POST-GRADUATE DEPARTMENT OF BOTANY

DARJEELING GOVERNMENT COLLEGE

(UNIVERSITY OF NORTH BENGAL)

SYLLABUS OF M.Sc. COURSE IN BOTANY

SEMESTER SYSTEM

(C.B.C.S.)

2022

DARJEELING GOVERNMENT COLLEGE

19 – LEBONG CART ROAD

DARJEELING: 734101,

WEST BENGAL

Post Graduate Department of Botany

Darjeeling Government College,
Semester-wise distribution of course

Semester	Courses	Marks	Lecture Hours	Credits
1st Semester	1. Core course (CC) 2. Discipline specific elective (DSE) 3. Ability enhancement course (AECC)	400	544	16
2nd Semester	1. Core course (CC) 2. Discipline specific course (DSE) 3. Skill enhancement course (SEC)	400	544	16
3rd Semester	1. Core course (CC) 2. Ability enhancement course (AECC) 3. Generic elective (GE)	400	544	16
4th Semester	1. Core course (CC) 2. Discipline specific course (DSE) 3. Ability enhancement course (AECC) 4. General elective (GE)	400	544	16
TOTAL		1600	2176	64

FIRST SEMESTER											
Course Type	**Course Name**	**Course Code**	**Groups**	**Credit Distribution & Lecture Hours**					**Total Lecture Hours**	**Total Credits**	**Total Marks**
				Theory	**Lecture Hours**	**Practical**	**Lecture Hours**	**Continuing Evaluation#**			
Core Course-I	Microbiology	DBOT-CC-1	Group-A	2	68	-	-	1	136	4	100
			Group-B	-	-	1	68				
Core Course-II	Mycology and Plant Pathology	DBOT-CC-2	Group-A	2	68	-	-	1	136	4	100
			Group-B	-	-	1	68				
Core Course-III	Taxonomy of Angiosperms	DBOT-CC-3	Group-A	2	68	-	-	1	136	4	100
			Group-B	-	-	1	68				
DSE-I (Any one to be selected)	Biophysics and Instrumentation	DBOT-DSE-1A	-	1.68	68	-	-	0.32	68	2	50
	Environmental Biology	DBOT-DSE-1B									
	Evolutionary Biology	DBOT-DSE-1C									
AECC-I	Functional English	DBOT-AEC-1	-	1.68	68	-	-	0.32	68	2	50
Total				9.36	-	3	-	3.64	544	16	400

#Continuing Evaluation: Class Test/Assignment/Project/Seminar/Field Studies/Scientific Outreach/Attendance etc.

SECOND SEMESTER											
Course Type	**Course Name**	**Course Code**	**Groups**	**Credit Distribution & Lecture Hours**					**Total Lecture Hours**	**Total Credits**	**Total Marks**
				Theory	**Lecture Hours**	**Practical**	**Lecture Hours**	**Continuing Evaluation[#]**			
Core Course-IV	Plant Physiology	DBOT-CC-4	Group-A	2	68	-	-	1	136	4	100
			Group-B	-	-	1	68				
Core Course-V	Plant Biochemistry	DBOT-CC-5	Group-A	2	68	-	-	1	136	4	100
			Group-B	-	-	1	68				
Core Course-VI	Cytology and Genetics	DBOT-CC-6	Group-A	2	68	-	-	1	136	4	100
			Group-B	-	-	1	68				
DSE-II[$] (Any one to be selected)	Mushroom Technology	DBOT-DSE-2A	Group-A	0.84	28	-	-	0.32	68	2	50
			Group-B	-	-	0.84*	40				
	Floriculture	DBOT-DSE-2B	Group-A	0.84	28	-	-				
			Group-B	-	-	0.84*	40				
SEC-I (Any one to be selected)	Plant Disease and Pest Management	DBOT-SEC-1A	-	1.68	68	-	-	0.32	68	2	50
	Plant Tissue Culture	DBOT-SEC-1B									
Total				8.52	-	3.84	-	3.64	544	16	400

[#]Continuing Evaluation: Class Test/Assignment/Seminar/Field Studies/Scientific Outreach/Attendance etc.

***Project/Related activities.**

[$] In DSE-II students will also have the option for substituting by NSS/NCC/designated MOOCS to complete the credit requirement.

THIRD SEMESTER											
Course Type	**Course Name**	**Course Code**	**Credit Distribution & Lecture Hours**						**Total Lecture Hours**	**Total Credits**	**Total Marks**
			Groups	**Theory**	**Lecture Hours**	**Practical**	**Lecture Hours**	**Continuing Evaluation[#]**			
Core Course-VII	Cryptogamic Botany, Gymnology and Palaeobotany	DBOT-CC-7	Group-A	2	64	-	-	1	128	4	100
			Group-B	-	-	1	64				
DSE-III* (Any one to be selected out of seven choices)	Elective Special Paper-I	DBOT-DSE-3A to G	-	1.68	64	-	-	0.32	64	2	50
DSE-IV* (Any one to be selected out of seven choices)	Elective Special Paper-II	DBOT-DSE-4A to G	-	1.68	64	-	-	0.32	64	2	50
DSE-V* (Any one to be selected out of seven choices)	Elective Special Paper-III	DBOT-DSE-5A to G	-	-	-	1.68	96	[$]0.32	96	2	50
AECC-II (Any one to be selected)	Web Technology	DBOT-AEC-2A	-	1.68	64	-	-	0.32	64	2	50
	Intellectual Property Rights	DBOT-AEC-2B									
GE-I (Any one to be selected)	Himalayan Tea Science	DBOT-GE-1A	Group-A	2	64	-	-	1	128	4	100
			Group-B	-	-	1	64				
	Bioinformatics	DBOT-GE-1B	Group-A	2	64	-	-				
			Group-B	-	-	1	64				
	Analytical Techniques	DBOT-GE-1C	Group-A	2	64	-	-				
			Group-B	-	-	1	64				
Total				9.04	-	3.68	-	3.28	544	16	400

[#]Continuing Evaluation: Class Test/Assignment/Project/Seminar/Field Studies/Scientific Outreach/Attendance etc.

***Only one Special Paper to be selected for DSE-III, DSE-IV and DSE-V among the following titles: (A) Cytogenetics (B) Microbiology (C) Mycology and Plant Pathology (D) Plant Physiology and Biochemistry (E) Plant Biochemistry and Molecular Biology (F) Taxonomy of Angiosperms and Ecology (G) Phycology.**

[$]Continuing Evaluation based on Review of Scientific Literature.

FOURTH SEMESTER											
Course Type	**Course Name**	**Course Code**	**Credit Distribution & Lecture Hours**						**Total Lecture Hours**	**Total Credits**	**Total Marks**
			Groups	**Theory**	**Lecture Hours**	**Practical**	**Lecture Hours**	**Continuing Evaluation[#]**			
Core Course-VIII	Plant Anatomy and Development and Bioresource Utilization	DBOT-CC-8	Group-A	2	64	-	-	1	128	4	100
			Group-B	-	-	1	64				
Core Course-IX	Ecology and Biostatistics	DBOT-CC-9	Group-A	2	64	-	-	1	128	4	100
			Group-B	-	-	1	64				
DSE-VI* (Title to be opted based on the elective special paper selected in Semester-III)	Dissertation / Review	DBOT-DSE-6A to G	-	-	-	1.68	96	[$]0.32	96	2	50
SEC-II	Biofertilizer and Agricultural Practices	DBOT-SEC-2A	-	1.68	64	-	-	0.32	64	2	50
	Medicinal Plant Cultivation	DBOT-SEC-2B									
GE-II	Ethnobotany	DBOT-GE-2A	Group-A	2	64	-	-	1	128	4	100
			Group-B	-	-	1	64				
	Conservation Biology	DBOT-GE-2B	Group-A	2	64	-	-				
			Group-B	-	-	1	64				
	Pharmacognosy	DBOT-GE-2C	Group-A	2	64	-	-				
			Group-B	-	-	1	64				
Total				7.68	-	4.68	-	3.64	544	16	400

[#]Continuing Evaluation: Class Test/Assignment/Project/Seminar/Field Studies/Scientific Outreach/Attendance etc.

***The student should opt for dissertation work under the same special paper title selected in the 3rd Semester. There are seven Special Paper titles under which the title of the dissertation / review would be finalized: (A) Cytogenetics (B) Microbiology (C) Mycology and Plant Pathology (D) Plant Physiology and Biochemistry (E) Plant Biochemistry and Molecular Biology (F) Taxonomy of Angiosperms and Ecology (G) Phycology.**

[$]Continuing Evaluation based on Seminar/Presentation of the Dissertation / Review Work.

SEMESTER – I

Course code: DBOT-CC-1 MICROBIOLOGY		
GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 68**
Continuing evaluation (CE)		
Credit: 1	**Full marks: 25**	

COURSE OBJECTIVES:

The course aims to increase understanding of the students about the taxonomical diversity of the microbes. Students will also learn about the ultra-structural details along with the metabolism, growth and nutrition. The course aims to increase the understanding of the students about the importance of microbes in food industry. The student will be taught role of microorganisms in disease development. The students will gain knowledge about the recent advances in the field of industrial microbiology. The course aims to increase the understanding of the students about the importance of biological nitrogen fixation. The students will also gain knowledge about the genetic recombination in microbes.

COURSE LEARNING OUTCOMES:

- Students will be able to understand and appreciate role of genetic engineering in bacteria.
- Students will develop theoretical skills of food industry.
- Students will be able to understand and appreciate fermentation technology.
- Students will develop practical skills in microbiological techniques and appreciate the versatile role of microbes in commercial fermented products.
- Students will be able to understand and appreciate role of microbes in biological nitrogen fixation.
- Students will also develop both theoretical and practical knowledge regarding study of microbial diversity.
- Students will be able to appreciate the resourceful part of microbes in overcoming major health problems of the world.

COURSE CONTENTS

(i) New approaches to Bacterial Taxonomy.

(ii) Ultra-structure of bacterial cell wall, capsule and slime, flagella, pili, ribosome, nuclear body, endospore, photosynthetic apparatus, reserve food material, gas vacuole and mesosome.

(iii) Metabolism: photosynthesis (anoxygenic and oxygenic); chemosynthesis, fermentation (alcoholic, ED Pathway; lactic acid–homo and hetero, Propionic acid, mixed acid, butanediol and butanol: Stickland reaction); Respiration (anaerobic and aerobic).

(iv) Bacterial growth; measurement of growth, generation time, continuous culture, synchronised growth, diauxic growth curve and environmental growth factors.

(v) Nutrition: Organic growth factors; inorganic requirements; physical and ionic requirements.

(vi) Organization and replication of genetic material in bacteria; extra chromosomal genetic elements and Genetic recombination.

(vii) Morphological classes of viruses; Principles of viral taxonomy; Structure of viruses; Assay of viruses; Lytic and lysogenic cycle.

(viii) Biological nitrogen fixation – Root nodulation; structure of nitrogenase and mode of action.

(ix) Food preservation and microbial control of food industry.

(x) Bacterial diseases of human – tuberculosis, leprosy, syphilis: causal organisms, mode of transmission and control.

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 68**

COURSE CONTENTS

(i) Staining – simple, negative, endospore, flagella, Gram staining of bacteria.
(ii) Sterilisation methods, preparation of media and stains.
(iii) Bacterial population count of soil, water and air.
(iv) Enumeration of bacterial population of liquid culture by Breed's method and Neubauer counting method.
(v) Study of population of rhizospheric microflora.
(vi) Study of population of phyllospheric microflora.
(vii) Determination of thermal death point of different bacteria.
(viii) Biochemical studies of the nitrogen fixing, nitrifying, sulphur oxidising and phosphate solubilising bacteria.

Course code: DBOT-CC-2
MYCOLOGY AND PLANT PATHOLOGY

GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 68**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJECTIVES:

This course will cover fundamental, practical, and molecular aspects of fungi in addition to host-pathogen interactions and control strategies. With current developments, crop plant diseases and their diagnosis will be taught. The students will also receive information regarding immunological and molecular diagnostics.

COURSE LEARNING OUTCOMES:

- Students will comprehend the function of fungi in several spheres of life, with a focus on agriculture.
- Students will gain knowledge of various plant-pathogen interactions, as well as how to diagnose and treat them.
- Students will study sustainable farming practices.
- Additionally, students will learn about current advances in plant-microbe interactions the importance and mechanism of it.

COURSE CONTENTS

(i) Cellular ultra-structure and cell wall composition of fungi.
(ii) Fungal growth and nutrition.
(iii) Fungi in industry, medicine: antibiotics-penicillin, organic acids–citric acid, plant growth regulators – gibberellins, alcohol and fungal enzymes.
(iv) Fungal toxins – host none selective toxins – mode of action of cercosporin; host specific toxins, structure, mode of action and concept of Vb Gene, Mycotxin – aflatoxin, biosynthetic pathway, genes and enzymes.

(v) Mycorrhizae; interaction; specific recognition in mycorrhizal association; application as biofertilizer and bioprotector in forestry and agriculture.
(vi) Molecular basis of disease development.
(vii) Control of plant diseases – chemical and biological measures.
(viii) Detailed studies of fungal disease: damping-off, powdery mildew, downy mildew, smut, burnt, rust, wilt, root rot, leaf spots, gall of economically important plants.
(ix) Virus diseases – symptoms, carrier, transmission, interaction of virus and the host, control strategies.
(x) Application of avirulence genes in control of plant pathogens.

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 68**

COURSE CONTENTS

(i) Morphological study of representative members of fungi – Yeast, *Mucor*, *Penicillium*, *Aspergillus*, *Alternaria*, *Xylaria*, *Fusarium*, Members of *Agaricales* and *Polyporales* (available in Darjeeling).
(ii) Sterilisation methods, preparation of media and stains, culture of fungus.
(iii) Histopathological studies of fungal diseases of economically important crops.
(iv) Identification of fungal culture: *Curvularia*, *Fusarium*, *Alternaria*, *Trichoderma*, *Pestalotiopsis*, *Exobasidium*, *Saccharomyces*.
(v) Antibiotic bioassay by agar disc method.
(vi) Detection of $ED_{50}$of fungicides by spore germination method.
(vii) Thin layer chromatography and bioassay of antifungal compounds.
(viii) Comparison of phenol content between healthy and artificially inoculated plants.
(ix) Extraction and essay of phenylalanine ammonia lyase activity in plants following infection.

Course code: DBOT-CC-3
TAXONOMY OF ANGIOSPERMS

GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 68**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJETIVES:
This course intends to teach the students with the basics and advances of Angiosperms taxonomy including flora and vegetation of Eastern Himalayas and some aspects of biodiversity conservation and traditional knowledge. The entire course consists of eleven units. Unit (i) to (v) attempt to teach the students with the history and development of plant taxonomy; identification, nomenclature, delimitation of taxa and classification, concept of characters and their evolution etc. whereas unit (vi) to (xi) target to teach different data sources for taxonomy and their importance, taxonomic literatures, phylogeny of different angiospermic groups, flora and vegetation of eastern Himalaya and conservation of biodiversity through traditional method.

COURSE LEARNING OUTCOMES:

- Students will acquire knowledge on history and development of plant taxonomy.
- They will understand the delimitation of taxa and their hierarchical arrangement and major system of angiosperm classification including APG classification.
- They will know about different methods and codes of nomenclature along with detailed accounts of ICN- its rules, regulations, applications etc.
- Students will have direct knowledge on concept of characters, their evolution and will be able to choose the suitable ones and to use them.
- Students will be able to understand the importance and significance of different branches of botany as taxonomic data source.
- Students will have knowledge on different Herbaria and Herbarium technique; Botanical gardens, taxonomic literatures and their importance in taxonomic study.
- They will understand the origin and evolution of angiosperms and affinities among different groups.
- They will know the diversity of flora and vegetation of E. Himalaya and understand the diversity of ethnic groups and their knowledge system on plants and their uses.

COURSE CONTENT

(i) Classification: Phases of Taxonomy (α, β, ω and others), needs and philosophy of some major systems of classification–Cronquist, Takhtajan, Dahlgren, Thorne and APG system of classification.
(ii) Taxonomic hierarchy, species, genus, family and other categories; principles used in assessing relationship, delimitation of taxa and attribution of rank.
(iii) Nomenclature– different methods, sources of names, salient features of the International Code of Botanical Nomenclature.
(iv) Biocode and Phylocode.
(v) Character concept and evolution of characters.
(vi) Taxonomic data sources; anatomy, palynology, embryology, cytology, Phytochemistry and molecular biology.
(vii) Herbarium, botanical garden, taxonomic literature and keys.
(viii) Taxonomy and phylogeny of Magnoliales, Amentifereae, Asterales, Helobiae, Glumi florae, Scitamineae and Orchidales.
(ix) Flora and vegetation of Eastern Himalayas.
(x) Species concept.
(xi) Traditional methods of conservation; sacred grove.

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 68**

COURSE OBJECTIVES:

This course intends to teach the students how to work out, describe and identify the local plants using available taxonomic literature and preparation of artificial keys. They will be trained for using and handling different taxonomic literatures, calculation of similarity coefficient, and preparation of Dendrograms. They will be taught how to study different palynomorph of local plants. This paper also teaches them the basic techniques for anatomical study like maceration of woods, nodal anatomy, anatomical modification due to ecological adaptations, different secretary tissues etc.

COURSE LEARNING OUTCOMES:

- Students will know the basic techniques of work out, description, identification of local plants using different literatures, comparison of different taxa and preparation of artificial keys.
- They will have practical knowledge on palynomorph of local plants etc.
- Students will learn the basic techniques for anatomical study like wood maceration, staining and study of anatomical specimens
- They will acquire practical knowledge on anatomical adaptation as well as secretary tissues.

COURSE CONTENT

(i) Work out of locally available plants, identification of specimen up to species following literature and preparation of artificial keys.
(ii) Training in using taxonomic literature flora, herbaria, Journals, etc.; familiarity with Taxonomic Literature (e.g. Index Kewensis, Wall-Cat, Icons, Bibliographies, Dictionaries, Keys, Floras, etc.)
(iii) Comparisonofdifferentspeciesofagenusanddifferentgenusofafamilyto calculation of similarity coefficient and preparations dendrograms.
(iv) Palynological study of some taxa.
(v) Wood maceration from soft and hard tissues.
(vi) Study of nodal anatomy.
(vii) Anatomical study of different plant materials in relation to ecological adaptations.
(viii) Study of secretory tissues.

Course code: DBOT-DSE-1A **BIOPHYSICS AND INSTRUMENTATION**	
Credit: 2 (1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)]Lecture hours: 68**

COURSE OBJECTIVES:
This course aims to familiarize the students with different techniques used in biological sciences. Students will focus on the principle and application of different techniques in plant sciences. Students will be taught about the basics of experimental lab-work through detailed information of buffer, ampholytes including knowledge of bioelectricity and bio-photons. This paper also aims to introduce different molecular biology techniques that are being exploited in research in biological sciences.

COURSE LEARNING OUTCOMES:
- Students will learn about different molecular techniques in biological sciences.
- Students will get detailed knowledge of different chromatographic techniques in biochemistry.
- Students will get information about spectrophotometry, centrifugation and radiobiology.
- Students will understand different microscopic techniques.

COURSE CONTENTS

(i) Physico-chemical properties of water; ionic product of water, pH, buffers, ampholytes, surface tension, viscosity and application of biomolecules.
(ii) Microscopy: General principles and applications of compound microscopy, light microscope, bright-field and dark field microscope, phase contrast microscope, fluorescent microscope, electron microscope and atomic force microscope.
(iii) Spectrophotometry: Principle of calorimetry, visible, UV, IR, atomic absorption spectrophotometry.
(iv) Centrifugation: Basic principles, fluorometry centrifugation.
(v) Radiobiology: Law of radioactivity, radioactive carbon dating, application of radioactive

isotopes in biological system.

(vi) Chromatography: Basic principles and application of thin layer chromatography, gas liquid chromatography, HPLC, mass spectrometry.

(vii) Protein immunoblotting, RIA and ELISA.

(viii) Bio-electricity and bio-photons, rudimentary nervous mechanism in plants, analysis of biomolecules by mass spectrometry and NMR.

Course code: DBOT-DSE-1B **ENVIRONMENTAL BIOLOGY**	
Credit: 2 (1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)]Lecture hours: 68**

COURSE OBJECTIVES:

This course will cover the raising peoples' awareness of environmental problems. To disseminate fundamental information on environment and awareness related to environmental problems. To encourage the people to get involve in environmental conservation and improvement.

COURSE LEARNING OUTCOMES:

- Understand how ecological and physical science theories and methodologies are used to solve environmental problems.
- Recognize the ethical, historical, cross-cultural, and linkages between human and natural systems contexts of environmental challenges.

COURSE CONTENTS

(i) An introduction to environmental biology; ecosystem functions: energy flow and biogeochemical cycles.

(ii) Pollutants and contaminants, photochemical smog, PAN, heavy metal stress, serpentine soil and plants there-on, phytoremediation, metallophytes and geobotany, microbial clean-up of oil spill on ocean surface, BOD, COD, NOD, SOD, degradation of pesticides by microbes, solid waste management; electronic waste (e-waste), sources and types, impacts, recycling and management

(iii) Environmental toxicology, LD_{50}, case study of some pollution events: Bhopaldisaster, Chernobyl, Three miles' island, Itaiitai or Ouch-ouch, Minamata, London smog, acid mine drainage, DDT disaster, thalidomide and teratogeny.

(iv) El Nino and La Nina.

(v) Environmental law and policies, environmental ethics, environmental economics.

(vi) Impact of man-plant relationship on environment; afforestation, deforestation, reforestation, agroforestry and social forestry.

(vii) Environmental Biotechnology: concept of waste management, biodegradation of xenobiotics and hydrocarbons, vermi-composting, farmyard manure, production and utilization of biofuels, bio-fertilizers and biopesticides.

Course code: DBOT-DSE-1C **EVOLUTIONARY BIOLOGY**	
Credit: 2 (1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)]Lecture hours: 68**

COURSE OBJECTIVES:

The present course has been designed with the perspective of achieving the following principle objectives:

- Providing comprehensive overview involving the concept of evolution.
- Detailed explanation relating to Origin of Life (Both prokaryotic and eukaryotic).
- Exploration of salient features in respect of evolutionary theories (Lamarckism, Darwinism and Neo-Darwinism)

- Imparting detailed understanding of Analogy, Homology, Paleontological and embryological evidences including Molecular Phylogeny.
- Providing adequate information about Geological Time Scale and neutral theory of molecular evolution.
- Developing comprehensive knowledge regarding various sources of variations and their role in evolution.
- Imparting detailed explanation of key concepts in population genetics corresponding to Hardy-Weinberg law, genetic drift and types of natural selection.
- Providing adequate knowledge about Micro-evolutionary changes, speciation and adaptive radiation.
- Imparting detailed explanation of Extinction and its types.
- Providing a descriptive knowledge regarding origin and evolution of man.
- Understanding the concept of phylogenetic trees besides highlighting their construction methodology and interpretation.

COURSE LEARNING OUTCOMES:

After successful accomplishment of the course, the learners would have a detailed knowledge regarding the essential aspects of evolutionary biology which would further help them in acquiring better understanding of the subject.

COURSE CONTENT

(i) Life's beginnings – concept of evolution; origin of life; origin of prokaryotes and eukaryotes.
(ii) Historical review of evolutionary concept – theories of evolution.
(iii) Evidences of evolution – analogy and homology; embryological evidences of evolution; evolutionary paleontological evidences; molecular phylogeny.
(iv) Variations and mutations and their sources.
(v) Hardy-Weinberg Law and Genetic Drift; types of natural selection.
(vi) Product of evolution – micro-evolutionary changes; concept of species and speciation; adaptive radiation.
(vii) Extinctions – an overview.
(viii) Origin and evolution of human being.
(ix) Study of phylogenetic trees.

Course code: DBOT-AECC-1 **FUNCTIONAL ENGLISH**
Credit: 2 (1.68 + 0.32) Full marks: 50 [42 (T) + 8 (CE)]Lecture hours: 68

COURSE OBJECTIVES:

- Learn how to write an essay, précis, summary, abstract, note, notice, memo, agenda, minutes, report and paper.
- Understand different types of writing.
- Learn how to prepare a power-point presentation and present a topic/paper/dissertation work.
- Get an idea about group discussion and interview.
- Improving writing skills, presentation skills and communication skills.

COURSE LEARNING OUTCOMES:

- Students will be able to use Functional English in their day-to-day life.

COURSE CONTENTS

(i) Writing Skills I
   a. Essay writing
   b. Precis writing
   c. Summarizing
   d. Note-making

(ii) Writing Skills II
   a. Notice, memo, agenda, minutes.
   b. Writing report on project field study.
   c. Types of writing –descriptive, argumentative, expository, narrative.
   d. Elements of a paper-selecting topic, thesis statement, introductory, developmental, transitional and concluding paragraphs.

(iii) Verbal Communication and Presentation Skills
   a. Preparing a Power Point Presentation
   b. Presenting a paper.
   c. Group discussion
   d. Interview

SEMESTER II

Course code: DBOT-CC-4 PLANT PHYSIOLOGY		
GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 68**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

OBJECTIVES:

This course aims to teach the students the basics and advances of Plant Physiology. This course aims to enhance the understanding of the students about importance of plant physiology. This course will give the students and understanding of plant functions and physiology in plant system.

COURSE LEARNING OUTCOMES:

- Students will learn about the location, importance, and mechanisms of photosynthesis. They will learn about the photosynthetic light harvesting system and C1, C2, C3, C4 and CAM in plants.
- Students will learn about the various plant growth substances. Their chemistry and biosynthesis and their mode of action.
- During this course student will learn about plant water relation and how mineral are a source of nutrition in plants
- Students will learn about, phytochromes and biochemical signaling in plants and photoperiodism. They will be taught about seed germination, dormancy in details and the role of hormones in seed germination.
- Students will learn about various the major biochemical pathways of plant physiology, they will also gain knowledge about senescence and programmed cell death.
- Students will learn about solute transport, membrane transport its mechanism-organization of import molecules and ion channels.

COURSE CONTENTS

(i) Photosynthesis: Photosynthetic light harvesting system and C1, C2, C3, C4 and CAM.
(ii) Plant growth substances: Chemistry and biosynthesis and mode of action.
(iii) Plant water relation and mineral nutrition: water potential and nutrient uptake.
(iv) Flowering: phytochrome, biochemical signalling and photoperiodism.
(v) Seed germination and dormancy: types, methods of breaking dormancy, hormonal role in seed germination.
(vi) Major biochemical pathways: Glycolysis, Kreb's cycle, Pentose phosphate pathway, gluconeogenesis, Shikimate pathway; Senescence and programmed cell death: pattern, mechanism and PCD in plants.
(vii) Solute transport: passive and active transport, membrane transport process, membrane transport proteins.
(viii) Membrane transport mechanism – organisation of import molecules, ion channels.

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 68**

COURSE CONTENT

(i) Determination of osmotic pressure of an integrated plant tissue.
(ii) Extraction and estimation of total chlorophyll from leaves of different chronological ages.
(iii) Effect of uncoupler and inhibitor on the rate of photosynthesis.
(iv) Determination of the effect of respiratory inhibitor on the rate of respiration.
(v) Study of leaf pigments by filter-paper chromatography
(vi) Study and separation of leaf anthocyanin by thin layer chromatography
(vii) Experiments on bioassay of IAA and kinetin
(viii) Effect of plant hormone on water uptake.
(ix) Effect of heavy metal on seed germination.
(x) Photomorphogenetic effect of light on the development of seedling

Course code: DBOT-CC-5 PLANT BIOCHEMISTRY		

GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 68**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJECTIVES:

This course aims to teach the students the basics and advances of plant biochemistry. The students will learn about the basic and modern concepts of biomolecules including proteins, carbohydrates, lipids and enzymes. It also enhances the understanding of the students about nucleosides, nitrogen metabolism and secondary metabolites and its biosynthetic pathways.

COURSE LEARNING OUTCOMES:

- Students will be taught about various types of metabolism in plants like amino acid metabolism, protein metabolism and lipid metabolism their chemistry, structure and synthesis in details.
- Students will gain knowledge about bioenergetics -thermodynamic principles, energy rich compounds and phosphorylation.
- Students will learn about what carbohydrates are its classification, structure and biosynthesis along with its function.
- Students will learn about enzymes, its classification and enzyme kinetics. Biosynthesis of purine and pyrimidine ribonucleotides.
- Students will learn about nitrogen metabolism in plants and secondary metabolites. Various types of secondary metabolites its biosynthetic pathways, and role in defense mechanism.

COURSE CONTENTS

(i) Bioenergetics: thermodynamic principles, energy rich compounds and phosphorylation.
(ii) Carbohydrates: classification, structure and biosynthesis, glycosides – structure and function.
(iii) Amino acid metabolism.

(iv) Protein metabolism: chemistry, structure and synthesis.
(v) Lipid metabolism: biosynthesis of fatty acids, lipid oxidation, triglycerol synthesis and membrane lipid biogenesis.
(vi) Enzymes: classification, kinetics and inhibition.
(vii) Nucleosides: biosynthesis of purine and pyrimidine ribonucleotides and deoxy-ribonucleotides.
(viii) Nitrogen metabolism: nitrate and nitrite uptake and reduction, regulation of nitrogen metabolism.
(ix) Cell wall – molecular architecture, biosynthesis and assembly.
(x) Secondary metabolites – types, biosynthetic pathways, role in plant defence mechanism.

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 68**

COURSE CONTENT

(i) Preparationofstandardcurveofaknownprotein(BSA)andestimationofanunknownproteinby Lowry's method.
(ii) Extraction and estimation of peroxidase from plant sample.
(iii) Extraction and estimation of free amino acid from plant sample.
(iv) Extraction and estimation of IAA-oxidase from plant sample.
(v) Extraction and estimation of nitrate reductase from plant sample.
(vi) Extraction and estimation of amylase from plant sample.
(vii) Extraction and estimation of Ascorbic acid from plant sample.
(viii) Extraction and estimation of Phenols from plants ample.
(ix) Extraction of phosphorous using K_2HP_4 standard curve.
(x) Extraction and estimation of titrable acids in plant sample

Course code: DBOT-CC-6
CYTOLOGY AND GENETICS

GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 68**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJECTIVES:
This course aims to teach the students with the basics and advances of Cytology and Genetics. They being inter-dependent branches of life sciences, the course has been designed covering topic related to both external and internal environment of a cell including cell membrane to chromosome/DNA and also organelles DNA and their related structure and functions. Besides, the implication of knowledge about chromosome, DNA and gene in terms of chromosome and genetic mapping are also included. In addition, through this course student are aimed to learn the implication study of chromosome and gene in the field of plant breeding and population biology related to the species evolution.

COURSE LEARNING OUTCOMES:
- Students will gain knowledge about structure of prokaryotic and eukaryotic chromosome and also their molecular constitution and respective gene expression pattern.
- Students will learn the concept of nucleolar gene expression and extra-chromosomal inheritance.
- Students will gain knowledge about molecular and genetic markers and their implication in gene

mapping.

- Students will learn the concept of transposon, mutation and related disease like cancer.
- Students will know the implications of cytology and genetics in plant breeding and population genetics.

COURSE CONTENTS

(i) Organisation of prokaryotic and eukaryotic genome, chromosomes – DNA packaging, organisation of centromere and telomere, nucleolus and ribosomal RNA genes; euchromatin and heterochromatin; karyotype analysis.
(ii) Genetics of mitochondria and chloroplast.
(iii) Regulation of gene expression: prokaryotes and eukaryotes.
(iv) Concept of gene, mapping of genome; genetic marker, tetrad analysis, construction of molecular maps, correlation of genetic and physical maps; somatic cell, genetic and alternative approach to gene mapping.
(v) Transposable elements in prokaryotes and eukaryotes, transposition, mutation induced by transposons, site directed mutagenesis, DNA damage and repair mechanism, defects in DNA repair and related inherited human diseases, initiation of cancer at cellular level, proto-oncogenes and oncogenes.
(vi) Homologous and non-homologous recombination; breeding behaviour and genetics of structural heterozygotes, translocation heterozygote.
(vii) Transfer of whole genome, transfer of individual chromosomes and chromosome segments; genetic basis of inbreeding and heterosis, exploitation of hybrid vigour.
(viii) Population genetics – gene pool, gene frequency, Hardy-Weinberg Law, concepts and rate of change in gene frequency.
(ix) Flow cytometry, *in situ* hybridisation – concept and technique.

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 68**

COURSE CONTENTS

(i) Study of plant chromosome, chromosome staining schedules, study of abnormal chromosomes, comparative study of mitotic index for the treatment by environmental stress and toxicity.
(ii) Isolation of nuclei and identification of histones by SDS-PAGE.
(iii) Isolation of plant DNA and its quantification by spectrophotometric method.
(iv) Restriction digestion of plant DNA and separation by agarose gel electrophoresis and visualisation by ethidium bromide staining.
(v) Isolation of RNA and quantification by spectrophotometric method.
(vi) Demonstration of SEM and TEM.
(vii) Staining of nucleolus.

Course code: DBOT-DSE-2A
MUSHROOM TECHNOLOGY

GROUP: A (THEORY)
Credit: 0.84Full marks: 21Lecture hours: 28

Continuing evaluation (CE)	
Credit: 0.32	**Full marks: 8**

COURSE OBJECTIVES:

This course will cover fundamental by creating income and employment opportunities, mushroom production will enhance the socioeconomic situation and address the employment issues of rural economies. This course's primary goal is to encourage self-employment.

COURSE LEARNING OUTCOMES:

- Due to the high demand for wholesome and high-quality food products, mushroom gardening is now a source of income.
- Mushrooms are also used to produce a variety of goods with additional value.
- The cultivation process is characterized by low start-up costs and continuous output.

COURSE CONTENT

(i) Introduction, history of mushroom cultivation; biology of mushrooms; nutritional value, medicinal value; poisonous mushrooms and edible mushroom.

(ii) Cultivation technology: Infrastructure, equipment's and substrates in mushrooms cultivation- Polythene bags, vessels, inoculation hook, inoculation loop, sieves culture racks, Mushroom unit or mushroom house, water sprayer, tray, boilers, driers, pure culture; Spawn- Types of spawn preparation of spawn, mushroom bed preparation and factors affecting mushroom bed preparation; Principles of composting, machinery required for compost making, materials for compost preparation; Methods of composting- Long Method of Composting (LMC) and short method of composting(SMC); Casing, raw material used for casing, preparation of casing material; important sanitation during various stages of mushroom cultivation.

(iii) Cultivation of important Mushroom: general process for the cultivation of *Agaricus bisporous*, *Pleurotus ostreatus* and *Volvariella volvaceae*.

(iv) Harvesting of mushroom: Identification of right stage of Mushroom harvesting; Methods of harvesting, packaging storing and grading of Mushroom and post-harvest procedures; Preparation of value added products of Mushroom.

(v) Disease control and pest management of mushrooms.

(vi) Research centres, farms at national level and regional level, marketing and mushroom in India and across the world. Present scenario and prospects for Mushroom cultivation.

GROUP: B (PROJECT / ACTIVITIES RELATED TO MUSHROOM TECHNOLOGY)		
Credit: 0.84	**Full marks: 21**	**Lecture hours: 40**

Course code: DBOT-DSE-2B FLORICULTURE		

GROUP: A (THEORY)		
Credit: 0.84	**Full marks: 21**	**Lecture hours: 28**

Continuing evaluation (CE)	
Credit: 0.32	**Full marks: 8**

COURSE OBJECTIVES:

This course helps the students to understand the importance and scope of nursery prospects of protected floriculture in India, and know about the different type of protected structure such as Greenhouses, Polyhouses, shade houses etc. and idea about the landscape and gardening. Explore the students with different field nursery management, site selection, layout and water nutrient management, and acquire the fundamental knowledge about pest disease management, weed management. This course also helps the students to gain the knowledge about different types of plant propagation techniques, production techniques of flower crops, post-harvest technology of cut flowers. Students can explore with the idea about the dehydration technique, Urban landscaping and special types of gardens.

COURSE LEARNING OUTCOMES: By the end of the course the students should be able to

- Explore with the prospects of protected floriculture in India.
- Gain the knowledge about different types of protected structure for floriculture.
- Assess the idea about the landscape and gardening.
- Understand field nursery management, site selection layout and water nutrient management.
- Assess about different techniques of plant propagation such as vegetative and sexual methods.
- Explore with idea about commercial floriculture for the production of flower crops like Marigold, Rose, Orchid, *Chrysanthemum* etc.
- Gain a deeper knowledge in post-harvest techniques in cut flowers dehydration technique for drying of flowers and foliage.
- Assess with landscaping for specific Institutions, Industries, Road sides, IT parks and corporates.
- Explore with idea about special types of gardens such as vertical garden, Roof Garden, Bog Garden, sunken garden, rock garden and Sacred groves.

COURSE CONTENTS

(i) Scope and importance of nursery. Prospects of Protected floriculture in India, Types of protected structures- Green houses, Polyhouses, Shade houses, rain shelters etc.; Prospects of landscape gardening.

(ii) Field nursery management: site selection, layout, water, nutrient management etc.; Pest & Disease management-IPM; Weed management.

(iii) Plant Propagation Techniques: Sexual & Vegetative methods of Propagation, Soil Sterilization, Seed Sowing, Pricking, Shading, Defoliation, Wintering, Mulching, Topiary, and Role of Plant Growth Substances.

(iv) Commercial Floriculture: Production Techniques of Flower crops like Marigold, Rose, Orchid, *Chrysanthemum*, Jasmine, Carnation etc. Post-harvest technology of Cut flowers, Dehydration technique for drying of flowers and foliage, Factor affecting flower production.

(v) Urban landscaping, Landscaping for specific Institutions, Industries, Roadsides, Traffic Islands, IT Parks, Corporates.

(vi) Special types of Gardens-Vertical garden, Roof garden, Bog garden, Sunken garden, Rock garden and Sacred groves.

GROUP: B **(PROJECT / ACTIVITIES RELATED TO FLORICULTURE)**		
Credit: 0.84	**Full marks: 21**	**Lecture hours: 40**

Course code: DBOT-SEC-1A PLANT DISEASES AND PEST MANAGEMENT		
Credit: 2 (1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 68**

COURSE OBJECTIVES:

This course aims to familiarize the students with different disease management and control strategies. This subject will focus on chemical control of disease and pests. The students will be taught about biological control of disease and pests. This paper also aims to introduce different disease management of crops.

COURSE LEARNING OUTCOMES:

- Students will learn about different plant disease management techniques.
- Students will get detailed study of disease and pest control chemicals.
- Students will get information about different fungicides and its applications.
- Students will understand Integrated Pest management and Integrated Disease Management.

COURSE CONTENT

(i) Principles of plant disease management and control through cultural, physical, biological, chemical, organic amendments and botanical methods; integrated control measures of plant diseases; resistance to diseases and molecular approach to disease management.

(ii) History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals; classification of chemicals used in plant disease control and their characteristics.

(iii) Application of chemicals on foliage, seed and soil; role of stickers, spreaders and other adjuvant; plant health in respect to environment hazards, residual effects and safety measures.

(iv) History of fungicides and antibiotics; concepts of pathogenic immobilization; nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals.

(v) Formulations, mode of action and application of different fungicides, chemotherapy and phytotoxicity of fungicides; handling, storage and precautions to be taken while usage of fungicides.

(vi) Concept of biological control and bio-agents, history of biological control, merits and demerits of biological control.

(vii) Classification of biological interactions, competition, myco-parasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophyticity, antibiosis, induced resistance, mycorrhizal associations and operational mechanisms including its relevance in biological control.

(viii) Factors governing biological control vis-à-vis role of physical environment, agro-ecosystem; operational mechanisms and cultural practices in biological control of pathogens and antagonists along with their relationship; bio-control agents, compatibility of different bio-agents; comparative approaches to biological control of plant pathogens by resident and introduced antagonists.

(ix) Commercial production, delivery system, application and monitoring of antagonists; biological control in Integrated disease management (IDM), Integrated pest management (IPM) and organic farming system; available biopesticides in market; quality control of bio-control agents.

(x) Components of integrated disease management (IDM) – limitations and implications; IDM in important crops viz. rice, wheat, cotton, sugarcane, chickpea, rapeseed, mustard, kharif pulses, vegetable crops and fruits crops.

Course code: DBOT-SEC-1B PLANT TISSUE CULTURE		
Credit: 2 (1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 68**

COURSE OBJECTIVES:

This course intends to teach the students about ability of plant cell and tissues either to produce or regenerate entire plantlet and subsequent stages of growth and development in vitro conditions. Moreover, students will also gain the knowledge about the different growth conditions such as light, temperature, plant growth regulator and nutrient media, required for the plants' growth in artificial conditions and also the plants parts (explants) used for tissue culture and their further management.

COURSE LEARNING OUTCOMES:

- Students will learn the basic concepts of totipotency, plant tissue culture and techniques involved like sterilisation, media preparation, inoculation and required artificial culture conditions.
- Students will gain knowledge about the variants of explants used in tissue culture.
- Students will obtain knowledge about importance of tissue culture in production of Secondary metabolites, pharmaceuticals and virus-free plants and *in vitro* biodiversity conservation.
- Students will acquire the knowledge commercial aspects and perspectives of tissue culture.

COURSE CONTENT

(i) Introduction: Definition, Concept of cellular totipotency, composition of different culture media, Role of chemicals, growth regulators, adjuvants and light in plant tissue culture.

(ii) Techniques of cell and tissue culture: Design of laboratory and commercial tissue culture facility, Media preparation, Sterilization of media, tissue culture room and other accessories, inoculation of cultures, preparation of explant materials.

(iii) Suspension culture, protoplast isolation, culture and fusion, callus culture- initiation and maintenance.

(iv) Shoot-tip and axillary bud culture, micropropagation through reproductive parts, caulogenesis, rhizogenesis and xylogenesis.

(v) Micropropagation through organogenesis and embryogenesis, artificial seeds and embryo culture.

(vi) Anther culture: Development of haploids, diploidization and its applications; Somaclonal variation and *in vitro* selection for crop improvement.

(vii) Application: Production of Secondary metabolites, pharmaceuticals, meri-cloning for virus-free plants and *in vitro* conservation.

SEMESTER III

Course code: DBOT-CC-7 CRYPTOGAMIC BOTANY, GYMNOLOGY AND PALEOBOTANY		
GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 64**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJECTIVES:

This course is designed to discuss the cell structure of algae, different types of pigments and food reserved in them and gain the knowledge in recent trend on algal classification, salient features of important groups, the evolution of algal chloroplast and explore the economic and ecological importance of algae as a biofertilizers and their uses in industry. Elaborate the thallus organization of Lichens and physiological relationship, gain the deeper knowledge on general account of major groups of Bryophytes, Pteridophytes and Gymnosperms, their classification salient features and reproduction and discuss about the Geological time scale and radiometric dating.

COURSE LEARNING OUTCOMES:

By the end of the course the students should be able to-

- Gain the adequate knowledge on structural organization, classification and economic importance of algae.
- Evaluate the thallus organization of Lichens.
- Learn about the recent classification of Bryophytes their general account, biogeographical distribution, hotspots, ecology and endemism.
- Assess the origin and evolution of Pteridophytes, general features of different groups of Pteridophytes.
- Learn about the general account of different groups of Gymnosperms. Their detailed structure and reproduction.
- Know about the Geological time scale, continental drift plate tectonics and Radiometric dating.

COURSE CONTENT

(i) Cell structure, pigments, reserve food and flagella.
(ii) Evolution of algal chloroplast and recent trend in algal classification and salient features of major groups - Cyanophyceae, Chlorophyceae, Phaeophyceae, Bacillariophyceae, and Rhodophyceae.
(iii) Algal blooms, algal bio-fertilisers and uses in algal biotechnology, pharmaceuticals and nutraceuticals, bioluminescence, and commercial aspects.
(iv) Ecological importance of algae.
(v) Thallus organization in lichen and their physiological relationship.
(vi) Recent classification of bryophytes and general account of major groups with reference to ICN recommendation and Crandall-Stotler system.
(vii) Bryophytic distribution, ecology, endemism, biogeographical distribution and hotspots of bryophytes.

(viii) Bryophytes through geological ages.
(ix) Origin and evolution of Pteridophytes; General features of Psilopsida, Lycopsida, Sphenopsida and Pteropsida.
(x) General account of Cycadeodales, Cordaitales andPteridospermales.
(xi) Structure and reproduction in Cycadales, Ginkgoales, Coniferales andGnetales.
(xii) Geological time scale and stratigraphy.
(xiii) Continental drift and plate tectonics.

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 64**

COURSE OBJECTIVES:

This course is designed to help the students to understand the morphological, anatomical studies of different genera of algae, locally available lichens, different bryophytes and Pteridophytes members. Course enlighten the students about the comparative study of the anatomy of vegetative, reproductive parts of gymnosperms and study of important fossil pteridophytes and gymnosperms from prepared slides and specimen.

COURSE LEARNING OUTCOMES:

By the end of the course the students should be able to-

- Identify morphology of different algal genera such as *Rivularia*, *Fucus*, *Scytonema*, *Zygnema*, and *Batrachospermum*.
- Know about the morpho-anatomical studies of some locally available members of asco, basidio and cyano lichen.
- Understand about the morphological study of representative bryophytes and Pteridophytes.
- Compare the anatomy of vegetative and reproductive parts of *Cryptomeria*, *Taxus*, *Cedrus*, *Cephalotaxus* and *Abies*.
- Study of important fossil pteridophytes and gymnosperms from prepared slides.

COURSE CONTENT

(i) Morphological study of the following algal genera: *Scytonema*, *Rivularia*, *Zygnema*, *Fucus* and *Batrachospermum*.
(ii) Morpho-anatomical studies of some locally available members of asco-, basidio- and cyano-lichen.
(iii) Morphological study of representative bryophyte members – *Lunularia*, *Porella*, *Dumortiera*,Targionia and *Plagiochasma*.
(iv) Morphological study of representative pteridophyte members – *Gleichenia*, *Cheilanthus*, *Polystrichum*, *Athyrium* and *Cyathea*.
(v) Comparative study of the anatomy of vegetative and reproductive parts of *Cryptomeria*, *Taxus*, *Cedrus*, *Cephalotaxus* and *Abies*.
(vi) Study of important fossil Pteridophytes (*Lepidodendron*, *Lepidocarpon* and *Calamites*) and Gymnosperms (*Lyginopteris*,*Medullosa*and *Glossopteris*) from prepared slides and specimen

Course code: DBOT-DSE-3A CYTOGENETICS (THEORY)		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

This course is designed to impart the concept of Mendelian and post Mendelian gene concepts and their implications; cell cycle related events such as signal transduction and cancer and also the notion of gene expression regulation in prokaryotes and eukaryotes and their further allusion in the basic techniques in biotechnology. These techniques include molecular hybridization, amplification and selection and usage of molecular markers and their execution in welfare of human being like crop improvement, diagnosis, species identification etc. Further, this course intends students to get the knowledge of genomics and proteomics, which are the most recent aspects of life sciences.

COURSE LEARNING OUTCOMES:

- Students will gain the concept of Mendelian principles and its extension and also their implication in the field of genetics.
- Students will acquire the knowledge of cell cycle, cell signalling and their role in control of cellular mechanisms mainly cell division and abnormalities like cancer.
- Students will know the gene regulation mechanism at transcription, post-transcription, translation and post translation levels.
- Students will be acquainted with the concepts of molecular hybridization, mapping and its implication in the field of crop improvement.
- Students will obtain the knowledge of functional and structural genomics.

COURSE CONTENTS

(i) Concept of gene; extension of Mendelian principles; polygenic inheritance, QTL mapping.
(ii) Cell cycle –regulation and control; Cell signalling –signal transduction pathways and their regulation, receptors and their roles in signal transduction pathways, second messengers, light signalling in plants, quorum sensing; Cancer – genetic rearrangements in progenitor cells, oncogenes, tumour suppressor genes, cancer and cell cycle, virus-induced cancer, metastasis, interaction of cancer and normal cells, apoptosis, therapeutic inventions of tumour cells.
(iii) Gene silencing, DNA methylation and imprinting, gene amplification, Dosage compensation, Homeotic genes.
(iv) The techniques of Molecular Genetics – an overview of molecular genetic techniques, Southern Northern-Western blot hybridisation, PCR, PAGE, FACS, TEM and SEM. Major plant genetic marker for crop improvement – AFLP, RFLP, RAPD, SSR, STS, EST, SNPs etc.
(v) Regulation of gene expression in prokaryotes and eukaryotes.
(vi) Structural and functional genomics – concept, techniques and implementations.

Course code: DBOT-DSE-3B MICROBIOLOGY (THEORY)		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

This course is designed to acquaint students with the microbial flora and equip them with the understanding of their structure and biology. This course aims to increase understanding of the students with the metabolism and growth of the microbial flora. Students will also learn about the concepts of soil and water microbiology. This course serves to impart advanced concepts to the students in the field of Microbiology with focus on diversity, bioprospecting and application of microbes for various biologically active metabolites and in diary industry.

COURSE LEARNING OBJECTIVES:

- To provide value-based education, with academic excellence and advanced research based skills in microbiology.
- To make students understand the diversity in structure and functioning in microbial biota.
- To understand the concepts of metabolism and growth of prokaryotes.

COURSE CONTENT

(i) General account: mycoplasma; gliding bacteria; actinomycetes.
(ii) Growth and growth control; counting viable but non-culturable prokaryotes; Quorum sensing; Growth control by physical exclusion, heat, radiation and chemicals.
(iii) Microbial metabolism: Bacterial photosynthesis, respiration, fermentation.
(iv) Virus: Classification; principles of viral taxonomy; Purification and assay of viruses; Lytic and lysogenic cycle.
(v) Extremophilic microorganisms: Characteristic of archaebacteria, thermophiles, halophiles, barophiles.
(vi) Water microbiology: Microbial load in water, examination of water quality, purification techniques.
(vii) Dairy microbiology: types and sources of microorganisms in milk, preservation techniques, role of microorganisms in production of different milk products.
(viii) Soil-microbiology: Soil environment; soil microorganisms and interaction among them, role of microbes in biochemical transformations of nitrogen, phosphorous, carbon, sulphur compounds, PGPR, Plant-microbe interaction
(ix) Human microbiome: Commensal microbiota of human body, interaction with the host; impact of gut microbiota in human body.

Course code: DBOT-DSE-3C **MYCOLOGY AND PLANT PATHOLOGY (THEORY)**		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

This course will give an overall knowledge of fungi with special reference to structure, growth and metabolites and its application. Details of the molecular biological concepts are given to the students to study, analyze, and control of plant diseases. Developments of immunology, molecular techniques of pathogen related proteins and classical aspects of plant virology, mycology and also of other pathogens are taught. Students are given knowledge in transgenics, signaling, mushroom cultivation etc. Molecular biology of host-pathogen interaction is also taught in this paper.

COURSE LEARNING OUTCOMES:

- Students will understand molecular interaction of host-pathogen.
- Students will knowledge about different products from fungi and their application in human life.
- Students will learn about biocontrol of plant pathogens.

- Students will learn different diagnostic techniques applied in pathology and will also be able to diagnose plant disease for proper recommendation of control measures.
- Students will learn basics of research and publications in molecular as well as classical plant pathology.

COURSE CONTENT

(i) Physiology and Biochemistry of fungi: Nutritive uptake, sensing and translocation; fungal growth; metabolism of fungi, secondary metabolites.
(ii) Cell Biology and Genetics of Fungi: Cell components of fungi; fungal cell division; chromosome theory, chromosome mapping; Parasexual cycle; gene as functional unit; the fine structure of genes; mechanism of genetics exchange, heterothallism; genetics of sporulation; extracellular inheritance.
(iii) Molecular biology: yeast genome; the two-micron circle; yeast cell cycle and its regulation; molecular biology of yeast killer system.
(iv) Applied mycoses: mycotoxins; mushroom cultivation, nutritional and medicinal importance, Industrial production of citric acid, alcohol, antibiotics, enzymes (amylase, cellulase and pectinase).
(v) Plant disease epidemiology.
(vi) Genetics of plant disease.

Course code: DBOT-DSE-3D **PLANT PHYSIOLOGY AND BIOCHEMISTRY (THEORY)**		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

The course aims to teach the students with the basic and advances of physiology and biochemistry of plants. It aims to enhance the understanding of the students about the physiological and biochemical aspects of plant metabolism. It gives the students an understanding of plant function and behavior, encompassing all the dynamic processes of growth, metabolism, reproduction, defence and communication that occur in plant system.

COURSE LEARNING OUTCOMES:

- Students will learn about various plant pigments, its biosynthesis ad degradation.
- Students will learn about Nitrogen Fixation and assimilation of nitrogen in plants
- Students will learn about the plant and its reaction will stress both biotic and abiotic
- Students will be gain knowledge about fruit ripening and its biochemistry
- Students will be gain knowledge about signal transduction, signalling pathways, chemical signals and cellular receptors
- Students will learn about translocation in phloem: pathways, pattern of pressure flow model for phloem transport, phloem loading and unloading
- Students will learn about various crop physiology in plants, blue light response and stomatal movements and morphogenesis.
- Students will gain knowledge about mechanism and regulation or K^+ transport, phosphorous nutrition and transport, plant responses of mineral toxicity and Protein biochemistry including transcriptional and post transcriptional modification and translation.

COURSE CONTENT

(i) Plant pigments: Types, biosynthesis and degradation.
(ii) Nitrogen fixation: Nitrogen fixation and assimilation, components of nitrogenase.

(iii) Stress physiology: abiotic and biotic stress, role of amino acids and polyamines in stress tolerance.
(iv) Fruit ripening: Biochemistry and molecular basis.
(v) Signal transduction: signalling pathways, chemical signals and cellular receptors.
(vi) Translocation in phloem: pathways, pattern of pressure flow model for phloem transport, phloem loading and unloading.
(vii) Blue light response-stomatal movements and morphogenesis.
(viii) Crop physiology: new ideotypes, physiological basis of crops, economic index, and harvest index
(ix) Molecular physiology of mineral nutrients – mechanism and regulation or K^+ transport, phosphorous nutrition and transport, plant responses of mineral toxicity.
(x) Protein biochemistry: transcriptional and post-transcriptional modifications, translation.

Course code: DBOT-DSE-3E **PLANT BIOCHEMISTRY AND MOLECULAR BIOLOGY (THEORY)**		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES

The course aims to teach the students the basics and advances of Plant Biochemistry. This course would enhance the understanding of the students about the significance of the modern principles and techniques in providing a transparent idea of the underlying biochemical mechanisms involved in a plant system besides providing an in depth knowledge of the metabolic activities occurring in a cell. The course would aim to provide a background for development of independent thinking, thus boosting research based inquisitiveness and experimental designing.

COURSE LEARNING OUTCOMES

- The learners would have a comprehensive idea of the concept of protein biochemistry initiating from transcription to organellar protein targeting and characterization.
- The students would gather knowledge of the varied sorts of metabolic events evident in plants viz. amino acid, brassinosteroid and sulphate metabolism including their chemistry, structure, biosynthesis and assimilatory pathways in details.
- The pupils would obtain a transparent idea of protein sorting mechanism and vesicle traffic machinery in addition to Golgi apparatus based protein modification.
- The learners would precisely understand the concept of RNA-i and antisense technology.
- The students would know in detail about enzymes with reference to its purification and immobilisation strategies besides learning about allosteric enzymes and multi-substrate reactions.

COURSE CONTENT

(i) Protein biochemistry: Transcription and post-translational modifications, translation, protein targeting and characterisation.
(ii) Amino acids metabolism: Biosynthesis of aspartic and aromatic amino acid families.
(iii) Brassinosteroids –structure, occurrence, biosynthesis, metabolism and effect on growth and development.
(iv) Sulphate metabolism – chemistry, uptake and transport, assimilation pathway.
(v) Alkaloids – chemistry, classification, biosynthesis, industrial application.
(vi) Protein sorting and vesicle traffic: machinery of protein sorting, targeting to mitochondria, plastids, peroxisomes, ER, vacuole, protein modification in Golgi apparatus.
(vii) RNAi and antisense RNA technology.
(viii) Enzymes: Purification of enzymes, enzyme immobilisation, allosteric enzymes, multi-substrate reactions.

Course code: DBOT-DSE-3F TAXONOMY OF ANGIOSPERMS AND ECOLOGY (THEORY)		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

This course targets to introduce the students to the field of angiosperms taxonomy and its different components in details and to create interest for further study and develop expertise for research in taxonomic field. Total course is divided into 11 units each having specific objective(s). Unit (i) & (ii) aim to teach the students with history of Indian plant taxonomy and development of classification with reference to some major systems whereas unit (iii) to (vii) targets to teach them with every details of nomenclature and nomenclatural codes, identification of unknown plants using different taxonomic literatures and methods, Cladistics and Numerical taxonomy, species concept and different aspects of biosystematics. Unit (viii) to (xi) aim to give concrete idea to the students regarding origin and evolution of angiosperms, palynological and others tools for taxonomic study; and different software and their application in taxonomy.

COURSE LEARNING OUTCOMES:

- Students will be able to develop the concept on history of Indian plant taxonomy and contributions of Indian scholars in this field. They will also know the major system of plant classification from Pre and Post Darwinian period.
- Students will be familiar with different methods and codes of nomenclature and will acquire special knowledge on ICN.
- They will learn description and identification methods, taxonomic literatures and keys, their application and preparation.
- Students will learn about numerical taxonomy and other modern branches of taxonomy and systematic- Cladistics, molecular systematics. They will also know about different aspects of biosystematics.
- They will be familiar to concept of species, delimitation of species and other taxa using different taxonomic data source like palynology.
- Students will develop clear idea regarding different modern tools for taxonomic study including software for data analysis and construction of Dendrograms.
- Ultimately, students will develop a complete and concrete concept on angiosperm taxonomy and also the skills and expertise.

COURSE CONTENT

(i) History of Indian Plant Taxonomy.
(ii) Pre-Darwinian and Post-Darwinian systems of classification: a historical background, A critical evaluation of the classification of Takhtajan, Cronquist, Dahlgren, Thorne and APG system of classification.
(iii) ICBN and other codes, application of code with problems; nomenclature of cultivated and hybrid plants.
(iv) Molecular systematic, molecular clock, cladistics and numerical taxonomy.
(v) Taxonomic Literature, keys, methods of identification, nomenclatural problems.
(vi) Species concept, evolution of terms: homology, analogy, plesiomorphy, apomorphy,

symplesiomorphy, synapomorphy, anagenesis, cladogenesis, stasigenesis.

(vii) Biosystermatics: Importance, categories and major areas of biosystematics and its prospects, genecology, interaction between genes and environment, genetic barrier, phenotypic plasticity, speciation, heterobathmy.

(viii) Origin, evolution of diversity and phylogeny of angiosperms, cradle ofangiosperms.

(ix) Application of palynology as tool.

(x) Analysis of data; commonly available software, construction of Dendrograms.

Course code: DBOT-DSE-3G PHYCOLOGY (THEORY)		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

This course aims to make students understand the classical concepts of the polyphyletic group- algae, and be able to classify them with in a phylogenetic framework, to elucidate the general features of different groups of algae, to give an insight into the distribution of different algal in Indian Continent.

COURSE LEARNING OUTCOMES:

- After completion of the course, the students will be able to:
- Provide an overview of algal systematics explaining algal origin and apply their knowledge in explaining the evolutionary significance.
- Address the general features of different important groups of algae and compare them with different forms.
- Elucidate the theories of chloroplast evolution and use it as a basis for understanding the evolutionary pathways to the other plant groups.

COURSE CONTENT

(i) Prochlorophyta and Glaucophyta – General characteristics and phylogenetic importance.

(ii) Cyanobacteria in geo-thermal habitat: Geographic distribution, distribution determination by biomarker and 16s rRNA.

(iii) Heterokontophyta – Different classes and phylogenetic significance of each groups.

(iv) Chlorophyta – Different classes and phylogenetic significance of each groups.

(v) Distribution of algal genera in ocean with particular emphasis on Indian Continent.

Course code: DBOT-DSE-4A CYTOGENETICS (THEORY)		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

This course is designed in such a way that the students will be familiar with concepts of biotechnological intervention such as plant tissue culture and its varied methods and also their role in plant variety improvement, conservation and production of useful metabolites. Besides, genetic manipulation of plants through *Agrobacterium* and uses of different kinds of suitable vectors are also included. Through this course the students will know the concepts of biodiversity, its conservation and its manipulation in the production of new variety i.e. genetically modified organism

(GMO) and related intellectual property right. In addition, notion of structural and functional proteomics and embryonic stem cell technology will be imparted to the students.

COURSE LEARNING OUTCOMES:

- Students will learn basic and essential techniques of plant improvement and conservation through the steps of plant tissue culture.
- Students will be familiar with tools and process of recombinant DNA technology and also the uses of *Agrobacterium* and different vectors and selection of recombinant cells implies in this techniques.
- Students will acquire the knowledge about importance of biodiversity for the human civilisation and its healthy manipulation in the production of genetically modified plants and related intellectual property rights.
- Students will learn the concepts and role of functional and structural proteomics and embryonic stem technology.

COURSE CONTENT

(i) Basic concepts of plant cell, tissue and organ cultures, somatic embryogenesis, somaclonal variation – application in crop improvement, synthetic seeds, haploid production – its applications, protoplast culture – somatic hybridisation and application of protoplast technology; genetic fidelity testing.
(ii) Biotechnological strategies and methods of genetic manipulation in plants, *Agrobacterium tumefaciens* a natural tool for plant transformation, updated molecular mechanism for T-DNA transfer to plant cell by Ti-plasmid.
(iii) Tools of DNA technology-restriction enzymes, Vectors: plasmid, bacteriophage, other viral vectors, cosmid, phage M13, Ti plasmid, YAC, BAC, HAC, MAC etc. cDNA and gDNA library; selection strategies of recombinant cells; application of plant transgenic technology.
(iv) Genetically Modified Organisms (GMOs).
(v) Biodiversity and Intellectual Property Rights (IPR).
(vi) An overview of the general approaches of structural and functional proteomics.
(vii) Embryonic stem cell technology.

Course code: DBOT-DSE-4B MICROBIOLOGY (THEORY)		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

This course is designed to acquaint students with the mechanism of gene expression and advantage of this process in genetic engineering. Students will also learn about the concepts of immunology. The course aims to increase the understanding of the students about the importance of microbes in industry. The student will be taught role of microorganisms in production of antibiotics, steroids, enzymes etc. The students will gain knowledge about the recent advances in the field of industrial microbiology. The course aims to increase the understanding of the students about the importance of microbes in environmental microbiology. The students will also gain knowledge about the possible roles of microorganisms in bioremediation. The students will gain knowledge about bio-energy production.

COURSE LEARNING OUTCOMES:

- Students will be able to understand and appreciate role of genetic engineering in bacteria.
- Students will develop theoretical skills of industrial microbiology and understand the molecular mechanisms underlying the gene cloning.
- Students will be able to understand and appreciate fermentation technology.
- Students will develop practical skills in microbiological techniques and appreciate the versatile role of microbes in commercial products.
- Students will be able to understand and appreciate role of microbes in sustainable environment.
- Students will be able to appreciate the resourceful part of microbes in overcoming major environmental problems of the world.

COURSE CONTENT

(i) Industrial microbiology: Fermentation technology, Bioreactors; Strain development, Production of antibiotics (penicillin & streptomycin), organic acid (citric & acetic acid), enzymes (amylase, protease & lipase), insulin, bio-transformation of steroids, commercial production of biofertilizer.
(ii) Antibiotics: Sources, chemistry, biosynthesis and mechanism of action; probiotics; prebiotics; symbiotics.
(iii) Genetics: Genetic code – its nature and deciphering; transcription, post-translational RNA processing, translation, operon (Lac operon & Trp operon).
(iv) Genetic Engineering: Splicing of DNA; insertion of DNA into vector; detection of recombinant molecules; PCR and its applications; expression of cloned genes.
(v) Role of plasmids and bacteriophages as cloning vectors; resistance plasmids; cosmids.
(vi) Immunology: Antigens, immunoglobulins; antigen presentation; monoclonal antibodies; complement fixation, interleukin, immune-diagnosis; immunological techniques; development of vaccines; interferons – characteristics, production, chemical induction, regulation of production, mode of application.
(vii) Biodegradation of xenobiotics; degradative genes in the environment; genetically engineered microbes for biodegradation; bio-surfactants; bio-pesticides.
(viii) Microbiology of bio-energy production: substrate digester, production of biogas, biodiesel, biohydrogen.

Course code: DBOT-DSE-4C **MYCOLOGYAND PLANT PATHOLOGY (THEORY)**		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

This course will give an overall knowledge of the plant's immunity against pathogens and the signaling mechanism associated with the defense mechanism. Details of biotechnological techniques associated with the management of viral diseases in recent era. Developments of genetically modified plasmid from the pathogenic bacteria like Ti-plasmid from *Agrobacterium tumefaciens* will be provided by this group. Students are given knowledge about the molecular biology of plant pathogen interaction. Avirulent gene for crop disease management and molecular biological techniques for disease management is also taught in this paper.

COURSE LEARNING OUTCOMES:

- Students will understand the concept of plant immunity and defence signalling.
- Students will knowledge about the management of viral disease by biotechnology methods.

- Students will learn about genetic engineering of pathogenic plasmids.
- Students will learn about avirulent gene for crop disease management and molecular biological techniques for disease management.

COURSE CONTENT

(i) Modern concept of plant immunity and mechanisms of plant defence signalling.
(ii) Biotechnological approaches for the viral disease management.
(iii) Phytopathogenic bacterial plasmids and their genetic engineering.
(iv) Molecular biology of plant pathogen interaction.
(v) Avirulent gene for crop disease management.
(vi) Molecular biological techniques for disease management.

Course code: DBOT-DSE-4D **PLANT PHYSIOLOGY AND BIOCHEMISTRY (THEORY)**		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

The course aims to teach the students with the basic and advances of physiology and biochemistry of plants. It aims to enhance the understanding of the students about the physiological and biochemical aspects of plant metabolism. It gives the students an understanding of plant function and behaviour, encompassing all the dynamic processes of growth, metabolism, reproduction, defence and communication that occurs in plant system.

COURSE LEARNING OUTCOMES

- Students will learn about amino acid metabolism, sulphate metabolism their chemistry and assimilation pathway.
- Students will gain knowledge about Brassinosteroids its structure, biosynthesis and its metabolism
- Students will gain knowledge about alkaloids its chemistry, classification, biosynthesis and its industrial application
- Students will learn about protein sorting and its details
- Students will learn about the latest technology of RNAi. They will gain detail knowledge about enzymes in plants.
- Students will learn about DNA replication in plants, role of topoisomers and DNA repair.
- Students will gain knowledge about restriction endonuclease and cloning vectors, construction of cDNA, genomic libraries, identification of specific clones and DNA Sequencing.

COURSE CONTENT

(i) Amino acid metabolism: biosynthesis of aspartic acid and aromatic amino acid families.
(ii) Brassinosteroids – structure, occurrence, biosynthesis, metabolism and effect on growth and development.
(iii) Sulphate metabolism – chemistry, uptake and transport, assimilation pathway.
(iv) Alkaloids – chemistry, classification, biosynthesis, industrial application.
(v) Protein sorting and vesicle traffic: machinery of protein sorting, targeting to mitochondria, plastids, peroxisomes, ER, vacuole, protein modification in Golgi apparatus.
(vi) RNAi and antisense RNA technology.

(vii) Enzymes: Purification of enzymes, enzyme immobilisation, allosteric enzymes, multi-substrate reactions.
(viii) DNA replication, role of topoisomerase, DNA repair.
(ix) Plant Molecular biology: Restriction endonuclease and cloning vectors, construction of cDNA and genomic libraries, identification of specific clones, DNA sequencing.

Course code: DBOT-DSE-4E PLANT BIOCHEMISTRY AND MOLECULAR BIOLOGY		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES

The course aims to teach the students the fundamentals and advances of Molecular Biology. This course would enhance the understanding of the students about the significance of the modern principles and molecular techniques in the perspective of plant system besides providing an in depth knowledge of the mechanism of DNA replication; DNA repair; genetic engineering; gene regulation and PCR chemistry. The course would aim to provide a background for the development of independent thinking, thus boosting research based inquisitiveness and experimental designing.

COURSE LEARNING OUTCOMES

- The pupils would obtain a clear idea about DNA replication mechanism in addition to DNA repair schemes.
- The learners would know about the enzymatic molecular scissors, cloning vectors, cDNA & genomic libraries, clonal screening and gene sequencing methodologies.
- The students would have an understanding of the modern concept of gene besides gene duplication phenomenon and pseudo-genes.
- The pupils would have comprehensive knowledge about regulation of gene expression in plants including transcriptional and post transcriptional control of gene expression.
- The learners would understand the principles, techniques and application of Recombinant DNA technology.
- The students would know about the Polymerase Chain Reaction phenomenon including its types and application.

COURSE CONTENT

(i) DNA replication, role of topoisomerase, DNA repair.
(ii) Plant Molecular biology: Restriction Endonucleases and cloning vectors, construction of cDNA and genomic libraries, identification of specific clones, DNA sequencing.
(iii) Molecular concept of gene, gene duplication and pseudogenes.
(iv) Regulation of gene expression in plants: plant gene structure and expression, regulatory mechanisms, control of transcription, post-transcriptional control of gene expression.
(v) DNA manipulation and alien gene transfer and application of recombinant DNA technology.
(vi) Polymerase chain reaction – PCR; types and application.

Course code: DBOT-DSE-4F TAXONOMY OF ANGIOSPERMS AND ECOLOGY (THEORY)		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

This course aims to make the students familiarize with basic principles of origin of life, concept of evolution etc. They will be taught about different phytogeographic regions, structure and function of ecosystem, biodiversity, megadiversity countries, biodiversity hotspots, conservation of biodiversity etc. The students will be given the understanding of different ecological problems and the concept of environmental biotechnology to mitigate the problems like waste management, degradation of xenobiotics etc. Students will be taught about remote sensing for ecological study, functional genomics for studying taxonomic and ecological variations, molecular and adaptive variations etc.

COURSE LEARNING OUTCOMES:

- Students will learn the concept of origin of life on earth and their evolution.
- They will know about the phytogeographic regions, major biomes of the world, megadiversity countries, biodiversity hotspots, loss and conservation of biodiversity.
- They will learn about different ecological principles, structure and function of ecosystems, origin and extinction of species, natural selection etc.
- Students will get detailed study of some ecological issues, environmental biotechnology to mitigate the problems
- Students will learn the applications of ecological concept for benefit to different life forms, and different national and international organizations working on ecological issues.
- They will learn about remote sensing and its application in ecological study, functional genomics for studying taxonomic and ecological variations, molecular and adaptive variation etc.

COURSE CONTENT

(i) Phyto-geographic zones and floristic regions of India and World, megadiversity countries and conservation hotspot, major biomes of the world: forest, wetland, grassland, desert, tundra, ocean.

(ii) Biosphere-II, planetary ecosystem and planetary engineering–biopoiesis and ecopoiesis, case study of a hypothetical planetary engineering project: terra formation on Mars, origin of life and evolution: Darwinism, Gaia and Red Queen hypothesis.

(iii) Natural selection, ring species, race, cline, industrial melanism and natural selection, mechanism of speciation and extinction, Hardy-Weinberg Genetic Equilibrium, genetic polymorphism and selection, allele fixation, bottle neck, founder principle.

(iv) IUCN, Red List criteria, CITES, endemism and exotic flora of India, Ramsar sites.

(v) Case study of some ecological issues in India: Himalayan problems, desertification in India, salinity increase and decline of Sundari tree in Sunderbans, Chipko movement, ecological and environmental problems leading to decline of Indus valley civilization, Narmada bachao andolan, arsenic problem in drinking water, dams and rivers, instability of substratum in Raniganj coal field.

(vi) Environmental Biotechnology: concept of waste management, biodegradation of xenobiotics and hydrocarbons, vermicomposting, farmyard manure, production and utilization of biofuels, biofertilizers and biopesticides.

(vii) Molecular and adaptive variation: hitch-hiking of gene, phylogeography and conservation genetics; role of NBPGR in conservation of Indian biodiversity.

(viii) Functional Genomics to study taxonomic and ecological variation- approaches to analyze differential expression of genes-ESTs, SAGE, microarrays and their applications; principles inverse genetics: gene tagging; gene trapping; gene silencing; knock-out mutants; transcriptome; ribotype concept; concept, methodology and applications of proteomics.

(ix) Remote sensing for study of ecosystem.

Course code: DBOT-DSE-4G PHYCOLOGY (THEORY)		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

This course aims to make students understand the applied aspects of the group algae and also about their ecology, physiology and genetical aspects. This course also deals with the cultivation details which can be very useful in human welfare. This course aims to increase the understanding of the students about the wetland ecology and phytoplankton diversity. This course deals with the stress factors that imposed on algae.

COURSE LEARNING OUTCOMES:

- Students will be able to understand the commercial aspects regarding algae.
- Students will be able to learn the structural details and life history of different fossil thallophytes.
- Students will also gain knowledge regarding the physiological and biochemical aspects of the lower group of plants.
- Students will be able to learn the phytoplankton diversity.
- Students will also acquire knowledge about culturing techniques.
- Students will be able to learn about the acclimation and environmental stress.

COURSE CONTENT

(i) Palaeo-botanical study and role of Algae in Petroleum industry.
(ii) Algal light harvesting complex: phycobiliproteins, constructing core and rod elements of PBS, linker polypeptide, chromatic adaptation, structure and regulation of light harvesting genes.
(iii) Basic culturing techniques and mass cultivation: Biological principles, types of reactors for phototrophic algae, downstream processing of cell mass production, heterotrophic production of marine algae for aquaculture.
(iv) Role of algae in wet-land ecology; Phytoplankton community– structure and function; water pollution, phytoremediation, Algal bloom, Red tide, Algae as ecological indicator and secondary metabolite production from algae.
(v) Environmental stress physiology:
   a. Eco-toxicology of inorganic chemical stress on algae.
   b. Photo-acclimatization.
   c. Photo-inhibition and culture productivity.
   d. Salinity stress.

Course code: DBOT-DSE-5A CYTOGENETICS (PRACTICAL)		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 96**
CE (Continuing evaluation based on Review of Scientific Literature)		

COURSE CONTENT

(i) Study of plant chromosome, chromosome staining schedule, chromosome staining by fluorescence dye, differential staining of euchromatin and heterochromatin.
(ii) Differential in-situ staining of DNA and RNA of plant cells.
(iii) Isolation of plant genomic DNA and RNA from plant tissues and quantification by spectrophotometric method.
(iv) Separation of DNA and RNA on agarose gel electrophoresis and visualisation by ethidium bromide staining.
(v) Digestion of genomic DNA with restriction enzymes.
(vi) PAGE and SDS-PAGE of plant proteins and chloroplast protein profile.
(vii) Meristem, anther-pollen, callus cultures and plant regeneration from embryo.
(viii) Isolation and culture of plant protoplast and its viability test.
(ix) Amplification of DNA by PCR.
(x) Study of plant genetic marker such as isozyme markers.

Course code: DBOT-DSE-5B **MICROBIOLOGY (PRACTICAL)**		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 96**
CE (Continuing evaluation based on Review of Scientific Literature)		

COURSE CONTENT

(i) Study of physiological and biochemical activities of bacteria (hydrolysis of starch, lipid, protein and urea: degradation of cellulose and pectin; catalase activity; nitrate reduction, IMVi Creation, liquefaction of gelatin, oxidation and fermentation of carbohydrates.
(ii) Microbial growth kinetics.
(iii) Chemical estimation of sugar by DNS method.
(iv) Separation and identification of amino acids/sugars by paper/thin layer chromatographic method.
(v) Effect of substrate concentration and temperature on enzyme activity.
(vi) PAGE separation of microbial proteins.
(vii) Agarose gel separation of prokaryotic DNA.
(viii) Bacteriological examination of water using multiple tube fermentation/membrane filtration method.
(ix) Enumeration of bacteriophage from environmental samples.
(x) Enrichment and isolation of photosynthetic, endospore forming, phosphate solubilizing, sulphur oxidising, ammonifying, nitrogen fixing bacteria.
(xi) Isolation of antibiotic resistant mutants.
(xii) Isolation of antibiotic producers from soil.
(xiii) Estimation of microbial biomass carbon by chloroform fumigation incubation method.
(xiv) Isolation of Rhizobia from root nodules and *Azotobacte*r, determination of their PGPR ability.
(xv) Isolation and characterization of pesticide degrading microorganisms from soil

Course code: DBOT-DSE-5C **MYCOLOGY AND PLANT PATHOLOGY (PRACTICAL)**		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 96**
CE (Continuing evaluation based on Review of Scientific Literature)		

COURSE CONTENT

(i) Growth curve and sporulation of Yeast.
(ii) Fermentation of citric acid and alcohol.
(iii) Antifungal antibiotic sensitivity test.
(iv) Quantitative estimation of protein, carbohydrate, amino acid, fat, DNA, RNA from fungi.
(v) TLC and paper chromatography of amino acids.
(vi) Isolation DNA, RNA and plasmid from yeast.
(vii) Agarose gel electrophoresis of DNA, RNA and Plasmid.
(viii) PAGE of proteins.
(ix) Koch's postulate.
(x) Enzyme assay of cellulose and pectinase.
(xi) In vitro antagonism study by bio-control agents.

Course code: DBOT-DSE-5D **PLANT PHYSIOLOGY AND BIOCHEMISTRY (PRACTICAL)**		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 96**
CE (Continuing evaluation based on Review of Scientific Literature)		

COURSE CONTENT

(i) Extraction and estimation of plant carbohydrate by anthrone method.
(ii) Extraction of chloroplast pigments from leaves and estimation of chlorophylls and carotenoids.
(iii) Extraction and estimation of plant phenols by Bray and Thrope method.
(iv) Extraction and estimation of lipids from seeds.
(v) Extraction of plant protein and its estimation by Lowry's method.
(vi) Determination of Iodine value of fat sample.
(vii) Determination of saponification value from fat sample.
(viii) Estimation of water content and Dry matter.
(ix) Estimation of free amino acids.
(x) Determination of Iodine value of fat sample.
(xi) Determination of saponification value from fat sample.
(xii) Breaking of seed dormancy by scarification of seed coat.
(xiii) Seed viability of different seeds using TTC test.
(xiv) Study of photolysis of water by Hill reaction with isolated chloroplast.
(xv) Separation of Sugars by Paper Chromatography.
(xvi) Separation of Amino Acids by Thin Layer Chromatography.
(xvii) Study of Catalase and Peroxidase Activity.
(xviii) Separation of isozymes of peroxidase by native –PAGE.
(xix) SDS-PAGE of soluble proteins extracted from plant material.
(xx) Extraction of Plant Genomic DNA and RNA form plants.
(xxi) Estimation of DNA and RNA.
(xxii) Qualitative analysis of DNA by Agarose Gel Electrophoresis.
(xxiii) Fractionation of protein by gel-filtration chromatography.
(xxiv) Fractionation of protein by ion exchange chromatography.

Course code: DBOT-DSE-5E **PLANT BIOCHEMISTRY AND MOLECULAR BIOLOGY (PRACTICAL)**		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 96**
CE (Continuing evaluation based on Review of Scientific Literature)		

COURSE CONTENT

(i) Extraction and estimation of plant carbohydrate by anthrone method.
(ii) Extraction and estimation of plant phenols by Bray and Thrope method.
(iii) Extraction of plant protein and its estimation by Lowry's method and Bradford's method.
(iv) Extraction and estimation of oil from fatty seeds.
(v) Determination of Iodine value of fat sample.
(vi) Determination of saponification value from fat sample.
(vii) Separation of Sugars by Paper Chromatography.
(viii) Separation of Amino Acids by Thin Layer Chromatography.
(ix) Catalase and Peroxidase Activity.
(x) Separation of isozymes of peroxidise by native–PAGE.
(xi) SDS-PAGE of soluble proteins extracted from plant material.
(xii) Fractionation of protein by gel-filtration chromatography.
(xiii) Fraction of protein by ion exchange chromatography.
(xiv) Extraction of genomic DNA and RNA from plants.
(xv) Estimation of DNA and RNA.
(xvi) Qualitative analysis of DNA by Agarose Gel Electrophoresis.
(xvii) Isolation of plasmid from the selected transformants by mini-prep method.
(xviii) DNA fingerprinting and barcoding.

Course code: DBOT-DSE-5F **TAXONOMY OF ANGIOSPEMRS AND ECOLOGY (PRACTICAL)**		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 96**
CE (Continuing evaluation based on Review of Scientific Literature)		

COURSE CONTENT

(i) Seasonal collection of local flora, processing, herbarium management.
(ii) Study of phenology of some common weeds.
(iii) Study of seed, endosperm, embryo and seedling morphology, study of leaf diversity including venation and vein islets in relation to identification of different angiosperm species.
(iv) Work out of different angiospermic plants (fresh and dry), their identification using literature and preparation of artificial keys, study of the trend of floral evolution of some locally available plants following some specific biota.
(v) Determination of correct name of a species.
(vi) Construction of dendrogram or phenogram from a given data on character states with the help of software.
(vii) Preparation of pollen slides, description of common palynomorphs, preparation of identification keys.
(viii) Study of Raunkiaer life forms and biological spectrum in field or from a given dataset.
(ix) Determination different biodiversity indices from a field or given data set (Shannon, Simpson, Brillouin, Peat, McIntosh, Association index, Similarity index, etc.)
(x) Physico-chemical analysis of soil in relation to organic carbon and N, P, K profile.
(xi) Determination of BOD and COD of a given sample.
(xii) Study of noise pollution in a congested area with a sound level meter.
(xiii) Measurement of slope, elevation and tree height with Abney Level.

Course code: DBOT-DSE-5G **PHYCOLOGY (PRACTICAL)**		
Credit: 2(1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 96**
CE (Continuing evaluation based on Review of Scientific Literature)		

COURSE CONTENT

(i) Survey on algal group of different ecological niche of surrounding locality.
(ii) Chromosomal study of Algae.
(iii) Study of different biochemical parameters (dissolved O_2, dissolved CO_2, pH, temperature and salinity in relation to different algal genera.
(iv) Culture and maintenance of algae in laboratory condition.
(v) Study of algal flora in a permanent habitat.
(vi) Study of cyanobacteria flora in rice field.
(vii) Standardization of extraction procedure of algal DNA.
(viii) Chemical study of algal extracts in water ecosystem.

Course code: DBOT-AECC-2A WEB TECHNOLOGY		
Credit: 2 (1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)]**	**Lecture hours: 64**

COURSE OBJECTIVE:

- Explain the evolution of Internet and the Web.
- Understand various services of Internet and WWW.
- Discuss the functions and features of the Web browsers and Search Engines.
- Differentiate the Websites based on the way they function and categorize them based on the content and the client it caters to.

COURSE LEARNING OUTCOMES:

- Students will be able to learn Web Technology in detail and apply them in daily activities.

COURSE CONTENTS

Unit 1: Web Technology- An Overview- Internet: History Features, Services and Protocols- WWW: History, Features, Web Servers, Web Clients; Web 2.0. Semantic Web, Cloud Computing.

Unit 2: Web Browsers and Services- History, Function, Features of Browsers (IE, Firefox, Chrome).

Unit 3: Websites- Tools and Techniques; Types of Websites, Web contents, Static web contents, Dynamic Web Contents.

Unit 4: Search Engines- Types, Features, Function, Evaluation-Search Algorithms- Security Issues Database Connectivity.

Course code: DBOT-AECC-2B INTELLECTUAL PROPERTY RIGHTS		
Credit: 2 (1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)]**	**Lecture hours: 64**

COURSE OBJECTIVES:

- Understand the need and importance of IP.

- Give a brief idea about IPR and related rights.
- Learn about different organization working in IP in India and abroad.
- Analyse the legal issues, challenges and protection related to IP.
- Learn about the government initiatives and policies to protect IP.

COURSE LEARNING OUTCOMES:

- Students will be able to understand about Intellectual Property Rights (IPR) and apply the knowledge while filing their patents and copyrights.

COURSE CONTENTS

(i) Intellectual Property Rights: Concept, definition, purpose and functions of IPR, significance in the present scenario, some important examples of IPR protection of IPR.
(ii) Different Types of IPR: Copyrights and related rights, Patents, Trade Marks, Industrial Designs, Geographical Indications, Traditional Knowledge, Plant Variety Protection, Biological Diversity, Protection of Integrated Circuits Layout Design, Protection of Undisclosed Information.
(iii) Leading International Laws on IPR: Berne Convention, Universal Copyright Convention, Role of WIPO and UNESCO related to IPR.
(iv) Management of IP: IP Policies, Licensing, Legal Issues, Commercialization of IPR in Internet age.
(v) IPR in Digital Environment: Need and uses, electronic resources licensing, rules and laws governing IPR in India and abroad its development and amendments-Plagiarism- DRM.

Course code: DBOT-GE-1A **HIMALAYAN TEA SCIENCE**

GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 64**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJECTIVES:

This course aims to introduce the students with complete and details account of Himalayan tea science and related technologies. They will be familiar with History, Geographical distribution Climate for tea cultivation, its prospects etc. They will be taught with different varieties of tea, genetic diversity of tea plants, its qualitative and quantitative traits of tea plants. This course also attempts to teach them physiology of tea, integrated tea pest and diseases managements, weed managements, soil and integrated nutrient management, organic farming and vermiculture etc. They will be taught the management of tea gardens like plucking, processing, packaging and marketing of Tea; pharmacology-chemical components in tea leaf, controlling quality of tea.

COURSE LEARNING OUTCOMES:

- Students will learn the history, Climate for cultivation, Geographical distribution, plantations, scope and prospects of tea cultivation in Himalayan region, Morphology and anatomy of Tea plants.
- They will know about genetic diversity of tea plants; Qualitative and quantitative traits of

tea plants; varieties of tea, clones of different tea growing area (with special reference to Himalayan region), selection of vegetative clones.

- Students will know how to how to do land preparation, catchment planning, terracing, layout and style of planting, spacing, pits and trenches for tea planting, planting material and techniques, maintenance and management of tea plants.
- They will be able to develop idea on different aspects of shade trees, tea- irrigation and drainage system.
- They will develop practical knowledge and experience on integrated tea pest and diseases managements including- cultural practices, chemical control, Biological control, Weed management, integrated weed management techniques, soil and integrated nutrient management etc.
- Ultimately they will have practical experience regarding different aspects of cultivation and processing, quality control and marketing of tea and will be familiar with the industry.

COURSE CONTENTS

(i) History of tea, Climate for tea cultivation, Geographical distribution of tea plantations, scope and prospect of tea cultivation in Himalayan region, Morphology and anatomy of Tea plants.
(ii) Genetic diversity of tea plants; Qualitative and quantitative traits of tea plants; varieties of tea, clones of different tea growing area (with special reference to Himalayan region), selection of vegetative clones.
(iii) Land preparation, catchment planning, terracing, layout and style of planting, spacing, pits and trenches for tea planting, planting material and techniques.
(iv) Planting, maintenance and management of tea plants (Management of young and mature tea plants), photoperiodism, dormancy of seeds and buds; winter and inter-flush dormancy.
(v) Shade trees- importance and common species; water management in tea- irrigation and drainage system.
(vi) Integrated tea pest and diseases managements- cultural practices, chemical control, sex pheromones, insect growth regulators, Biological control.
(vii) Weed managements, integrated weed management techniques; soil and integrated nutrient management, organic farming and Vermiculture.
(viii) Plucking, processing, packaging and marketing of Tea; Tea pharmacology-chemical components in tea leaf and their alteration during processing; controlling Quality of tea.

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 64**

COURSE CONTENTS

(I) Morphological and anatomical study of Tea plants
(II) Characterization of different varieties of tea (with Special ref to Himalayan region)
(III) Qualitative &/ quantitative estimation of different phytochemicals of tea
(IV) Study of shade trees
(V) Study and identification of common tea pest and diseases
(VI) Study of common tea garden weeds
(VII) Study of physicochemical properties of tea soil
(VIII) Visit to tea gardens and factory for studying plucking, processing, packaging etc.
(IX) Pharmacognostic study of tea leaf/ Quality controlling

Course code: DBOT-GE-1B **BIOINFORMATICS**

GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 64**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJECTIVES:

Bioinformatics is an interdisciplinary field chiefly concerned with the development of methods and employment of software application towards understanding biological problems and analysis of biological data. The course has become particularly important after the advent of a range of genome projects. Therefore, Bioinformatics would serve as an integrated field for studying the mystery of life. Students will also learn about the fundamentals of bioinformatics including biomolecular sequence analysis, proteomics, genomics, metabolomics and cheminformatics.

COURSE LEARNING OUTCOMES:

- Pupils will gain insights on the concept and history of bioinformatics including the varied database resources and file formats of biomolecular sequences.
- Students will gain knowledge regarding the concept and different tools used in bioinformatics in addition to the different approaches of biomolecular sequence analysis, phylogenetic methodologies and sequence based database searches.
- The learners will have an in-depth knowledge about proteomics, genomics, microarray technique and metagenomics.
- The pupils would also have a basic understanding of metabolomics and cheminformatics, aiding in novel approaches to computer based drug designing.

COURSE CONTENTS

Introduction to Bioinformatics

i. Bioinformatics– an overview, definition and history; evolution of bioinformatics, scope and potential of bioinformatics, Human Genome Project.
ii. Biological databases: NCBI, EMBL, PIR, SWISS-Prot, PubChem, KEGG-Pathway, ChEMBL, Binding (DB); analysis of 3-D structure of proteins, RCSB-PDB, primary and secondary database.
iii. File formats of bio-molecular sequences: GenBank, Fasta, GCG, Msf, Nbrf-Pir etc.; concepts of sequence similarity, identity and homology, definitions of homologues, orthologues and paralogues.

Bio-molecular sequence analysis

i. Pairwise and multiple sequence alignments: basic concepts of sequence alignment, use of pairwise alignments and multiple sequence alignment for analysis of nucleic acid and protein sequences and interpretation of results (Codon usage pattern).
ii. Sequence based database searches: What is sequence based database searches? Blast and fasta algorithms, various versions of basic Blast and Fasta.
iii. Phylogeny: phylogenetic analysis, definition and description of phylogenetic trees and various types of trees, method of construction of phylogenetic trees [distance based method (Upgma, Nj), maximum parsimony and maximum likelihood method].

Proteomics

i. Prediction of protein structure from sequences, homology modelling, functional sites, protein folding problem, secondary structure analysis and prediction, motifs, profiles, patterns and fingerprints search, protein structural databases (pdb), purpose of 3-D structure comparison and concepts, RMSD, Z-score.
ii. Molecular interaction fields and docking, concept of active site of enzymes, protein-protein and protein-ligand docking; basics of molecular simulation, computer aided drug designing.

Genomics

i. Genomics: Genome annotation, genome assembly, structural and functional genomics, comparative genomics.
ii. Microarray technique, design, analysis and drug target identification.
iii. Metagenomics: Introduction, metagenome, shotgun metagenomics (Pyrosequencing), tools in metagenomics, MEGAN, MG-RAST seed, application in gene survey, environmental genomes and microbial diversity.

Metabolomics

i. Metabolic pathway database (Kegg pathway database), concept of metabolome and metabolomics.
ii. Drug discovery and design: target identification, target validation, lead identification, lead optimization, preclinical pharmacology & taxology.

Cheminformatics

i. Cheminformatics: Cheminformatics tools for drug discovery, chemical structure representation (SMILE & SMART), ADMET, Lipinski's rule of five.
ii. Chemical databases: CSD, ACD, WDI, ChemBank, hazardous chemical database and PubChem.

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 64**

COURSE CONTENTS

(i) Sequence retrieval from database and alignment.
(ii) Method of construction of phylogenetic trees [distance based method (Upgma, Nj), maximum parsimony and maximum likelihood method].
(iii) Prediction and analysis of protein structure from sequences.
(iv) Applications of BLAST.
(v) Physicochemical characterization of drug molecules.
(vi) Molecular docking.
(vii) ADMET study.
(viii) Employment of KEGG pathway database and PDB.

Course code: DBOT-GE-1C
ANALYTICAL TECHNIQUES

GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 64**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJECTIVES:

This paper aims to introduce theoretical aspects of imaging, radiolabeling, biophysical, biochemical and molecular techniques that are being exploited in research in biological sciences. After successful completion of the course the students could apply these techniques in their research dimensions paralleled with accurate analysis of the results obtained.

COURSE LEARNING OUTCOMES:

- Students will understand the concepts, techniques and usages of various techniques used in biological science.
- The pupils would get a fair idea of the applications related to molecular biology and recombinant DNA technology.
- The learners would gather knowledge about histochemical and immunotechniques. The students would get acquainted with imaging and radio-labelling techniques associated with biology.
- The pupils are expected to be well informed of biophysical and statistical methods for error free interpretation of obtained results.
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COURSE CONTENTS

(i) Molecular Biology and Recombinant DNA methods: Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods, analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, Isoelectric focusing gels; Molecular cloning of DNA or RNA fragments in bacterial systems; Expression of recombinant proteins using bacterial, animal and plant vectors; Isolation of specific nucleic acid sequences; Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors; in vitro mutagenesis and deletion techniques; Protein sequencing methods, detection of post translation modification of proteins; DNA sequencing methods, strategies for genome sequencing; Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques; Isolation, separation and analysis of carbohydrate and lipid molecules; RFLP, RAPD, AFLP, RT-PCR and DNA barcoding techniques; Brief knowledge about CRISPER CAS technique.

(ii) Histochemical and Immunotechniques: Antibody generation, Detection of molecules using ELISA, RIA, Western blot, immunoprecipitation, flow-cytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

(iii) Biophysical Method: Molecular analysis using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy; molecular structure determination using X-ray diffraction and NMR; Molecular analysis using light scattering and different types of mass spectrometry.

(iv) Statistical Methods: Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); Sampling distribution; Difference between parametric and non-parametric statistics; Confidence interval; Errors; Levels of significance; Regression and Correlation; t-test; Analysis of variance; X^2test; Basic introduction to Multivariate statistics, etc.

(v) Radiolabelling techniques: Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines; laws of radioactivity, radioactive carbon dating and application of radioactive isotopes in biological systems.

(vi) Microscopic techniques: Visualization of cells and sub-cellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, image processing methods in microscopy.

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 64**

COURSE CONTENTS

(i) Isolation of genomic DNA.
(ii) Isolation of plasmid DNA.
(iii) DNA barcoding.
(iv) UV/Vis spectroscopic analysis.
(v) Regression and Correlation analysis.
(vi) T-test calculations.
(vii) Usage of SPSS.
(viii) Employment of TLC and Column chromatography.
(ix) Microscopic techniques.

SEMESTER IV

Course code: DBOT-CC-8 PLANT ANATOMY, DEVELOPMENT AND BIORESOURCE UTILISATION

GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 64**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJECTIVES:

This course is designed to understand the comparative Anatomy as a modern botanical discipline, discuss the physiological and anatomical classification of plant tissue. Course helps the students to explore the idea about the development of wood in relation to different environmental factors and control of tissue differentiation, provide the students with the overview of plant and civilization, acquire the knowledge of plant as a source of renewable energy and understand the principles of plant breeding, polyploidy and genetic variability also the chemistry and the application of different medicinal plants.

COURSE LEARNING OUTCOMES:

- By the end of the course the students should be able to
- Evaluate Anatomy as a modern discipline.
- Assess the physiological and anatomical classification of plant tissue.
- Evaluate the control of tissue differentiation.
- Know about the development of wood in relation to environmental factors.
- Learn about the overview of plant and civilization and plant as a source of renewable energy.
- Explain the principles of plant breeding.
- Learn about polyploidy and genetic variability.
- Know about chemistry and application of *Swertia, Gloriosa, Digitalis*, *Taxus*, *Stevia*, *Chlorophytum* and *Podophyllum*.

COURSE CONTENT

Plant Anatomy and Development:

(i) Anatomy as a modern discipline; physiological-anatomical classification of plant tissue.
(ii) Development of root, shoot and leaf in higher plants.
(iii) Control of tissue differentiation

(iv) Anomalous secondary growth and mechanical tissue development

Bioresource Utilisation

(i) Plant and civilization- centre of origin, botany, utilisation, cultivation and improvement of food plants, drugs and fibre.
(ii) Plant as a source of renewable energy,
(iii) Traditional knowledge: Ethnological resources in India; documentation and utilization of ethnic knowledge;
(iv) Principles of plant breeding, conventional methods, non-conventional methods, polyploidy, genetic variability.
(v) Chemistry and application of *Swertia*, *Gloriosa*, *Digitalis*, *Taxus*, *Stevia*, *Chlorophytum* and *Podophyllum*.

GROUP: B (PRACTICAL)	
Credit: 1	**Full marks: 25 Lecture hours: 64**

(i) Study of nodal anatomy
(ii) Wood maceration from soft and hard tissues.
(iii) Anatomical study of different plant materials in relation to ecological adaptations
(iv) Study of secretary tissues
(v) Emasculation and hybridization technique in self and cross pollinated crops.
(vi) Microscopic and macroscopic analysis of crude drugs related to theory syllabus.
(vii) Artificial pollination in self-pollinated crops.
(viii) Demonstration of fiber production of Himalayan Nettle plants.
(ix) Morphological and cytological characterization of polyploid crops.
(x) Educational tour related to drug yielding plant along with a field visit to local herbal healers of hilly areas of North Bengal.

Course code: DBOT-CC-9
ECOLOGY AND BIOSTATISTICS

GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 64**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJECTIVES:

The first part of the course i.e. ecology intends students to distinguish between species, population, communities, ecosystems biomes and understand the factors that affect population size, density, distribution, and dynamics. Moreover, this course has been designed to inculcate the knowledge of plant biodiversity, speciation and effects of different kinds of pollution on the organisms including

both plants and animals and their remedial measures. The second part of the course describes the role and uses of biostatistics in plant science experiments and researches.

COURSE LEARNING OUTCOMES:

- Students will acquire knowledge about the structural and functional aspects of ecosystem, in terms of different ecological processes operating between environment and biotic components.
- Students will know the process of adaptation of plants to new as well as adverse environmental conditions.
- Students will gain knowledge about the pollution and related environmental issues and their effects and remedial measures.
- Students will acquire knowledge about biodiversity, their importance and conservation strategies.
- Students will know the basic concepts of biostatistics and their role in the interpretation of biological experiments and researches.

COURSE CONTENTS

(i) Pollution: parameters, regulation and genetics; community: concept, structure, dominance, fluctuations, succession.
(ii) Interaction between environment and biota, concept of habitat and niche, limiting factors, energy-flow, food chain, food web and trophic level, ecological pyramids, biogeochemical cycles of Nitrogen, Phosphorous, Sulphur, Calcium, Carbon, Carbon-Silicate, Arsenic cycle in water.
(iii) Adaptation of wetland plants, plants on serpentine soil, phytoremediation, metallophytes, geobotany, cavernicolous life.
(iv) Air, water, soil and radioactive pollution sources, consequences and effect on biodiversity, different control measures.
(v) Global environmental issues– global warming, green-house effect and Goldilock's phenomenon, degradation mechanism, Montreal and Kyoto protocol, modern technology and environment, dams and rivers, climatic changes, population explosion, sustainable development, the Great Flood in old literatures, environmental impact assessment and PAP.
(vi) Biodiversity–type, causes of decline and extinction, bio-invasion and Blitzkrieg hypothesis, Case study of Dodo and Martha; importance of biodiversity, conservation, MA/b, keystone species and umbrella species, flagship species, biodiversity and ecosystem stability, hotspots, Brazilian rain-forest and Chico Mendes, Earth summit.
(vii) Population, statistics, data, mean, median, mode, SD, co-efficient of correlation, regression, ANOVA, probability, χ^2test, T test, F test, construction of dendrograms.

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 64**

COURSE CONTENTS

(i) Determination of frequency, density and abundance in field by quadrat method or from a given dataset.
(ii) Determination of soil pH, soil texture, moisture content and soil humus of a supplied sample.
(iii) Quantitative estimation of dissolved oxygen and carbon dioxide of supplied water sample.
(iv) Determination of SD, co-efficient of correlation, regression, ANOVA, χ^2test, T test, F test.
(v) Construction of dendrograms with the help of software.

Course code: DBOT-DSE-6A to 6G
DISSERTATION /REVIEW
Credit: 2 (1.68 + 0.32)
Full marks: 50 [42 (Practical) + 8 (CE/Seminar/Presentation)]
Lecture hours: 96

DBOT-DSE-6A (CYTOGENTICS)
DBOT-DSE-6B (MICROBIOLOGY)
DBOT-DSE-6C (MYCOLOGYAND PLANT PATHOLOGY)
DBOT-DSE-6D (PLANT PHYSIOLOGY AND BIOCHEMISTRY)
DBOT-DSE-6E (PLANT BIOCHEMISTRY AND MOLECULAR BIOLOGY)
DBOT-DSE-6F (TAXONOMY OF ANGIOSPEMRS AND ECOLOGY)
DBOT-DSE-6G (PHYCOLOGY)

Course code: DBOT-SEC-2A
BIOFERTILIZER AND AGRICULTURAL PRACTICES

Credit: 2 (1.68 + 0.32) **Full marks: 50 [42 (T) + 8 (CE)** **Lecture hours: 64**

COURSE OBJECTIVES:

This course aims to increase understanding of the students about classification and importance of biofertilizers. This course aims to increase understanding of the students about the quality control and marketing aspects of the biofertilizers. This course deals with the knowledge of important microbes used in crop cultivation.

COURSE LEARNING OUTCOMES:

- After completion of the course the learners will be able to elucidate different types of fertilizers using biological organisms.
- The learners will be able to apply the knowledge gained in utilization of biofertilizers in organic farming.
- The students will develop practical skills on growth and crop yield.

COURSE CONTENTS

(i) Introduction, History and concept of Biofertilizer, status scope and importance of Biofertilizers, classification of Biofertilizers, Nitrogen fixation.
(ii) *Rhizobium*-identification, isolation, mass multiplication and carrier based inoculants; Actinorrhizal symbiosis.
(iii) *Azotobacter*, maintenance and mass multiplication, characteristics, classification, *Azospirillum*, characteristics, isolation and mass multiplication-carrier based inoculants.
(iv) Cyanobacterial biofertilizer- *Anabaena*, *Nostoc*, *Hapalosiphon*, Blue green algae and *Azolla* in rice cultivation.
(v) Structure and characteristic features of fungal biofertilizer, types of mycorrhizal association, colonization of VAM-isolation and inoculum production of VAM and its influence on growth and yield of crop plants.
(vi) Storage, shelf life, quality control and marketing, Factors influencing the efficacy of Biofertilizers, Green manuring, method of vermi-composting-Application in field.

Course code: DBOT-SEC-2A

MEDICINAL PLANT CULTIVATION		
Credit: 2 (1.68 + 0.32)	**Full marks: 50 [42 (T) + 8 (CE)**	**Lecture hours: 64**

COURSE OBJECTIVES:

This course attempts to introduce the students with different aspects of medicinal plants- past and present status, importance, different aspects of cultivation, storage, processing, quality control etc. They will be taught about the important indigenous medicinal plant. Students will be made familiar with different national bodies related to promotion of medicinal plant cultivation, marketing and conservation etc. and they will be given the outlines of different technologies for processing and production of different phytochemicals having medicinal properties. Ultimately this course attempts to develop skilled human recourse for cultivation, processing, marketing and conservation of medicinal plants.

COURSE LEARNING OUTCOMES:

- Students will know about past and present of Medicinal plants and their importance.
- They will be familiar with taxonomy, morphology, distribution of important medicinal plants.
- They will learn about the cultivation of important medicinal plants, harvesting, storage and preservation, and quality control and they will develop expertise in it.
- They will learn about different organization related to promotion of medicinal plants cultivation, marketing, production technologies, conservation etc.
- Through the project work they will be able to develop some skill in this field and will be familiar and close to the herbal industries.

COURSE CONTENTS

(i) Medicinal Plants – past and present status in world and India. Diversity of medicinal plants & local healthcare. Medicinal plant conservation – issues and approaches. Medicinal plant conservation areas (MPCA), Non-timber forest products (NTFP), Good Agriculture Practices (GAP); Indian Himalayan region (IHR).

(ii) Promotion of medicinal plant sector at national level: National Medicinal Plant Board and State Medicinal Plant Boards- objectives and functions. Demand and supply of medicinal plants; Herbal industries.

(iii) Important medicinal plants of India with their systematics, geographical distribution and uses. *Andrographis paniculata*, *Adhatoda vasica*, *Abrus precatorius*, *Aloe vera*, *Swertia chirata*, *Stevia rebaudiana*, *Atropa belladonna*, *Cinchona* and *Withania somnifera*.

(iv) Production technology for Medicinal plants- *Solanum*,Isabgol, Poppy, Safed musli, *Stevia rebaudiana*, *Mucuna pruriens*, *Ocimum* sp.

(v) Post-harvest handling – Drying, Processing, Grading, Packing and Storage, processing and value addition; GMP and Quality standards in herbal products.

Course code: DBOT-GE-2A ETHNOBOTANY

GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 64**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJECTIVES:

Exploring how these plants are utilized for food, clothing, shelter, fuel, fodder, and furniture, as well as how their therapeutic uses relate to other aspects of the plant species, is the goal of ethnobotanists. It mainly focuses on the study of a region's plants along with the practical knowledge of those plants with the help of the traditional knowledge of local people and their culture.

COURSE OUTCOMES:

- Studies on ethnobotany can shed light on how communities locally interact with their natural resources.
- For accurate recording of local knowledge regarding therapeutic herbs.
- Preservation of oral tradition based herbal plant knowledge.
- Protect our national treasure before it disappears.

COURSE CONTENT

(i) Ethnobotany: Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of Eastern Himalaya and India and their life styles. Plants used by the tribals: (a) food plants (b) intoxicants and beverages (c) resins and oils (d) aromatic and miscellaneous uses.

(ii) Methodology of Ethnobotanical Studies: Field work, Herbarium, Ancient Literature, Archaeological findings, temples and sacred places.

(iii) Role of ethnobotany in modern Medicine: Medico-ethnobotanical sources in India; Significance of the following plants in ethno botanical practices (along with their habitat and morphology)
(a) *Azadirachta indica* (b) *Ocimum sanctum* (c) *Vitex negundo* (d) *Glorisa superba* (e) *Tribulus terrestris* (f) *Pongamia pinnata* (g) *Cassia auriculata* (h) *Indigofera tinctoria*

(iv) Role of ethnobotany in modern medicine with special example – *Rauvolfia serpentina, Trichopus zeylanicus, Artemisia, Withania*.

(v) Role of ethnic groups in conservation: Conservation of plant genetic resources, Endangered taxa and forest management (participatory forest management); sustainable development, sacred groves. Ethnobotany and legal aspects: Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 64**

COURSE CONTENT

(i) Survey and documentation of different categories of Plants used by the tribals - a) Food plants b) intoxicants and beverages c) oils and aromatic.

(ii) Survey of available literature, visit to temples and other religious places in search of ethnoreligious plants and belief.

(iii) Study of habitat and morphology of locally available ethno-medicinal plants: (a) *Azadiractha indica* (b) *Ocimum sanctum*, (c) *Bergenia ciliata*(d) *Artemisia vulgaris*(e) *Drymaria cordata*.

(iv) Development of Questionnaire for ethnobotanical survey.

(v) Survey and documentation of biodiversity of nearby sacred groves/forests.

(vi) Phytochemical analysis of some ethnobotanical plants: nutrient contents, antioxidant activity,

therapeutic substances etc.

(vii) Preservation of voucher specimens for ethnobotanical study

Course code: DBOT-GE-2B CONSERVATION BIOLOGY

GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 64**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJECTIVES:

This course helps the students to know about the diverse use of bioresources and its conservation and cause of over exploitation of bioresources and the management of degraded soil resources, methods to control soil erosion and conservation of soil factors affecting the soil erosion. Explore the students with the knowledge of renewable and non-renewable resources, causes and consequences of deforestation vital role of individual and organization in conservation of natural resources. Students are able to understand various threats of biodiversity and strategies for conservation.

COURSE LEARNING OUTCOMES:

- By the end of the course students should able to-
- Gain a deeper knowledge about conservation of bioresources and its causes of overexploitation.
- Understand the methods to control soil erosion and conservation of different factors affecting the soil erosion.
- Explore with the ideas of causes and consequences of deforestation and role of individual to control it.
- Understand the various threats of biodiversity and strategies for conservation.
- Explore with knowledge of biodiversity protection laws, wildlife protection acts etc.

COURSE CONTENTS

(i) Bioresources: Diverse uses of bioresources; importance of conservation; causes of over exploitation of bioresources.

(ii) Management of degraded soil resources: Degradation, erosion and conservation of soil; factor affecting soil erosion; methods to control soil erosion; reclamation of soil; phytoremediation.

(iii) Overexploitation of Resources: Renewable and non-renewable resources; deforestation: causes and consequences; role of an individual and organizational efforts in conservation of natural resources.

(iv) Biodiversity: concept, threat and conservation: Overexploitation, fragmentation, habitat loss, poaching of wildlife; Hotspots, endemism, captive breeding, in situ and ex situ conservation.

(v) Management of biodiversity: Organizations associated with biodiversity management methodology for execution, IUCN, UNESCO, UNEP, WFF and NBPGR; Environmental impact assessment (EIA), Social impact assessment (SIA), Geographical information system (GIS), Ecological footprint with more emphasis on Carbon footprint; Waste management.

(vi) Biodiversity protection laws: National legislations: Wildlife protection acts and amendments, Biodiversity act 2002-rules and their amendments, Wildlife protection act-1972; Forest

(Conservation) act, 1980; Case studies relevant to resource management and conservation [example- World heritage sites (natural)/ Sacred groves/ Biodiversity heritage sites/ Protection of plant varieties].

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 64**

COURSE CONTENT

(i) Experimental analysis: Measurement of rainfall, air temperature, wind speed, humidity, dissolved Carbon dioxide, BOD, COD, Water turbidity, pH, conductivity of water, TDS, TSS, SPM.
(ii) Demonstration- UV-Vis spectrophotometer, AAS, Kjeldahl apparatus, HPLC, PCR, PAGE.
(iii) Determination of Ascorbic Acid using iodometric titration.
(iv) Vegetation mapping and nested Quadrate analysis.
(v) Study of campus flora and fauna.
(vi) Study of nearby forests and wetlands.
(vii) Case-studies related to degraded ecosystem from mining and deforestation.
(viii) Local industry visits.
(ix) Identification of Mangrove/Intertidal mud-flat flora-fauna.

Course code: DBOT-GE-2C PHARMACOGNOSY		

GROUP: A (THEORY)		
Credit: 2	**Full marks: 50**	**Lecture hours: 64**

Continuing evaluation (CE)	
Credit: 1	**Full marks: 25**

COURSE OBJECTIVES:

This course helps the students to gain fundamental knowledge about the history and scope of Pharmacognosy, including the indigenous system of medicine. Explore the students with the traditional system of medicine and techniques for drug evaluation, different methods for extraction of drugs and quality control of plant drugs. Gain the detailed study about adulteration of natural drugs, occurrence, distribution and uses of different medicinal plants and phytochemistry of secondary metabolites of different medicinal plants.

COURSE OUTCOMES:

By the end of the course the students should able to-

- Understand the definition history and scope of Pharmacognosy.
- Gain the knowledge about traditional and indigenous system of medicine.
- Explore the ideas of organized and unorganized drugs and classification of drugs
- Know about adulteration of natural drugs and evaluation of drugs by organoleptic, microscopic, physical, chemical and biological methods.
- Understand the detailed study of occurrence, distribution, pharmacological and uses of the

medicinal plants such as Swertia chirata, Urtica dioica, Ocimum sanctum etc.

- Know about different methods of extraction of drugs quality control of drugs classical and modern approaches.
- Understand the phytochemistry and importance of alkaloids
- Understand about the definition, properties and classification of drugs constituents and their uses.

COURSE CONTENTS

(i) Introduction: Definition, history, and scope of Pharmacognosy including indigenous system of medicine. Pharmacognosy in various system of medicine: Role of Pharmacognosy in traditional systems of medicine namely Ayurveda, Unani, Siddha, Homeopathy and Chinese systems of medicine.

(ii) Organized drugs and unorganized drugs (dried latex, dried juices, dried extracts, gums and mucilaginous, oleoresins) Classification of Drugs: Alphabetical, morphological, taxonomical, chemical, pharmacological and chemotaxonomical classification of drugs.

(iii) Adulteration of drugs of natural origin, drug evaluation by organoleptic, microscopic, physical, chemical and biological methods.

(iv) Detailed study of occurrence, distribution and pharmacological aspect and uses of the following medicinal plants: *Swertia chirata*, Urtica dioica, Ocimum sanctum, *Azadirachta indica*, *Artemisia vulgaris, Rauvolfia serpentina*, *Cinchona*, *Papaver somniferum, Atropa belladonna, Camellia sinensis.*

(v) Different methods of Extraction of drugs, Quality control of plant drugs: Classical and modern approaches.

(vi) Phytochemistry and Importance: Alkaloids: Definition, properties, classification, drugs *Rauwolfia, Catharanthus*, *Datura*-constituents and uses; Volatile oils: Composition, drugs *Eucalyptus, Citronella, Mentha;* Phenolic compounds: Types, activity, drugs- *Senna, Hypericum*; Glycosides-General Account, Cyanogenic glycosides and glucosinolate compounds.

GROUP: B (PRACTICAL)		
Credit: 1	**Full marks: 25**	**Lecture hours: 64**

COURSE CONTENT

(i) Determination of Ash values of a crude drug.
(ii) Determination of volatile oil content of a crude drug.
(iii) Isolation of Curcumin from turmeric.
(iv) Isolation of caffeine form tea.
(v) Extraction of Aloin from *Aloe*.
(vi) The chemical Examination of crude drugs.
(vii) General procedure for the detection of alkaloids in crude drugs.
(viii) The techniques of paper chromatography.
(ix) Field Study of Medicinal Plants

SUGGESTED READINGS

Microbiology

1. Bacterial Metabolism – G. Gottschalk (Springer).
2. Biochemistry – L. Stryer (WH Freeman).
3. Brock Biology of Microorganisms – MT Maldigan, JM Martinko and J Parker (Prentice Hall International).

4. Essay in Microbiology – JR Norris and MH Richmond, eds. (John Wiley & Sons).
5. Food Microbiology – MR Adams and MO Moss (The Royal Society of Chemistry, Cambridge).
6. General Microbiology – BD Davis, R Dulbecco, HN Eisen and HS Ginsberg (Harper & Row).
7. General Microbiology – HG Schlegel (Cambridge University Press).
8. General Microbiology – RY Stanier, EA Adelberg and JA Ingrahm (MacMillan).
9. Introduction to Modern Virology – NJ Dimmock and SB Primrose (Blackwell Science).
10. Microbial Biotechnology: Fundamentals of Applied Microbiology – AN Glazer, H Nikaido (WH Freeman).
11. Microbiology – M.J. Pelczr, Jr, ECS Chan and NR Krieg (Tata Mc-Graw Hill).
12. Microbiology Physiology – AG Moat and JW Foster (John Wiley & Sons).
13. Molecular Biology of the Gene – JD Watson, NH Hopkins, JW Roberts, JA Steiz and AM Weiner (Benzamin – Cummings).
14. Physiology and Biochemistry of Prokaryotes – D. White (Oxford University Press).
15. The Prokaryotes: A Handbook on the Biology of Bacteria, Ecophysiology, Isolation, Identification and Application, Vol. 4 – A Balows, HG Truper, M Dworkin, W Harder and K.H. Schleifer, eds. (Springer-Verlag).
16. Bergey's Manual of Systematic Bacteriology, Vol 1-4 – NR Krieg and JG Holt, eds. (Williams and Mikins).
17. Encyclopaedia of Microbiology, Vol. 1 – 4 – J Lederberg, ed. (Academic Press).

Mycology

1. Fungal Biology – Jennings &Lysek (Bios Scientific Publisher).
2. Introduction to Mycology – J. Webster (Cambridge University Press, London).
3. Introductory Mycology – C.J. Alexopoulos and C.W. Mims (Willey and Sons, New York).
4. Modern Mycology – J.W. Deaca (Blackwell Scientific Publishers).
5. Physiology of Industrial Fungi – D.R. Berry (Blackwell Scientific Publisher).
6. The Fungi – Carlili, Watkinos, & Gooday (Academic Press).
7. The Fungi an Advance Treaties – C.G. Ainsworth, F.R. Sparrow and A.S. Sussman (Academic Press, New York).

Plant Pathology

1. Introduction to Plant Disease Epidemiology – CL Campbell and LV Meden (Wiliey and Sons, New York).
2. Plant Diseases – R.S. Singh (New Age India, New Delhi).
3. Plant Pathology – G.N. Agrios (Academic Press).
4. Plant Pathology – R.S. Mehrotra and A. Agarwal (Tata Mc-Graw Hill, New Delhi).

Taxonomy of Angiosperms

1. A Hand Book of Field & Herbarium Methods – S.K. Jains and R.R. Rao (Today and Tomorrow Printers Publishers).
2. A Hand Book of Field & Herbarium Methods – S.K. Jains and R.R. Rao (Today and Tomorrow Printers Publishers).
3. An Advanced Text Book on Biodiversity: Principles and Practice – K.V. Krishnamurty (Oxford & IBH Publishing Co. Pvt. Ltd.).
4. An Aid to the International code of Botanical Nomenclature – A.N. Henry and M. Chandrabose (Today & Tomorrow's Printers and Publishers).
5. An Introduction to Plant Taxonomy – C. Jeffrey (Cambridge University Press).
6. Cladistics: The Theory and Practices of Parsimony Analysis – I.J. Kitching, P.L. Forey C.J. Humphires, D.M. Williams (Oxford University Press).
7. Classification of Flowering Plants, Vol I & II – A.B. Randle.
8. Diversity and Classification of flowering Plants – A. Takhtajan (Columbia University Press, New York).
9. Phylogeny and Evolution of angiosperms – D.E. Solitis, P.S. Solitis, P.K. Endress and M.W. Chase (Sina Associates, Inc. Publishers Sunderland Massachusetts).
10. Plant systematic: A Phylogenic Approach, W.S. Judd C.S. Cambell, E.A. Kellogg, P.F. Steven and Donoghue, Sinatier Associates Inc. USA.
11. Plant Systematics: Jones &Luchsinger, Mc Graw- Hills Book Co. New York.
12. Plant Systematics: M.G. Simpson, Elsevier Academic Press.

13. Plant Systematics: Theory & Practice: G. Singh, Oxford & IBH Publishing Co. Ltd., New Delhi.
14. Plant Taxonomy and Biosystematics: C.A. Stace, Edward Arnold, London.
15. Principles of Angiosperm Taxonomy: Davis & Heywood, Oliver &Bayd, London.
16. Taxonomy of Angiosperms – V.N. Naik (Tata Mc-Graw Hill, New Delhi).
17. Taxonomy of Vascular Plants – G.H.M. Lawrence (Oxford & IBH Publishing Co. Pvt. Ltd.).

Biophysics and Instrumentation in Biological Analysis/Analytical Techniques

1. ABC of Research Methodology and Applied Biostatistics by M.N. Parikh and NithyaGogtay.
2. Analytical Techniques in Plant Sciences by Dr.Sanjeeb Kumar Nath.
3. Biological Instrumentation and Methodology (Tools & Techniques in Biology) by Dr. P.K. Bajpai.
4. Concepts of Laboratory Techniques in Biology by Kiran Singh, Manish Sharma and Vinay Oraon.
5. Techniques in Molecular Biology by Suraksha Agrawal.
6. Tools, Techniques and Assessment in Biology by John Adds, Erica Larkcom, Ruth Miller and Robin Sutton.
7. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology.

Ecology/Environmental Biology

1. A Textbook of Plant Ecology – R.K. Sukla and P.S. Chandel (S. Chand).
2. Concept of Ecology – EJ Kormondy (Prentice Hall).
3. Concept of Ecology – R.L. Smith.
4. Ecology – Chapman and Reiss (Cambridge University Press).
5. Ecology – M. Begon and J.L. Harper, C.R. Towsend (Blackwell Science).
6. Ecology and Environment – P.D. Sharma (Rastogi Publishers, Meerut).
7. Ecology: Concept and Application – M.C. Molles Jr. (Mc-Graw Hill Higher Education).
8. Ecology: Theories and Applications – P. Stiling (Prentice Hall of India Pvt.).
9. Environmental Problems and Solutions – D.K. Asthana and M. Asthana (S. Chand).
10. Environmental Science – S. Ray (A comprehensive Treaties on Ecology and Environment Publishing syndicate, Kolkata).
11. Environmental Science – S.C. Santra.
12. Fundamentals of Ecology – E.P. Odum.
13. Fundamentals of Ecology – MC Dash (Tata McGaw Hill)

Plant Physiology

1. Advanced Physiology – Welkins (Blackwell).
2. Introduction to Plant Physiology – Hopkins (Slim).
3. Plant Physiology – Taiz and Zeiger (Sinauer).

Biochemistry

1. An Introduction to Plant Biochemistry – Goodwin and Mercer (Academic Press).
2. Biochemistry – Berg, Tymoczho and Styer (W.H. Freeman).
3. Biochemistry – Voet and Voet (PanimaDisfrb).

Cytology and Genetics

1. Advanced Molecular Biology – R.M. Twyman (Viva Books Private Limited India).
2. An Introduction to Genetic Analysis – A.J. Grifiths, J.H. Miller, D.T. Suzuki, R.C. Lewontin and W.M. Gelbart (WH Freeman and Company, New York).

3. An Introduction to Plant Tissue Culture – K.K. De (New Central Book Agency, Kolkata, India).
4. Cell and Molecular Biology: Concepts and Experiments – G. Karp (John Wiley and Sons, Inc.USA).
5. Cell Biology – S.C. Roy and K.K. De (New Central Book Agency, Kolkata, India).
6. Essentials of Genetics – W.S. Klug and M.R. Cummings (Prentice Hall Upper Saddle River, New Jersey).
7. Essentials of Molecular Biology – G.M. Malacinski and D. Freifelder (Jones and Bartlett Publishers, Massachusetts, USA).
8. Evolution – M.W. Strickberger (Macmillan Publishing Co. Inc. New York).
9. Gene XI – B. Lewin (Oxford University Press, New York, USA).
10. Genetics – B.D. Singh (Kalyani Publishers, India).
11. Genetics – P.J. Russel (Benjamin/ Cummings Publishing Company Inc. USA).
12. Genetics – P.K. Gupta (Rastogi Publication, Meerut, India).
13. Genetics: Analysis of Genes and Genomes – D.L. Hartl and F.W. Jones (Jones and Bartlett Publishers Massachusetts, USA).
14. Genetics: Principles and Analysis – D.L. Hartl and F.W. Jones (Jones and Bartlett Publishers Massachusetts USA).
15. Genome 3 – T.A. Brown (Wiley Liss – A John Wiley & Sons Inc. Publication).
16. Molecular Biology of the Cell – B. Albert, D. Bray, J. Lewis, M. Raff, K. Roberts and J.D. Watson (Garland Publishing Inc. New York).
17. Plant Cytogenetics – R.J. Singh (CRC Press, New York).
18. Plant Tissue Culture Theory and Practice – S.S. Bhojwani and M.K. Razdan (Elsevier Science Publication, New York, USA).
19. Principles of Genetics – D.P. Snustad and M.J. Simmons (Johan Wiley & Sons Inc. USA).
20. Principles of Genetics – E.J. Gardner, M.J. Simmsons and D.P. Snustad (John Wiley & Sons Inc. USA).
21. The Cell: A Molecular Approach – G.M. Cooper and R.E. Hausman (Sinauer Associates, Inc. Sunderland, Massachusetts).
22. The Science of Genetics – A.G. Atherty, L.J.R. Griton, and J.F. McDonald (Saunders College Publishing, Fort Worth, USA).
23. The World of Cell – W.M. Becker, L.J. Keinsmith, and J. Hardin (Pearson / Benjamin Cummings, New York).
24. Plant Cell and Tissue Culture – I.K. Vasil and T.A. Thorpe (Kluer Academic Publishers, Netherland).
25. Plant Cell Culture – H.A. Colins ad S. Edwards (Bios Scientific Publishers, Oxford UK).
26. An Introduction to Plant Tissue Culture – M.K. Razdan (Oxford & IBH Publishing Co. Ltd. Kolkata).
27. Plant Propagation by Tissue Culture Vol. 1 and Vol. 2 – E.F. George (Exegeltic Limited, England).

Mushroom Technology

1. A hand book of edible mushroom, S.K Kannaiyan and K. Ramasamy (1980). Tomorrows printers and publishers, New Delhi.
2. Handbook on Mushrooms, Nita Bahl, oxford and IBH Publishing Co.
3. Mushroom Cultivation, Tripathi, D.P. (2005) Oxford and IBH Publishing Co. PVT. LTD, New Delhi.
4. Tewan and Pankaj Kapoor S.C. 1993. Mushroom cultivation. Mittal Publication. Delhi.
5. Mushroom Production and Processing Technology, Pathak Yadav Gour (2010) Published by Agrobios (India).

Floriculture

1. Bose, TK. Maiti RG, Dhua RS & Das P. 1999. Floriculture and Landscaping. Nayaprokash.
2. "Commercial Flowers" – Bose, TK and LP Yadav (Eds) 1988. NayaProkash.
3. Lauria A & Victor HR. 2001. Floriculture –Fundamentals and practices Agrobios.
4. Plant Propagation. Principles and Practices, Hartman, HT and Kester, D.E..1976, Prentice Hall of India Pvt. Ltd.
5. Plant Propagation. Sadhu, M.K.1996. New Age International Publishers, New Delhi.
6. Prasad S & Kumar U.2003.Commercial Floriculture. Agrobios.
7. Randhawa, G.S. and Mukhopadhyay, A. (1986). Floriculture in India. Allied Publishers.

8. Reddy S, Janakiram B, Balaji T, Kulkarni S & Mishra RL. 2007 High-tech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.
9. Text book on Floriculture and Landscaping, N. Roy Choudhury & H.P. Mishra.

Plant Disease & Pest Management

1. Principles of Plant Disease Management- Subhashini Sinha and Manjula Sharma,Campus Books International.
2. Principles of Plant Disease Management- William E. Fry, Academic Press.
3. Agrochemicals in Plant Disease Management- N.G. Ravichandra, Scientific Publishers.
4. Biological Control of Plant Diseases- S. B. Chincholkar; K. G. Mukerji, Crc Press.
5. Biological Control of Plant Diseases and Weeds- Pratibha Sharma, ICAR, New Delhi.
6. Integrated Plant Disease Management- edited by R. C. Sharma and J. N. Sharma, ScientificPublishers.

Plant Tissue Culture

1. An Introduction to Plant Tissue Culture – K.K. De (New Central Book Agency, Kolkata, India).
2. An Introduction to Plant Tissue Culture – M.K. Razdan (Oxford &IBH Publishing Co. Ltd. Kolkata)
3. Plant Cell and Tissue Culture – I.K. Vasil and T.A. Thorpe (Kluer Academic Publishers, Netherland).
4. Plant Cell Culture – H.A. Colins ad S. Edwards (Bios Scientific Publishers, Oxford UK).
5. Plant Propagation by Tissue Culture Vol. 1 and Vol. 2 – E.F. George (Exegeltic Limited, England).
6. Plant Propagation by Tissue Culture, Vol. 1. Background: Edwin F. George, Michael A. Hall and Geert-Jan De Klerk, Springer Pub.
7. Plant Propagation by Tissue Culture, Vol. 2.: Edwin F. George, Michael A. Hall and Geert-Jan De Klerk, Springer Pub.
8. Plant Tissue Culture by TimirBaranJha&Biswajit Ghosh, Platinum Pub.
9. Plant Tissue Culture Theory and Practice – S.S. Bhojwani and M.K. Razdan (Elsevier Science Publication, New York, USA).

Phycology

1. The Structure and Reproduction in Algae, Vol. 1 and 2 – Fritch (Cambridge University Press, London).
2. The Fresh Water Algae of United States – Smith (Mc-Graw Book Company, New York).
3. Cyanophyta – Desikachary (ICAR).
4. Cyanobacteria – Prof.Samit Roy (New Age International, New Delhi).
5. An Introduction to Algae – Bold and Wyne (Prantice Hall of India, New Delhi.
6. Phycology – Lee (Cambridge University Press, London).
7. Algae-An Introduction to Phycology – Van der Hock (Cambridge University Press, London).
8. Algae – Lindagrahm (Cambridge University Press, London).

Lichenology

1. Handbook of Lichenology – Awasthi (New Age India, New Delhi).
2. Lichenology – Awasthi (New Age India, New Delhi).
3. The Lichens – V. Ahmadajiman and M.E. Hele (Academic Press).

Bryology

1. Biology of Bryophytes – R. N. Chopra and P. K. Kumra.
2. British Mosses & Liverworts – E.V. Watson (Cambridge University press).
3. Bryophytes Biology – A.J. Shaw and B. Foffinet (Cambridge University Press).
4. Bryophytes Ecology – A.J.E. Smith (Cmupman& Hall).
5. Cryptogamic Botany (Vol. II) / Bryophytes and Pteridophytes – E. W. Sinnott.
6. Handbook of Indian Mosses – H. C. Gangulee (Amerind Publshing Co. Pvt. Ltd.).

7. Hepaticology in India Vol I – R. K. Bapna and P. Kachiroo (Himanshu Publication, India).
8. Introduction to Bryology – W.B. Schofield (Macmilan Publishing Co., New York Macmillan Publishers, London).
9. Practical Manual of Bryophyta – S. S. Ranjan (Anmol Publications Pvt. Ltd. New Delhi).
10. The Structure and Life Bryophytes – E.V. Watson (Hutchinson University Library, London).

Pteridology

1. An Introduction to Embryophyta, Vol. II Pteridophyta – N. S. Parihar (Central Book Depo, Allahabad).
2. An Introduction to Pteridophyte: Diversity Development and Differentiation – Rashid A. (Vikash Publishing House Pvt. Ltd., New Delhi).
3. Cryptogamic Botany, Vol 2 – G. M. Smith (New York).
4. Gametophytes of Himalayan Ferns – P. N. Mehra& A. Gupta.
5. Morphology and Evolution of Vascular Plants – E.M. Gifford and A.S. Foster (Freeman, New York).
6. Pteridology in New Millenium – S. Chandra and Srivastava (NBRI Golden Jubilee Volume, Kluweer Academic Publisher).
7. The Morphology of Pteridophytes – K. R. Sprone (London).

Gymnology

1. Gymnosperms – S. S. Bhatnagar and A. Maitra (New Age India, New Delhi).
2. Morphology and Evolution of Vascular Plants – EM Gifford and AS Foster (W.H. Freeman Company, New York).
3. Morphology of Gymnosperms – J.M. Coulter and C.J. Chamberlin (University Chicago Press).
4. Morphology of Vascular Plants – D. W. Bierhost (Macmillan, New York).
5. The Morphology of Gymnosperms: The Structure and Evolution of Primitive Seed Plants – K. R. Sporne (Hutchinson University Library).

Palaeobotany

1. An Introduction to Palaeobotany – C.A. Arnold (New York and London).
2. Palaeobotany and Evolution of Vascular Plants – W.N. Stewart and G.W. Rothwell (Cambridge University press, London).

Plant Molecular Biology

1. Molecular Biochemistry – Glick (ASM Press).
2. Principles of Gene Manipulation and Genomics – Primrose and Twynman (Blackwell).
3. Gene Cloning and DNA Analysis – T.A. Brown (Blackwell).
4. Gene Transfer to Plants – Twynman (Bio Scientific Publishers).
5. Gene Cloning and Manipulation – Christopher Howe (Cambridge University Press).
6. Introduction to Genomics – Arthur Lesk (Oxford University Press).
7. Molecular Evolution – W.H. Li (Sinauer – Associate).
8. RNA Interference – D. Engelker (DNA Press).
9. Molecular Cell Biology – Lodish et al. (Panima, Distrb).
10. Molecular Biology of the Gene – Watson et al. (Pearson Education).

Ecology

1. Ecology: Concept and Application – M.C. Molles Jr. (Mc-Graw Hill Higher Education).
2. Ecology: Theories and Applications – P. Stiling (Prentice Hall of India Pvt.).
3. Ecology – Chapman and Reiss (Cambridge University Press).
4. Ecology and Environment – P.D. Sharma (Rastogi Publishers, Meerut).
5. A Textbook of Plant Ecology – R.K. Sukla and P.S. Chandel (S. Chand).

6. Environmental Science – S.C. Santra.
7. Environmental Problems and Solutions – D.K. Asthana and M. Asthana (S. Chand).
8. Environmental Science – S. Ray (A comprehensive Treaties on Ecology and Environment Publishing Syndicate, Kolkata) Ecology – M. Begon and J.L. Harper, C.R. Towsend (Blackwell Science).
9. Fundamentals of Ecology – E.P. Odum.
10. Concept of Ecology – R.L. Smith.
11. Concept of Ecology – EJ Kormondy (Prantice Hall).
12. Fundamentals of Ecology – MC Dash (Tata McGaw Hill).

Himalayan Tea Science

1. Tea – Eden (Longmans, Green and Co.).
2. Tea in India- Bala Subhramaniam (Wiley Eastern).
3. Heritage of Indian Tea (IIME).
4. Science and Practices in Tea Culture- D.N.Barua (Tea Research Association).
5. The Planters' Handbook- Tea Research Association.
6. Field Management in Tea- Tocklai Experimental Station.
7. Shade trees, Green Crops and Covers Crops- Memorandum 30 (Tea Research Association).
8. Drainage in Tea- J. Chakravartee (Tea Research Association).
9. Diseases of Tea and Associated crops in North east India K.C. Shjarmah (Tea Research Association-Scientific Department).
10. Pest Managements in Tea- N. Muraleedharan (United Planters' Association of Southern India).

Bioinformatics

1. Essential Bioinformatics by JinXiong.
2. Introduction to Bioinformatics by Arthur M. Lesk.
3. Bioinformatics: Sequence and Genome Analysis by David W. Mount.
4. Understanding Bioinformatics by Marketa Zvelebil and Jeremy O. Baum.
5. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins edited by Andreas D. Baxevanis and B.F. Francis Ouellette.
6. Bioinformatics for Biologists edited by Pavel Pevzner and Ron Shamir.
7. Bioinformatics for Beginners: Genes, Genomes, Molecular Evolution, Databases and Analytical Tools by SupratimChoudhuri.
8. BIOS Instant Notes in Bioinformatics by Charlie Hodgman, Andrew French and David Westhead.

Analytical Techniques

1. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology.
2. Biological Instrumentation and Methodology (Tools & Techniques in Biology) by Dr. P.K. Bajpai.
3. Techniques in Molecular Biology by Suraksha Agrawal.
4. Tools, Techniques and Assessment in Biology by John Adds, Erica Larkcom, Ruth Miller and Robin Sutton.
5. Analytical Techniques in Plant Sciences by Dr.Sanjeeb Kumar Nath.
6. Concepts of Laboratory Techniques in Biology by Kiran Singh, Manish Sharma and Vinay Oraon.
7. ABC of Research Methodology and Applied Biostatistics by M.N. Parikh and NithyaGogtay.