VIDYASAGAR UNIVERSITY

Midnapore, West Bengal

PROPOSED CURRICULUM & SYLLABUS (DRAFT) OF

BACHELOR OF SCIENCE (HONOURS)

MAJOR IN BOTANY

4-YEAR UNDERGRADUATE PROGRAMME

(w.e.f. Academic Year 2023-2024)

Based on

Curriculum & Credit Framework for Undergraduate Programmes

(CCFUP), 2023 & NEP, 2020

VIDYASAGAR UNIVERSITY
BACHELOR OF SCIENCE (HONOURS) MAJOR IN BOTANY
(under CCFUP, 2023)

Level	YR.	SEM	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
								CA	ESE	TOTAL
B.Sc. (Hons.)	3rd	V	SEMESTER-V							
			Major-8	BOTHMJ08	T: Genetics and Plant Breeding; P: Practical	4	3-0-1	15	60	75
			Major-9	BOTHMJ09	T: Molecular Biology and Plant Biotechnology; P: Practical	4	3-0-1	15	60	75
			Major-10	BOTHMJ10	P: Palynology and Plant Reproductive Biology; P: Practical	4	3-1-0	15	60	75
			Major Elective-01	BOTHDSE1	Stress Biology OR Industrial and Environmental Microbiology	4	3-1-0/ 3-0-1	15	60	75
			Minor-5 (Disc.-I)	BOTMIN05	T: Plant Science-V; P: Practical *(To be taken from other Discipline)*	4	3-0-1	15	60	75
			Semester-V Total			20				375
		VI	SEMESTER-VI							
			Major-11	BOTHMJ11	T: Plant Physiology and Metabolism; P: Practical	4	3-0-1	15	60	75
			Major-12	BOTHMJ12	T: Immunology and Applied Microbiology; P: Practical	4	3-0-1	15	60	75
			Major-13	BOTHMJ13	T: Bioprospecting and Natural Resource Management; P: Practical	4	3-0-1	15	60	75
			Major Elective-02	BOTHDSE2	Biostatistics OR Basics of Forestry	4	3-1-0/ 3-0-1	15	60	75
			Minor-6 (Disc.-II)	BOTMIN06	T: Plant Pathology and Plant Health Science; P: Practical *(To be taken from other Discipline)*	4	3-0-1	15	60	75
			Semester-VI Total			20				375
			YEAR-3			40				750
			Eligible to be awarded Bachelor of Science in Botany *on Exit*			126	Marks (Year: I+II+III)			2325

MJ = Major, MI = Minor Course, DSE = Discipline Specific Elective Course, CA= Continuous Assessment, ESE= End Semester Examination, T = Theory, P= Practical, L-T-P = Lecture-Tutorial-Practical

SEMESTER-V

MAJOR (MJ)

MJ-8: Genetics and Plant Breeding **Credits 04 (Full Marks: 75)**

MJ-8T: Genetics and Plant Breeding (Theory) **Credits 03**

Unit	Topic
Unit- 1	Mendelian genetics and its extension: Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Polygenic inheritance.
Unit-2	Extensions of Mendelian principles : dominant epistasis (12:3:1), supplementary gene action (9:3:4), polygenic action (9:6:1), complementary gene action (9:7), inhibitory gene action (13:3), duplicate gene action (15:1)
Unit-3	Extra-chromosomal Inheritance: Organelle effects- Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in Paramecium.
Unit-4	Linkage, crossing over and chromosome mapping: Linkage and crossing over-Cytological and molecular basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping.
Unit-5	Gene mutations: Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogues, deamination, and intercalating agents); DNA repair mechanisms. Transposable elements and its role; Retroposon.
Unit-6	Population and Evolutionary Genetics: Allele frequencies, Genotype frequencies, Hardy-Weinberg Law and Factors-, role of natural selection, mutation, bottle neck, genetic drift, and founder effect.
Unit-7	Plant Breeding: Introduction and objectives. Breeding methods: self-pollinated, cross pollinated and vegetative propagated plants; Distant hybridization and role of biotechnology in crop improvement. Heterosis and Inbreeding Depression

MJ-8P: Genetics and Plant Breeding (Practical) **Credits 01**

Course Outline:

1. Basic schedules for chromosome preparation: Pre-treatment, Fixation, Staining, and Smear preparations.
2. Study of Mitosis through smear preparation of root tip of *Allium cepa,/ Allium sativum/ Aloe vera*
3. Study of Meiosis through smear preparation of root tip of *Allium cepa,/ Rhoeo sp.*
4. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
5. Incomplete dominance and gene interaction through plant samples (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
6. Demonstration of hybridization technique in a papilionaceous flower (*Cajanas cajan*) and in a graminaceous flower (*Oryza sativa*).
7. Demonstration of T-budding, I-budding in rose. Demonstration of grafting (Wedge grafting, V-grafting, tongue grafting, side grafting) and air layering (gootie) of plant specimens.

Recommended Readings

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John
2. Wiley & sons, India. 8th edition.
3. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India.5th edition.
4. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics.
5. Benjamin Cummings, U.S.A. 9th edition.
6. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to
7. Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.
8. Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7^{th} edition.
9. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding. Oxford-IBH. 2^{n} edition.
10. Acquaah, G. (2007). Principles of Plant Genetics & Breeding. Blackwell Publishing.

MJ-9: Molecular Biology and Plant Biotechnology **Credits 04 (Full Marks: 75)**

MJ-9T: Molecular Biology and Plant Biotechnology (Theory) **Credits 03**

Unit	Topic
Unit- 1	**Nucleic acids: Carriers of genetic information** Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty, Fraenkel-Conrat's experiment. DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; Organization of DNA in Prokaryotes, Viruses, and Eukaryotes. RNA Structure; Organelles DNA- mitochondria and chloroplast. Nucleosome structure; Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.
Unit 2	**The replication of DNA** Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semiconservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, θ (theta) mode of replication; Enzymes involved in DNA replication.
Unit 3	**Central dogma and genetic code** The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (salient features and deciphering**)**
Unit 4	**Transcription** Transcription in prokaryotes and eukaryotes. Principles of transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E.coli.* Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing.
Unit 5	**Processing and modification of RNA** Split genes-concept of introns and exons, Splicing- mechanism and types, eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes; RNA editing and mRNA transport.
Unit 6	**Translation** Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Protein synthesis- mechanism in Prokaryotes and Eukaryotes; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

Unit 7	**Plant Tissue Culture** Historical perspective; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Totipotency; Organogenesis; Somatic Embryogenesis ; Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploid culture; Cryopreservation; Germplasm Conservation).
Unit 8	**Recombinant DNA technology** Restriction Endonucleases (Types, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pBR322, pUC18/19, Ti plasmid); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC) and expression vector
Unit 9	**Gene Cloning** Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning; Gene Construct; DNA library, construction of genomic and cDNA libraries; complementation, and colony hybridization.
Unit 10	**Methods of gene transfer** *Agrobacterium*-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes (Luciferase, GUS, GFP).
Unit 11	**Applications of Biotechnology** Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Gentically Engineered Products–Humulin; Biosafety concerns.

MJ-9P: Molecular Biology and (Practical) **Credits 01**

Molecular Biology:

1. Preparation of LB and MS medium and raising E. coli.
2. Isolation of plasmid DNA from E. coli; Restriction digestion and gel electrophoresis of plasmid DNA.
3. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
4. RNA estimation by Orcinol method.
5. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
6. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.

Plant Biotechnology:

1. (a) Preparation of MS medium.
   (b) Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.
2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
3. Isolation of protoplasts.
4. Construction of restriction map of circular and linear DNA from the data provided.
5. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene
6. transfer by electroporation, microinjection, microprojectile bombardment.
7. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.
8. Isolation of plasmid DNA.
9. Restriction digestion and gel electrophoresis of plasmid DNA.

Suggested Reading:

a. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
b. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
c. Russell, P. J. (2010). i-Genetics- A Molecular Approach. Benjamin Cummings,
2. U.S.A. 3rd edition.
a. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.
3. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
4. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
5. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.
6. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.
7. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
8. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
9. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
10. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.
11. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniquesand Applications. John Wiley & Sons Inc. U.S.A.

MJ-10: Palynology and Plant Reproductive Biology **Credits 04(Full Marks: 75)**

MJ-10T: Palynology and Plant Reproductive Biology (Theory) **Credits 03**

Unit	Topic
Unit 1	**Introduction** History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope.
Unit 2	**Reproductive development** Induction of flowering; flower as a modified determinate shoot. Flower development: genetic and molecular aspects.
Unit 3	**Anther and pollen biology** Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure, MGU (Male Germ Unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.
Unit 4	**Ovule** Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female Gametophyte – megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac.
Unit 5	**Pollination and fertilization** Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization.
Unit 6	**Self-incompatibility** Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intra-ovarian and *in vitro* pollination; Modification of stigma surface, parasexual hybridization; Cybrids, *in vitro* fertilization.
Unit 7	**Embryo, Endosperm and Seed** Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in *Paeonia*. Seed structure, importance and dispersal mechanisms.
Units 8	**Polyembryony and apomixis** Introduction; Classification; Causes and applications.

MJ-10P: Reproductive Biology of Angiosperms (Practical) **Credits 01**

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.

2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture,psuedomonads, polyads, pollinia (slides/photographs,fresh material), ultrastructure of pollen wall(micrograph); Pollen viability: Tetrazolium test.germination: Calculation of percentage germination in different media using hanging drop method.

3. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).

4. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.

5. Intra-ovarian pollination; Test tube pollination through photographs.

6. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.

7. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

Suggested readings:

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.
2. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
3. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
4. Johri, B.M. l (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.

MAJOR ELECTIVE (DSE)

Major Elective -1: Stress Biology **Credits 04(Full Marks: 75)**

MJ DSE-1T: Stress Biology (Theory) **Credits 03**

Unit	Course contents
Unit 1	**Defining plant stress:** Acclimation and adaptation
Unit 2	**Environmental factors:** Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis– related (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates
Unit 3	**Stress sensing mechanisms in plants:** Calcium modulation, Phospholipid signaling
Unit 4	**Developmental and physiological mechanisms that protect plants against environmental stress:** Adaptation in plants; Changes in root: shoot ratio; Aerenchyna development; Osmotic adjustment; Compatible solute production.
Unit 5	**Reactive oxygen species**–Production and scavenging mechanisms.

MJ DSE-1P: Stress Biology (Practical) **Credits 01**

1. Quantitative estimation of peroxidase activity in the seedlings in the absence and presence of salt stress.
2. Superoxide activity in seedlings in the absence and presence of salt stress.
3. Zymographic analysis of peroxidase.
4. Zymographic analysis of superoxide dismutase activity.
5. Quantitative estimation and zymographic analysis of catalase.
6. Quantitative estimation and zymographic analysis of glutathione reductase.
7. Estimation of superoxide anions.

Suggested Readings:

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John
2. Wiley and Sons. U.S.A. 4th edition.
3. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and

OR

Major Elective -1: Industrial and Environmental Microbiology **Credits 04(FM: 75)**

MJ DSE-1T: Industrial and Environmental Microbiology (Theory) **Credits 03**

Unit	Course contents
Unit 1	**Scope of microbes in industry and environment**
Unit 2	**Bioreactors / Fermenters and fermentation processes** Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors- laboratory, pilotscale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.
Unit 3	**Microbial production of industrial products** Microorganisms involved, media, fermentation conditions, downstream processing and uses; spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin)
Unit 4	**Microbial enzymes of industrial interest and enzyme immobilization:** Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase**).**
Unit 5	**Microbes and quality of environment.** Distribution of microbes in air; Isolation of microorganisms from soil, air and water
Unit 6	**Microbial flora of water.** Water pollution, role of microbes in sewage and domestic waste water treatment systems. Determination of BOD, COD, TDS and TOC of water samples; Microorganisms as indicators of water quality, check coliform and fecal coliform in water samples.
Unit 7	**Microbes in agriculture and remediation of contaminated soils** Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots

MJ DSE-1T: Industrial and Environmental Microbiology (Practical) **Credits 01**

a. Principles and functioning of instruments in microbiology laboratory.
b. Hands on sterilization techniques and preparation of culture media.
c. Isolation of microorganisms from soil.
d. Demonstration of filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization,
e. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

Suggested Readings:

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition.

MINOR (MI)

Minor (MI)-5: Plant Science-V **Credits 04(Full Marks: 75)**

Minor (MI)-5T: Plant Science-V (Biochemistry and Metabolism) **Credits 03**

Unit	Topic
1.	**Bioenergetics:** Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as an energy currency molecule.
2.	**Forces stabilizing atomic and molecular interactions:** Formation, properties and biological significance of Van der Waals force, hydrogen bond, ionic bond, covalent bond and hydrophobic interaction, free radicals. pH and buffer: biological significance of pH, Characteristics of buffer.
3.	**Carbohydrate chemistry:** Classification and properties ofcarbohydrates with emphasis on glycosidic bond,
4.	**Protein chemistry:** Classification of proteins, primary, secondary, tertiary and quaternary structure of proteins; Properties of proteins.
5.	**Lipid Chemistry:** Definition and major classes of storage and structural lipids; Fatty acids structure and functions; Essential fatty acids; Triacylglycerols structure, functions and properties; Phosphoglycerides.
6.	**Nucleic acid chemistry:** Elementary concept of nucleoside, nucleotide, polynucleotide, elementary concept of DNA and RNA.
7.	**Enzymes:**Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; isoenzymes; Features of active site, substrate specificity, mechanism of action (activation energy), Michaelis – Menten equation.

Minor (MI)-5P: Plant Science-V (Practical) **Credits 01**

1. **Qualitative tests for-carbohydrates** of reducing and non-reducing sugars, glucose, fructose, sucrose, starch and **-lipids**.
2. Qualitative tests for detection of proteins, amino acids and organic acids (citric, oxalic. Qualitative tests for carbohydrate, protein, lipid.

Suggested Readings:

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman
4. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company

SEMESTER-VI

MAJOR (MJ)

MJ-11: Plant Physiology and Metabolism **Credits 04 (Full Marks: 75)**

MJ-11T: Plant Physiology and Metabolism (Theory) **Credits 03**

Unit	Topic
Unit 1	**Plant-water relations** Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap – cohesion-tension theory.Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement.
Unit 2	**Mineral nutrition and nutrient uptake** Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents, soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, facilitated diffusion, active absorption, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.
Unit 3	**Carbon assimilation** Historical background, photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO_2 reduction, photorespiration, C4 pathways; Crassulacean acid metabolism; Factors affecting CO_2 reduction.
Unit 4	**Translocation in the phloem** Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.
Unit 5	**Carbon Oxidation** Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, amphibolic role, anaplerotic reactions, regulation of the cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.
Unit 6	**ATP-Synthesis** Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers.
Unit 7	**Nitrogen metabolism** Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-

	legumes); Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.
Unit 8	**Plant growth regulators** Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid.
Unit 9	**Physiology of flowering and photobiology** Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy, Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.

MJ-11P: Plant Physiology and Metabolism (Practical) **Credits 01**

Course Outline:

1. Chemical separation of photosynthetic pigments.
2. Experimental demonstration of Hill's reaction.
3. Determination of osmotic potential of plant cell sap by plasmolytic method.
4. Determination of water potential of given tissue (potato tuber) by weight method.
5. Study of the effect of wind and light on the rate of transpiration in excisedtwig/leaf.
6. Calculation of stomatal index and stomatal frequency from the two surfaces ofleaves of a mesophyte and xerophyte.
7. Study of seed viability test through TTC.
8. Effect of carbon dioxide on the rate of photosynthesis.
9. To compare the rate of respiration in different parts of a plant.

Demonstration experiments

1. To demonstrate suction due to transpiration.
2. Fruit ripening/Rooting from cuttings (Demonstration).
3. Bolting experiment/*Avena* coleptile bioassay (demonstration).

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. JohnWiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.

MJ-12: Immunology and Applied Microbiology **Credits 04 (Full Marks: 75)**

MJ-12T: Immunology and Applied Microbiology (Theory) **Credits 03**

Unit	Topic
Unit 1	Innate and adaptive immune system, Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity.
Unit 2	B and T cell epitopes, structure and function of antibody molecules, monoclonal antibodies, antigen-antibody interactions, humoral and cell mediated immune responses, primary and secondary immune modulation, the complement system, inflammation, hypersensitivity and autoimmunity, congenital and acquired immunodeficiencies, vaccines types.
Unit 3	Immunotechniques: Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, FISH and GISH.
Unit 4	Bioreactors/Fermenters and fermentation processes, Solid-state and liquid-state fermentations; Batch fed batch and continuous fermentations, Components of a typical bioreactor, Types of bioreactors-laboratory, Constantly stirred tank fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.
Unit 5	Microbial production of industrial products in nutrition, healthcare and agriculture, Antimicrobial drugs; Antibiotics: Classification molecular mechanism of mode of action and resistance; Antifungal and antiviral drugs, Amino acids (glutamic acid), enzymes (amylase and protease), organic acids (citric acid), biofuel, bioplastic, waste water treatment.
Unit 6	Downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying
Unit 7	Microbial Ecology – Microbial interactions; role of microbes in carbon, sulphur, phosphorus and nitrogen cycles in forest soil and agriculture soil; Soil microorganisms associated with vascular plants (endophytes, epiphytes), Biological Nitrification Inhibition (BNI), Bioremediation, Uncultivable microorganisms, Process of making microbial inoculants, Challenge with the establishment of microbial inoculants.

MJ-12P: Immunology and Applied Microbiology (Practical) **Credits 01**

Course Outline:

1. Idea on microbial fermentations for the production of ethanol, organic acid and milk product.
2. Estimation of enzymes: amylase, urease, phosphatase, lipase activity.
3. Isolation and cultivation of nitrogen fixing microorganisms.
4. Demonstration of antigen-antibody interaction.
5. Demonstration/presentation of skin allergy.
6. Demonstrate the process of ELISA through photograph.

MJ-13: Bioprospecting and Natural Resource Management Credits 04 (Full Marks: 75)

MJ-13T: Bioprospecting and Natural Resource Management (Theory) Credits 03

Unit	Topic
Unit 1	Bioprospecting: Definition, Introduction, Current practices in Bioprospecting for conservation of Biodiversity and Genetic resources. Bioprospecting Act: Introduction, Phases of Bioprospecting, Exemption to Act. Fields of Bioprospecting.
Unit 2	Medicinal Plants Bioprospecting/ Pharmaceutical Bioprospecting: for new drugs, assays in Bioprospecting. Antioxidant assay – NO free radical scavenging assay, Antigenotoxicity assay – MTT assay, Antiviral activities of plants – SRB assay.
Unit 3	Marine Bioprospecting: Sources of marine planktons and their Bioprospecting, Isolation and cultivation of Marine bioresources, Isolation of Marine Yeast and its industrial applications, Bioactive chemicals from Seaweeds and their applications.
Unit 4	Microbial Bioprospecting: Isolation of Microbial metabolites and their bio-activity. Endophytic microbial products as Antibiotics.
Unit 5	Origin, evolution, botany, cultivation and uses of Food (wheat, sugarcane and potato), Fodder, Fibers (jute), Oil yielding crops (mustard), wood and timber (Sal and Mahua), Non-wood forest products (NWFPS): Bamboos, Gums, Dyes, Resins, Fruits etc.
Unit 6	Botany, Chemistry and uses of Medicinal and Aromatic plants.

MJ-13P: Bioprospecting and Natural Resource Management (Practical) Credits 01

Course Outline:

1. Study of economically important plants (rice/jute/ tea) through herbarium specimens and field study.
2. Study of cultivation practices in field and submission of report.
3. Study and collection of Non-wood forest products (NWFPS).
4. Study on handicrafts using plant parts.
5. Visit to small industries/museum/institutions related to NWFPS studies.

Suggested Reading:

1. Bole, P.V. and Vaghani, Y. (T986). Field guide to common Indian trees, Oxford University Press, Mumbai.
2. Thakur, R.S., Puri, H.S. and Husain, A. (1969). Major medicinal plants of India, Central Institute of medicinal and aromatic plants, Lucknow.
3. Swaminathan, M.S. and Kocchar, S.L. (Es.) (1989). Plants and Society, MacMillan Publication Ltd.,
4. Sharma, O.P. (1996). Hills Economic Botany, Tata McGraw Hill co., Ltd., New Delhi,
5. Kocchar, S.L. (1998). Economic Botany of the tropics, II Edn. MacMillan India Ltd.,
6. CSIR (1986), The useful plants of India Publication and Information directorate, CSIR^ New Delhi.
7. CSIR (1948 - 1976) The wealth of India, 53

MAJOR ELECTIVE (DSE)

Major Elective -2: Biostatistics **Credits 04(Full Marks: 75)**

MJ DSE-2T: Biostatistics (Theory) **Credits 03**

UNIT	TOPIC
Unit 1	**Biostatistics** Definition - statistical methods - basic principles. Variables - measurements, functions, limitations and uses of statistics.
Unit 2	**Collection of data primary and secondary** Types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data - sampling methods.
Unit 3	**Measures of central tendency** Mean, median, mode, geometric mean - merits & demerits. Measures of dispersion - range, standard deviation, mean deviation, quartile deviation - merits and demerits; Co- efficient of variations.
Unit 4	**Correlation** Types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression.
Unit 5	**Statistical inference** Hypothesis - simple hypothesis - student 't' test - chi square test.

MJ DSE-2P: Biostatistics (Practical) **Credits 01**

1. Calculation of mean, standard deviation and standard error
2. Calculation of correlation coefficient values and finding out the probability
3. Calculation of 'F' value and finding out the probability value for the F value.
4. Determination of statistical parameters (studied in theory) paper using filed data.

Suggested Readings

1. Biostatistic, Danniel, W.W., 1987.New York, John Wiley Sons.
2. An introduction to Biostatistics, 3rd edition, Sundarrao, P.S.S and Richards, J. Christian Medical College, Vellore
3. Statistical Analysis of epidemiological data, Selvin, S., 1991. New York University Press. Statistics for Biology, Boston, Bishop, O.N. Houghton, Mifflin.
4. The Principles of scientific research, Freedman, P. New York, Pergamon Press.
5. Statistics for Biologists, Campbell, R.C., 1998.Cambridge University Press.

OR

Major Elective -2: Basics of Forestry **Credits 04(Full Marks: 75)**

MJ DSE-2T: Basics of Forestry (Theory) **Credits 03**

UNIT	TOPIC
1	Forestry: Definition, Scope; Forest as natural Resources; Man and forestry; Sustainability & forestry; Importance of Forest in sustainable ecology and green house controlling
2	Forest resources, Forest classification, 2. Classification of Forest, Farm Forestry, Social Forestry & Agro-forestry; Different Forest related products- Major & Minor; Forest as a source of sustainable economy; Indian Forest & Forestry: Regional and Local Forest resources; Social forestry
3	Silviculture: Definition, scope & objective. Factors of locality: climatic (Light, temperature & Frost). Topographic (Affect of Altitude, Aspect & Exposure. Edaphic: General, Parental rock influence on vegetation, Pan formation. Biotic: Influence of plants, insects, wild animals, man and his animals; Concept of regeneration of forest.
4	Mensuration: definition, object and scope; Measurement of diameter and girth; Breast height - Rules of diameter measurement, diameter and girth class. Measurement of height of tree: Principles of height measurement (similar triangle, trigonometric). Volume: Measurement of volume of standing and felled trees, volume table.
5	Silviculture: Classification and objective, Clear felling system: clear strip and alternate strip system. Regeneration by Taungya and /or departmental plantation, Uniform system: Shelter wood system, kinds and pattern of felling, Periodic Block, Indian Irregular shelter wood system, Selection system, Coppice - System: Simple, Coppice with Standard
6	Principles and objective of Forest conservation and management, Reserve, Protected and un-classed forest. Sustained yield and progressive yield, joint Forest Management: Concept, working and sustainability; Role of JFM in the environmental restoration and biodiversity conservation. CAI, MAI, sustainable forest.
7	Idea on forest of South West Bengal; Forest products, Livelihood of Forest dwellers; Role of Forest in eco-tourism, Forest & future, NTFP.

MJ DSE-2P: Basics of Forestry (Practical) **Credits 01**

1. Measurement of height of a standing tree using Abney's level.
2. Measurement of diameter and girth of a standing tree using tape/callipers.
3. Measurement of volume of fallen logs.
4. Visit to local forest office.
5. Study of defects in wood.
6. Idea about forest fire.

MINOR (MI)

Minor (MI)-6: Plant Pathology and Plant Health Science Credits 04(Full Marks: 75)

Minor (MI)-6T: Plant Pathology and Plant Health Science (Theory) Credits 03

UNIT	TOPIC
Unit- 1	Definitions - disease, pathogen, inoculum, infection, resistance, incubation period, Disease cycle, Koch's postulates. Symptoms- necrotic, hypoplastic and hyperplastic.
Unit-2	Plant Pathogens and Diseases - Types of plant pathogens (viruses, bacteria, fungi); Life cycle of pathogens; Mode of transmission; Phytoalexins in defense mechanism; Systemic and Local acquired resistance.
Unit-3	Common plant diseases and their symptoms- Late blight of potato, Black stem rust of wheat, Disease development and progression.
Unit-4	Plant Disease and Health Management - Principles of integrated pest management.
Unit-5	Plant Health in Agriculture :–Disease management in the agricultural system; Role of plant health in sustainable agriculture; Food safety and plant health.

Minor (MI)-6P: Plant Pathology and Plant Health Science (Practical) Credits 01

1. Visual diagnosis of common diseased plant symptoms and signs–Bacterial leaf spots, Mosaic and ring spot, Leaf distortion, Powdery mildew, Fruit discoloration, Wilts, Blights, Damping off.
2. Laboratory testing of plant pathogens by microscopy and pathogen-selective media plates.
3. A field visit and assessment of plant disease incidence and severity.

Suggested Readings

1. Agrios, G. N. 1997. Introductory Plant Pathology. 4th ed. Academic Press, New York, NY.
2. Hansen, M. A. and R. L. Wick. 1993. Plant disease diagnosis: present and future prospects. Advances in Plant Pathology 10:65-126.
3. Hansen, M. A. and R. L. Wick. 1993. Plant disease diagnosis: present and future prospects. Advances in Plant Pathology 10:65-126.