity and Conservation. Oxford & IBH Pub. Co. Pvt. Ltd., New Delhi, 2001.
- Nayar, M.P. Hot spots of Endemic Plants of India, Nepal and Bhutan. Tropical Botanic Garden and Research Institute, Thiruvananthapuram, 1992.
- Pushpangadan, P. Ravi, K. and Santhosh, V. (Eds.). Conservation and Economic Evaluation of Biodiversity. Oxford IBH Pub. Pvt. Ltd., New Delhi, 1997.
- Radford, A.E., Dickison, W.C. Massey J.R and Bell, C.R. Vascular Plant Systematics. Harper and Row Publishers, New York., 1974.
- Rao, C.K., Geetha, B.L. and Geetha Suresh. Red List of Threatened Vascular Plant Species in India. ENVIS, Botanical Survey of India, Ministry of Environment and Forests, New Delhi, 2003.
- Swaminathan, M.S. and Jana, S. (Eds.). Biodiversity: Implications for Global Food Security. Macmillan India Ltd., Chennai, 1992.
- Singh, R.S. Introduction to Principles of Plant Pathology. Oxford &IBH Pub. Co. Pvt. Ltd., New Delhi, 1984.
- Sivarajan, V.V. Introduction to Principles of Plant Taxonomy (2nded). Edward Arnolod, London, 1991.
- Wills, J.C. A Dictionary of the Flowering Plants and Ferns (8th ed), revised by Airy-Sahw, H.K. Cambride University Press, Cambridge, 1973.

BS810403 Ecology and Ecoinformatics

Total Credits: 4

Total Hours: 90

1. Objective of the Course

The course aims to impart the fundamental concepts of ecology, important laws and conservation as well as restoration measures and finally introduces the student to ecoinformatics as it is relevant in the current big data era.

2. Course Content

Unit 1: Introduction to Ecology

Definition and scope of Ecology; Ecosystem: concept of ecosystem, significance of habitat, trophic levels, primary and secondary productivity; Population: population characteristics, population growth, biotic potential, factors affecting population growth, carrying capacity; Community ecology: classification of communities, qualitative, quantitative and synthetic characteristics. (22 h)

Unit 2: Phytogeography

Principles governing plant distribution; Phyto-geographic regions of the world and India; Adaptation; Speciation and extinction; Native, naturalized and exotic taxa; Endemism: Concept of endemism, endemic flora; Rarity: Rare, endangered and threatened category (IUCN) species.

(18 h)

Unit 3: Restoration of degraded lands

Reforestation of adverse sites, development of stress tolerant plants, use of mycorrhizae in reforestation, use of microbes for improving soil fertility, diverse aspects of reforestation of soils contaminated with heavy metals; Environment protection-issues and problems, International and national efforts for environment. (22 h)

Unit 4: Ecoinformatics

Introduction. Big data - novel data sources including remotely sensed data, social media, or citizen science, large scale patterns derived from Big data approaches regarding andasapes, pests and beneficial . Ecosystem Modeling – land use, soils and climate. Sensors in agriculture- - drone and big data management. Computation and informatics; applications of big data to animal production, crop and pest management, or breeding; decision - making based on big data. Privacy concerns regarding big data. Precision agriculture. (28 h)

3. Recommended Text books:

- Chapman and Reiss. Ecology principles and applications. Cambridge University.
- Odum E. P and Barret G W . Fundamentals of Ecology. W. B Saunders company, Philadelphia

- Odum E. P. Basic Ecology. Saunders College

4. Recommended References:

- Alleby M. Basics of Environmental Science. Routledge, New York
- Cunningham, W. P and Siago, B. W. Environmental science.
- Kewin T. P and Owen C. A., Introduction to global environmental issues. Routledge, London.
- Chiras,D.D, Environmental Science
- Goodchild, M.F., Parks, B.O., Steyaert, L.T., (Eds.), Environmental Modeling with GIS (Spatial Information Systems) Oxford University Press, USA, 1993.
- Agarwal, S.KEco-informatics, APH Publishing Corporation, 2002.
- Jorgensen, S. E., Chon, T-S., Recknage, F. A., Handbook of Ecological Modeling and Informatics, WIT Press, 2009.

ELECTIVES
Group C

BS820401Green House Management and Plant Protection

Total Credits: 4

Total Hours: 90

1. Objective of the Course

The course is designed to make the student familiar with methods in green house management and related techniques followed for plant protection from weeds and pathogen/ pest attack.

2. Course content

Unit 1: Plant propagation structures

Green House, hot beds, cold frames and lath houses. Miscellaneous propagation structures- fluorescent light boxes and propagating frames Carbon dioxide enrichment in green house. Containers for propagating and growing young plants. (18 h)

Unit 2: Media for propagating and growing nursery plants

Media components: Sand, peat sphagnum moss, vermiculite, pumice, perlite, synthetic plastic aggregates and compost. Mixtures for container growing. Preplanting treatments of soil and soil mixes, heat treatments, fumigation with chemicals. (18 h)

Unit 3: Sanitation, soil enrichment and other requirements of propagation

Physical propagation facilities, propagation media and plant material. Supplementary fertilizers controlled release fertilizers. Salinity in soil mixtures, water quality and soil pH. Handling of container grown plants. (18 h)

Unit 4: Plant protection from weeds

Types of weeds, crop-weed competition and weed control methods. Classification of herbicides. Working of selective weed killers. Biological and integrated weed control. (16 h)

Unit 5: Plant protection from diseases

Diseases of crops-definition, nature, and causes. Control of diseases by fungicides and antibiotics. Control of insect pests: Principles, physical and mechanical control, cultural control, host plant resistance, biological control, legislature or regulatory method, chemical control and other methods of insect control. (20 h)

3. Recommended Text books

- Hann J.J., Holley W.D. and K.L.Goldsberry : Greenhouse management

4. Recommended References:

- Furuta, T. : Nursery management handbook
- Langhans R.W. :Green house management

BS820402 Marine Biotechnology

Total Credits: 4

Total Hours: 90

1. Objective of the Course

The course incorporates topics which will make the students understand how interventions based on Biotechnology is augmenting solutions in Marine related issues as well as in tapping marine resources more efficiently.

2. Course content

Unit 1: Introduction to marine environment

World oceans and seas – ocean currents – physical and chemical properties of sea water – abiotic and biotic factors of the sea – ecological divisions of the sea – history of marine biology – bioecochemical cycles – food chain and food web. (18 h)

Unit 2: Important marine organisms

Phytoplanktons – zooplanktons – nektons – benthos – marine mammals – marine algae mangroves – coral reefs – deep sea animals and adaptation – intertidal zone – fauna and flora. (18 h)

Unit 3: Marine Environmental Biotechnology

Marine pollution – biology indicators (marine micro, algae) – biodegradation & bioremediation – marine fouling and corrosion. (18 h)

Unit 4: Marine Pharmacology

Medicinal compound from marine flora and fauna – marine toxin , antiviral and antimicrobial agents. (18 h)

Unit 5: Aquaculture Technology

Important of coastal aquaculture – marine fishery resources – common fishing crafts and gears – aquafarm design and construction. (18 h)

3. Recommended Text books:

- Fingerman , M., Mary R. N. and Thomson, F. Recent Advances in MarineBiotechnology, Science Publishers, 1998

4. Recommended References:

- Kim, Se-K. Springer Handbook of Marine Biotechnology. Springer, 2015
- Karleskint, G., Turner, R. and Small, J. Introduction to Marine Biology. Brooks Cole, 2009.

BS820403 Business Management and Entrepreneurship

Total Credits: 4

Total Hours: 90

1. Objective of the Course

The course aims to introduce to the student to general management principles and to the nuances in starting a enterprise

2. Course content

Unit 1: General Management

Introduction, significance and definition of management, Administration vs. management, Functions of management: planning, organizing, staffing, directing and controlling, Levels of management, Managerial skills, motivation, communication, decision making. Forms of business organization: Sole ownership, joint stock company, advantages and limitations and salient features of each, cooperatives, private and public companies, government companies.

(20 h)

Unit 2: Organization

Basic principles of organization: responsibility and authority, delegation and control, coordination, span of control. Management structure: line and staff and functional relationships, use of committees (14 h)

Unit 3: Management Theories

Henri Fayal's principles of management, Taylor's scientific management, Max Weber's theory of bureaucracy; human relations approach; Hawthorne studies, behavioral sciences and quantitative approaches. Personnel Management: Recruitment, sources, selection procedure, various stages, different types of employment tests, interviewing techniques, placement, transfers and promotions, exit interviews. (20 h)

Unit 4: Marketing and Financial management

Sales vs. marketing, functions of marketing, market research, sales promotion, and advertising. Training and development: Types of training, methods of training, management development, on &off the job training, performance appraisal.

Objectives of financial management, financial planning, functions of finance managers, sources of industrial finance. (16 h)

Unit 5: Entrepreneurship Management

Meaning and concept of entrepreneurship, skills required to be an entrepreneur, entrepreneurial decision process, and role models, mentors and support system Business ideas, methods of generating ideas, and opportunity recognition. Preparing a business plan, choosing

the legal form of new venture, protection of intellectual property, and marketing the new venture. Government and organizations and schemes towards encouraging entrepreneurship. Risks, rewards post launch of new venture. (20 h)

3. Recommended Text books:

- Chhabra, T.N. Principles and Practice of Management. Dhanpat Rai and Co. Pvt. Ltd., Delhi, 2002.
- Koontz, H. and Weihrich, H. Essentials of management. Tata McGraw Hill Pub. Co. Pvt. Ltd., New Delhi, 1998.
- Massie Joseph, L Essentials of Management (4th ed.). Prentice Hall of India Pvt. Ltd., New Delhi, 2000.

3. Recommended References:

- Singh, B.P., Chhabra, T.N. and Taneja, P.L. Personnel management and Industrial Relations. Dhanpat Rai and Co. Pvt. Ltd., Delhi, 2001.
- Terry, G.R. and Franklin, S.G. Principles of Management. (8th ed.). AITBS Publishers and Distributors, Delhi, 2000.
- Weihrich, H. and Koontz, H. Management: A Global Perspective. Tata McGraw Hill Pub. Co. Pvt. Ltd., New Delhi., 2001.

BS010401 Laboratory course IV

Total Credits: 4

Total Hours: 10 hours/ week

1. Objective of the Course:

To impart practical knowledge in plant tissue culture with emphasis on organ culture and protoplast fusion and in the area of molecular markers.

2. Course content

1. Anther-pollen and Ovary-ovule culture
2. Protoplast culture from friable callus, leaf cells stems, roots or hypocotyls.
3. Protoplast fusion and somatic cell hybridization.
4. Production of pathogen free plants through meristem culture.
5. Seed and embryo culture.
6. Mushroom culture.
7. Genotyping using Molecular markers – RFLP, ISSR, SNP

3. Recommnended Textbook

- Razdan, M. K. Introduction to Plant Tissue Culture. Science Publishers, 2003

4. Recommended References:

- Bhojwani. S.S and Razdan. M.K. Plant tissue culture. Science Publishers, 2004.
- Dixon, R.A. and Gonzales, R.A (Eds.). Plant Cell Culture: A Practical approach.
- Phytochemical Methods A Guide to Modern Techniques of Plant Analysis By JB Harborne. Springer, 1998.

MODEL QUESTION PAPERS

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

First Semester

BS010101 Biochemistry and Cell Biology

(2019 admissions onwards)

Time: Three Hour Maximum Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

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1. Structural polysasaccharides
2. Nucleosides
3. Ribosomes
4. Plasma membrane
5. Noncoding RNA
6. Plant vacuoles.
7. Cytoskeleton
8. Peroxisomes
9. Functions of mitochondria
10. Holoenzymes (8x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Mitochondria and male sterility.
12. Ramachandran plot.
13. Apoptosis in plant and animal cell,
14. Chromosomal DNA and its packaging
15. Enzyme nomenclature and classification
16. Cell signaling.

17. Chloroplast – ultra structure and function

18. Active and Passive transport (6x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5)

19. Mechanisms and molecules involved in active and passive transport. Proteins as molecular motors
20. Cell cycle and cell cycle regulation in animals
21. Brief overview of gene expression and control
22. Briefly explain Signaling via G-Protein-linked cell-surface receptors and enzyme-linked cell-surface receptors (2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

First Semester

BS010102 Microbiology and Immunology

(2019 admissions onwards)

Time: Three Hour Maximum Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Plasmids
2. Innate immunity
3. What is numerical taxonomy?
4. Prions
5. What are antimicrobial substances?
6. Louis pasteur
7. Virulence
8. First virus identified
9. Interleukin
10. Primary stain used in Gram staining (8x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

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11. Explain the storage of microbes.
12. Briefly describe the microbial metabolism.
13. Explain the method of testing antimicrobial substances.
14. Lytic and Lysogenic cycle.
15. Mode of action of Penicillin and Lysosyme

16. Organs associated with immune system
17. Write a note on phenol co-efficient test
18. Quorum sensing

(6x2=12)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Give an account on antibiotic sensitivity testing procedure.
20. Explain the various types of microbial locomotion with examples.
21. What is mutation? Discuss in detail about induced mutation.
22. Which are secondary lymphoid organs (2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

First Semester

BS010103 Genetics and Molecular Biology

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. What is the significance of telomeres in cancer formation?

2. What is the difference between maternal effect and maternal inheritance?

3. What is the significance of chromosomal aberrations in evolution?

4. How are DNA repair mechanism and cell cycle control mechanism related?

5. What are genetic switches?

6. Write briefly about non-standard Watson-Crick base pairing.

7. Write about the role of endoplasmic reticulum in post translational modification

8. What are DNA polymerases?

9. What is the contribution of Morgan towards the field of Genetics?

10. What is genetic drift?

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Write a note on chromosome mapping.

12. Write a short essay on Hardy Weinberg equilibrium and its significance.

13. Write in detail about pattern formation in Drosophila.

14. How is prokaryotic DNA replicated?

15. Write a note on post transcriptional modifications in eukaryotes

16. Write a short essay on ENCODE project

17. Write on RNA interference

18. Write a short note on cell type specialization.

(**6 x 2 = 12**)

Section C

(Answer any **two** questions. Each question carries a weight of 5)

19. Give a detailed account of mechanism of protein synthesis in eukaryotes and in what aspects it is different from that in prokaryotes

20. Write an essay on different RNA, their function and secondary structures

21. Write about operon model in prokaryotes with an example each for an inducible and repressible operon

22. Write in detail about molecular basis of codomianance, incomplete dominance and epistasis.

(**2 x 5 = 10**)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

First Semester

BS010104 Bioanalytical Techniques And Bioinformatics

(2019 admissions onwards)

Time: 3 hours **Maximum weightage: 30**

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

(8 x 1 = 8)

1. Beer-Lambert's law
2. Principle of centrifugation
3. Phylogenetic tree
4. Cryostat
5. Microtome
6. FASTA
7. Electroporation
8. PDB
9. Geoinformatics
10. Freeze etching

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. SDS PAGE
12. Principle of colorimetry.
13. Construction of phylogenetic tree.
14. Principle of ultrasonicator.
15. Principle and application of NMR.
16. Multiple sequence aligment tools.
17. Differentiate HPLC and HPTLC.
18. Application of bioinformatics in drug discovery.

(6 x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5)

19. What is the principle of spectroscopy? Explain various types of spectroscopy and mention their applications.
20. Explain distance matrix method and parsimony.
21. Explain various steps in amplification by traditional PCR and describe types of PCR based on their applications.
22. Write about various sequence analysis softwares.

(2× 5= 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Practical Examination, Month, Year

First Semester

BS010105 Laboratory Course I

(2019 admissions onwards)

Time: **Max. Weight: 15**

1. Major experiment	(4 weight.)
2. Minor experiment 1	(1 weight.)
3. Minor experiment 2	(1 weight.)
4. Minor experiment 3	(1 weight.)
5. Record	(3 weight.)
6. Viva	(5 weight.)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Second Semester

BS010201 Plant Cell Tissue and Organ Culture

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Disinfection
2. Somaclonal variation
3. Depth Filters
4. Give few examples of filers used in sterilization
5. Fumigation
6. Sucrose
7. DMSO
8. Acclimatization
9. Mercuric chloride
10. Stress resistant mutants (8 x 1= 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Instruments used in Plant Tissue Culture Laboratory
12. Isolation of somaclonal variants
13. Production of disease resistant mutants.
14. Sterilization scheme for culture chamber.

15. Freezing and storage.
16. Continuous culture.
17. Embryo rescue
18. Technique of Endosperm culture (6 x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5)

19. Define cloning. Describe the technique of isolation of single cells.
20. Describe the technique of micropropogation.
21. How variants can be selected in induced mutation breeding experiments?
22. What are transgenic plants? Give an account on transgenics for insect resistance in crop plant.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Second Semester

BS010202 Genetic Engineering

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. What is the application of chromosome walking in positional cloning?

2. Write a brief note on shotgun cloning.

3. The yeast expression vectors are usually shuttle vectors. Why?

4. Write about restriction mapping and its applications

5. Explain electroporation as a technique for transformation

6. What are reporter genes? How are selection marker genes different from reporter genes?

7. In a course of experiments involving molecular cloning when would you prefer GATEWAY cloning over conventional molecular cloning?

8. Write a note on Nanopore sequencing.

9. What is triparental mating?

10. What is calcium chloride mediated transformation?

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Explain how RNA is used for gene expression control experiments

12. How are genomic and cDNA libraries prepared?

13. Explain different vectors designed to be cloned in yeast cells.

14. Important enzymes used in Genetic Engineering

15. Linkers, Adapters and Homopolymer Tailing

16. Write a note on gene knock out techniques

17. Explain in detail CRISPR/ CAS technology.

18. Discuss different methods of selection and screening of recombinant clones.

(**6 x 2 = 12**)

Section C

(Answer any **two** questions. Each question carries a weight of 5)

19. Write an essay on various methods to overcome the problem of blunt ended cloning.
20. What are the different vectors used for rDNA experiments using *E. coli*
21. Write about the main blotting techniques
22. Write in detail about various sequencing techniques used discussing first generation sequencing and NGS methods.

(**2 x 5 = 10)**

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Second Semester

BS010203 Metabolism and Metabolic Engineering

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Write down any two features of metabolic pathways.

2. How are carbohydrates other than glucose used for energy production? What is the role of sugar nucleotides in this process?

3. What are phytochromes

4. What are C4 plants?

5. Write a note on Brassinosteroids.

6. Trace the reactions that result in formation of 2 molecules of NADPH, starting from glucose-6-phosphate.

7. What are anaplerotic reactions? Give an example.

8. Briefly state about chylomicron metabolism.

9. What is biological standard state & standard free energy change in coupled reactions?

10. What are benefits of *in vitro* production of secondary metabolites?

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Describe the steps involved in cellular fatty acid (FA) oxidation. Briefly explain how FA oxidation is different from its synthesis in an animal cell.

12. Which are the reactions of glycolysis that are bypassed during gluconeogenesis? Please explain how these reactions are bypassed.

13. Write notes on physical and biological nitrogen fixation

14. Write a note on photosynthetic pigments and light harvesting complexes

15. Regulation of the activity of phosphofructo kinase-1 and fructose-1,6-bisphosphatase is the most significant for controlling the flux toward glucose oxidation (glycolysis) or glucose synthesis (gluconeogenesis). Explain the mechanism by which these enzymes are regulated in a cell.

16. Write a note on high energy phosphate compounds

17. How is ΔG for a reaction determined?

18. Write a short essay on biological oxidation-reduction reactions

(6 x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Write a detailed note on TCA cycle and how it drives ETC

20. Write the molecules involved and electron transport in cyclic and noncyclic light reaction.

21. Write an essay on biosynthesis, physiological effects and mechanism of action of any four plant hormones

22. Write a detailed note on prospects and applications of metabolic engineering.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Second Semester

BS010204 Biomass and Bioenergy

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Give an account on Lignin
2. Give a brief description on Euphorbia
3. Define pyrolysis.
4. What are bio-energy plantations
5. Define and describe methanogenesis.
6. What are Halo bacteria?
7. What is the vision of Bioenergy programme of Department of Biotechnology, Govt. of India?
8. Give a brief idea about ethanol fermentation.
9. Give the advantages of installing a biogas plant.
10. Define Liquefaction. (8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Give and account on Silviculture energy farms.
12. What are the sources and the composition of wastes?
13. What are algal hydrocarbons? Give examples.
14. Give an overview of Global Bioenergy research.

15. Explain Hydrogen production.
16. Elaborate on Solubilization, Acidogenesis and Methanogenesis.
17. Give a brief idea about the Hydrolysis of lignocellulosic materials.
18. Give a brief description about any alternative forms of energy.

(6 x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Differentiate petroplants form other crop plants. Discuss the role of petroplants as energy source.
20. Give a sketch of biogas plant and explain the process involved in the production of biogas.
21. Briefly explain the use of organic waste as a source of energy. Differentiate between renewable and non renewable source of energy.
22. Describe about the non biological process of biomass conversion.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Practical Examination, Month, Year

Second Semester

BS010205 Laboratory Course II

(2019 admissions onwards)

Time: Max. Weight: 15

1. Major experiment (4 weight.)
2. Minor experiment 1 (1 weight.)
3. Minor experiment 2 (1 weight.)
4. Minor experiment 3 (1 weight.)
5. Record (3 weight.)
6. Viva (5 weight.)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Third Semester

BS010301 Plant Stress Biology

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Explain Systemic Acquired Resistance

2. Role of biogenic amines in plant abiotic stress response

3. Define heat shock proteins

4. What are saprophytes and parasites?

5. Elaborate the significance of cell wall degrading enzymes in pathogenicity

6. What are the strategies found in plants that limit food supply to an invading pathogen?

7. What are the legislative measures in place to containing plant disease?

8. What are PR-proteins?

9. How do environmental conditions significant in epidemics of crop diseases?

10. What is the role of salicylic acid in plant defense response?

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Give a general account on plant diseases classification.

12. Discuss on zig-zag model of plant-pathogen interaction.

13. Write a note on plant defense against bacteria and nematodes

14. Write about the cross talk between salicylic acid and jasmonic acid mediated pathways of plant defense

15. Explain the onset of HR during pathogen attack

16. Discuss the strategies that help in controlling plant diseases.

17. Explain the mechanism in plants that aid in countering salt stress

18. Explain how plants respond to post-infectional agents.

(**6 x 2 = 12**)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Explain in detail about pathogenesis in context of penetration and entry, colonization of the host and different factors affecting infection.
20. Write an essay on plant defense against insect pests.
21. Explain in detail plant response to various abiotic stress response.
22. Write an essay on the effect of environment on plant diseases development.

(**2 x 5 = 10)**

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Third Semester

BS010302 IPR and Translational Research

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Explain about GATT & TRIPs
2. What are the codes of ethics ?
3. Explain in brief about the Cartagena Protocol.
4. What is the significance of plant translational research?
5. Give a brief note on plagiarism.
6. Describe about bioterrorism.
7. Differentiate between plant patents and utility patents.
8. Explain Biodiversity Act.
9. What do you mean by conflict of interest?
10. What is PGR?

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Give a brief idea on Intellectual Property Rights.
12. What are the implications of patenting higher plants?
13. Give a note on regulatory ethics.
14. What are the challenges involved in Translational Research?
15. Give an account on biological warfare.
16. Elaborate on UN Declaration on Human Rights.
17. Give an idea about patenting biological material in Indian context.
18. Elaborate on the choice on Intellectual Property Protection.

(**6 x 2 = 12**)

Section C

(Answer any **two** questions. Each question carries a weight of 5)

19. Discuss on Product development and Entrepreneurship programmes in translational research.
20. Elaborate on environmental safety evaluation of genetically modified animals.
21. What are the implications for public trust in biotechnology?
22. Discuss about IPR in agriculture.

(2 × 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Third Semester

BS010303 Genomics and Proteomics

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1 Genomics

2 Microarray

3 Density gradient

4 ORF

5 Expressed Sequence Tags

6 Proteome

7 Microfluidics

8 Infectious diseases

9 Chaotropes

10 Sanger's sequencing method

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11 Gene inactivation

12 Strategies for genome sequencing

13 Affinity purification

14 Hydrophobic proteins

15 Plant genome project

16 2-D gel electrophoresis

17 Negative staining

18 Homology search

(**6 x 2 = 12**)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19 Explain various protein extraction methods.

20 Explain the principle and various applications of NMR.

21 Explain protein biomarkers and their validation.

22 Discuss about microarray and its applications

(**2 x 5 = 10)**

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Third Semester

BS010304 Bioprocess Technology and Engineering

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Agitation
2. KLa
3. Pseudoplastic Rheology
4. Load cells
5. Baffles
6. Reynold's number
7. Tacchometer
8. Secondary metabolites
9. Liquid-liquid extraction
10. Microbial Biomass

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Explain Newtonian and non-Newtonian fluids. What are the different types of non-Newtonian fluids?

12. Explain the problems associated with excessive foam production during a bioprocess. How can it be controlled?
13. Explain the design of a typical fermenter and function of different fermenter parts .
14. How can dissolved oxygen and temperature be measured in a fermenter? Give suitable examples.
15. Write about filter sterilization of inlet air and exhaust gas.
16. How is KLa determined?
17. Write about development of inocula for yeast processes.
18. Preservation of industrially important micro-organisms.

(6x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. How is steam employed in media sterilization? Write about batch and continuous media sterilization
20. Range of fermentation process.
21. Describe media formulation for industrial fermentation.
22. Write about
    1. Oxygen requirements of industrial fermentations.
    2. Factors affectinhKLa Values in fermentation vessels.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Practical Examination, Month, Year

Third Semester

BS010305 Laboratory Course III

(2019 admissions onwards)

Time: Max. Weight: 15

1. Major experiment (4 weight.)
2. Minor experiment 1 (1 weight.)
3. Minor experiment 2 (1 weight.)
4. Minor experiment 3 (1 weight.)
5. Record (3 weight.)
6. Viva (5 weight.)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

BS800401 Research Methodology and Science Communication

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. What is the general format of a research paper?

2. What is meant by pure and applied research?

3. What are the prospects of publishing in an Open Access Journal?

4. What is impact factor? What factors affect its credibility?

5. When is a student t-test done?

6. What is meant by experimental design?

7. Explain ANOVA.

8. What is the role of effective communication in science?

9. What is an RSS feed?

10. How is research carried out effectively?

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Explain the various ways in which research is carried out.

12. Give an account of experimental designs.

13. Give an account of different reference citation styles.

14. Write a note on Bibliometrics and Webometrics

15. Explain a chi-square test.

16. Write a short note on R software

17. Discuss on ethical issues in scientific research and academics

18. Write a short note on literature collection and report writing

(**6 x 2 = 12**)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Write an essay on research outlook.
20. Elaborate on the various factors and aspects linked to research publication
21. Write an essay on different avenues in practicing science communication.
22. Discuss on the basic statistical tools used in a biological research.

(**2 x 5 = 10)**

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

BS800402 Molecular Techniques for Crop Improvement

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight**questions. Each question carries a weight of 1)

1. Selection marker gene in chloroplast transformation
2. QTL
3. Cytogenetic maps
4. Binary vector
5. Linkage
6. Regeneration of plantlets after *Agrobacterium*-mediated transformation.
7. MAS
8. Biological Containment levels
9. Physical maps using in- situ hybridization
10. barnase/ barstar system

(8 x 1 = 8)

Section B

(Answer any**six**questions. Each question carries a weight of 2)

11. Explain any one model of T-DNA insertion into plant chromosomal DNA.

12. Explain gene tagging and write about its application in crop improvement.

13. Write in detail about FISH and its applications.

14. Compare and contrast RAPD and SSR markers.

15. Mitochondrial engineering

16. Applications of DNA bar coding in plants

17. Give case studies of development of virus resistant transgenic plant

18. What are gene banks? Write a note on their significance.

(**6 x 2 = 12**)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Explain in detail about genetic mapping using RFLP.

20. Explain in detail the steps involved in chloroplast engineering.

21.Give a detailed account on the structure of Ti plasmid and Agrobacterium- mediated transformation.

22. Write an essay on current Indian and world-wide scenario in agriculture biotechnology.

(**2 x 5 = 10)**

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

BS800403 Introduction to Nanotechnology

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Define nanotechnology
2. What is Moore's Law?
3. What are carbon nano materials?
4. What are inorganic nano materials?
5. What do you mean by Fermi function?
6. Define Quantum capacitance.
7. Define Density matrix.
8. Explain Model Hamiltonian.
9. Describe Human Implants.
10. Explain Broadening.

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. What are the Zero Dimensional Nano-Structures?

12. Draw the energy level diagram and give a short account on the same.

13. What is thermoelectric effect?

14. Describe NEGF Formalism.

15. What are the properties of nanotube devices?

16. Discuss on the environmental risks of nanotechnology.

17. Brief on the solutions to environmental problems that nanotechnology can offer?

18. What are nano transistors?

(6 x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Discuss on nano enabled military defence system.

20. Discuss on p-type operation and n-type operation.

21. Elaborate on the Molecular building blocks in nanostructure systems

22. Write a detailed description on Scanning Probe Microscope.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

BS810401 Plant Developmental Biology
(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Seed dormancy
2. Triple fusion
3. Root hairs
4. Trichomes
5. Vernalisation
6. Scarification
7. Syugamy
8. Hypodermis
9. Microgametogenesis
10. Chasmogamy

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Roles of hormones in leaf initiation.
12. Process of fertilization.
13. Development of dicot flower.
14. Types of seed dormancy.

15. Development of lateral roots
16. Mechanisms encouraging cross pollination.
17. Specification of floral whorls.
18. Development of male gametophyte.

(**6 x 2 = 12**)

Section C

(Answer any **two** questions. Each question carries a weight of 5)

19. Explain endosperm and seed coat development in angiosperms.
20. Describe the process that leads to the development of a seed.
21. Describe the ontogeny of leaf. Explain stomata development.
22. Describe in detail the mode of double fertilization.

(**2 x 5 = 10)**

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

BS810402 Systematic Botany, Biodiversity and Economic Botany

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Name the research institute where the plant resources of India are monitored.
2. Red data book
3. Field gene banks
4. Biosphere reserves
5. Monographs
6. Name two non- wood forest products
7. Principle of priority
8. Homestead gardens
9. Chemotaxonomy
10. Fatty oils and waxes

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Taxa and taxonomic hierarchy

12. Explain the need for Scientific names and system for plant nomenclature

13. Give a brief account on the factors causing biodiversity loss.

14. Differentiate between species diversity and genetic diversity

15. Explain the systems of classification- artificial, natural and phylogenetic.

16. Explain the importance of plant products to mankind.

17. Explain the preparation of herbarium.

18. Explain the concept of national park. Name the national parks in India.

(6 x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. How biosystematics studies differ from taxonomic studies?

20. Describe the international biodiversity laws and national legislation in India.

21. Discuss about the different taxonomic evidences.

22. Discuss about the legal and ethical issues of biodiversity.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

BS810403 Ecology and Ecoinformatics

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Define Ecoinformatics
2. What are the factors affecting population growth?
3. Describe the different trophic levels.
4. What is the concept of endemism?
5. Elaborate on Exotic taxa.
6. Give the different microbe used for improving soil fertility.
7. What is reforestation?
8. What is precision agriculture?
9. Give a note on Ecosystem Modelling.
10. What do you mean by community ecology?

(8 x 1 = 8

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Give the significance of habitat.
12. Discuss on Speciation and Extinction.
13. Discuss on the use of mycorrhizae in reforestation.
14. What are the privacy concerns regarding Big data?
15. Discuss on the development of stress tolerant plants.
16. Familiarize on the Phyto-geographic regions in India.
17. What are the principles governing plant distribution?

(**6 x 2 = 12**)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

18. Discuss on Primary and Secondary productivity.
19. Give an account on Rare, endangered and threatened category (IUCN) species.
20. Discuss on the diverse aspects of reforestation of soils contaminated with heavy metals.
21. Give the applications of big data to animal production and pest management.
22. Discuss on the International and national efforts in restoration of degraded lands.

(**2 x 5 = 10)**

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

BS820401 Green House Management and Plant Protection

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Pumice
2. Calcifuge
3. Temporary wilt
4. Soil moisture deficit
5. Ebb & flow
6. Compound fertilizers
7. Inorganic fertilizers
8. Compost
9. Hot beds
10. Lath houses

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Write about various plant propagation structures.
12. Write about fertilizers and their types.
13. Write about salinity in soil mixture.
14. Classification of weeds.
15. Write about Importance of soil pH. How can soil pH be adjusted?
16. What is the need for soil drainage and explain different types of artificial drainage?
17. What do you understand by Crop-weed Competition
18. Explain the role of fungicide in plant protection

(6 x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5)

19. Write in detail about different weed management strategies.
20. Write about pest, its effect on cultivation and different strategies for control of insect pests .
21. Explain alternative propagation media.
22. Write in detail about handling of container grown plants.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

BS820402 Marine Biotechnology

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Define Food chain and Food web.
2. What are the ecological divisions of the sea?
3. What are Benthos?
4. Give a description on intertidal zone.
5. What is biodegradation?
6. Explain marine fouling.
7. What are marine toxins?
8. Give the importance of coastal aquaculture.
9. Explain any two medical compounds derived from marine fauna.
10. Define adaptation

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Describe on the physical and chemical properties of sea water.
12. Give a brief idea about the different ocean currents.
13. Elaborate on coral reefs.
14. Differentiate between Phytoplanktons and Zooplanktons.
15. Discuss on the different marine biological indicators.
16. How do deep sea animals adapt to its environment? Discuss.
17. Give an account on the bioecochemical cycles
18. Discuss on the antimicrobial and antiviral agents found in the marine world

(6 x 2 = 12)

Section C

19. (Answer any **two** questions. Each question carries a weight of 5.) Give an account on the common fishing crafts and gears.
20. Discuss on the biotic and abiotic factors of the sea.
21. Elaborate on aquafarm design and its construction.
22. Give a detailed description on the history of marine biology.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

BS820403 Business Management and Entrepreneurship

(2019 admissions onwards)

Time: Three hours Max. Weight: 30

Section- A

(Answer any **eight** questions. Each question carries a weight of 1)

1. Entrepreneurship
2. Delegation
3. Marketing
4. Exit interviews
5. Joint stock company
6. Marketing management
7. Organization
8. Performance appraisal
9. Financial planning
10. Motivation

(8 x 1 = 8)

Section B

(Answer any **six** questions. Each question carries a weight of 2)

11. Compare sales and marketing.
12. Transfers and promotions
13. Methods of training
14. Difference between management and administration.
15. Hawthorne studies
16. Different types of employment tests.
17. Basic principles of organization
18. Forms of business organization

(6 x 2 = 12)

Section C

(Answer any **two** questions. Each question carries a weight of 5.)

19. Explain the objectives, functions of financial management.
20. Explain different aspects of personnel management.
21. Explain various management theories.
22. Discuss about functions, levels and significance of management.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) **Reg. No. ……**

Name …….

M.Sc. Plant Biotechnology Degree (C.S.S.) Practical Examination, Month, Year

Fourth Semester

BS010401 Laboratory Course IV

(2019 admissions onwards)

Time: Max. Weight: 15

1. Major experiment	(4 weight.)
2. Minor experiment 1	(1 weight.)
3. Minor experiment 2	(1 weight.)
4. Minor experiment 3	(1 weight.)
5. Record	(3 weight.)
6. Viva	(5 weight.)

10. FORMAT OF AWARDS TO BE ISSUED TO STUDENTS

10.1 GRADE CARDS/ MARK CUM GRADE CARDS FOR EACH SEMESTER

10.2 CONSOLIDATED GRADE CARD

10.3 PROVISIONAL CERTIFICATE

10.4 DEGREE CERTIFICATE