



**ST. JOSEPH'S COLLEGE (AUTONOMOUS)
JAKHAMA-NAGALAND**

**SYLLABUS
(Outcome Based Education)**

**CURRICULUM AND CREDIT FRAMEWORK
FOR
UNDERGRADUATE PROGRAMMES (NEP-2020)**



DEPARTMENT OF BOTANY

*With effect from the Academic Year 2023-2024
(1st to 4th FYUGP)*

Preamble

Today plant science is a fusion of the traditional components with the modern aspects of biochemistry, molecular biology and biotechnology. Over the years, plant science (Botany) has shown enormous gain in information and applications owing to tremendous inputs from research in all its aspects. With global recognition of the need for conservation, field plant biologists have contributed significantly in assessing plant diversity. Taxonomists have explored newer dimensions for the classification of plants. New insights have been gained in functional and structural aspects of plant development by utilizing novel tools and techniques for botanical research. Challenging areas of teaching and research have emerged in ecology and reproductive biology. Concern for ever increasing pollution and climate change is at its highest than ever before. Keeping these advancements in view, a revision of the curriculum at the undergraduate level is perfectly timed. From the beginning of 2021-2022 sessions, the Botany students across Indian Universities shall have the benefit of a balanced, carefully-crafted course structure taking care of different aspects of plant science, namely plant diversity, physiology, biochemistry, molecular biology, reproduction, anatomy, taxonomy, ecology, economic botany and the impact of environment on the growth and development of plants. All these aspects have been given due weightage over the six semesters. It is essential for the undergraduate students to acquaint themselves with various tools and techniques for exploring the world of plants up to the sub- cellular level. A paper on this aspect is proposed to provide such an opportunity to the students before they engage themselves with the learning of modern tools and techniques in plant science. Keeping the employment entrepreneurship in mind, applied courses have also been introduced. These courses shall provide the botany students hands on experience and professional inputs. On the whole, the curriculum is a source of lot of information and is supported by rich resource materials. It is hoped that a student graduating in Botany with the new curriculum will be a complete botanist at Honors level.

Introduction

The framework of curriculum for the Bachelor's program in Botany aims to transform the course content and pedagogy to provide a multidisciplinary, student-centric, and outcome-based, holistic education to the next generation of students.

Aside from structuring the curriculum to be more in-depth, focused, and comprehensive with significant skill-set for all exit levels; keeping in mind the job prospects; the emphasis has been to maintain academic coherence and continuum throughout the program of study and help build a strong footing in the subject, thereby ensuring a seamless transition into their careers. Special attention is given to eliminate redundancy, discourage rote learning, and espouse a problem-solving, critical thinking, and inquisitive mindset among learners.

The curriculum embraces the philosophy that science is best learned through experiential learning, not limited to the confines of a classroom but rather through hands-on training, projects, field studies, industrial visits, and internships.

This updated syllabus, with modern technology, helps students stay informed on the leading edge developments in plant sciences and promotes curiosity, innovation, and a passion for research, that will serve them well in their journey into scientific adventure and discovery beyond graduation.

The goal is to equip students with holistic knowledge, competencies, professional skills, and a strong positive mindset that they can leverage while navigating the current stiff challenges of the job market.

B.Sc Botany Programme Outcomes as per NEP 2020
Discipline Core: Botany
Year of implementation: 2023-2024

Program Outcomes

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

(Refer to literature on outcome based education (OBE) for details on Program Outcomes)

PO1: Skill development for the proper description using botanical terms, identification, naming and classification of life forms especially plants and microbes.

PO2: Acquisition of knowledge on structure, life cycle and life processes that exist among plant and microbial diversity through certain model organism studies.

PO3: Understanding of various interactions that exist among plants and microbes; to develop the curiosity on the dynamicity of nature.

PO4: Understanding of the major elements of variation that exist in the living world through comparative morphological and anatomical study.

PO5: Ability to explain the diversity and evolution based on the empirical evidences in morphology, anatomy, embryology, physiology, biochemistry, molecular biology and life history.

PO6: Skill development for the collection, preservation and recording of information after observation and analysis- from simple illustration to molecular database development.

PO7: Making aware of the scientific and technological advancements- Information and Communication, Biotechnology and Molecular Biology for further learning and research in all branches of Botany.

PO8: Internalization of the concept of conservation and evolution through the channel of spirit of inquiry.

PO 9: To enable the graduates to prepare for national as well as international level competitive examinations like UGC-CSIR, UPSC etc.

PO10: To enable the students for practicing the best teaching pedagogy as a biology teacher including the latest digital modules.

PO 11: The graduates should be knowledgeable and competent enough to appropriately deliver on aspects of global importance like climate change, SDGs, green technologies etc at the right opportunity.

PO 12: The graduate should be able to demonstrate sufficient proficiency in the hands-on experimental techniques for their area of specialization within biology during research and in the professional career.

Programme Structure

Semester	Major or Discipline Specific Core Paper (4 credits each)	Interdisciplinary Minor Paper (4 credits each)	Multidisciplinary course (4 credits each)	Skill Enhancement courses (SEC) OR Internship/ Apprenticeship/Project/Commu nity Outreach (2 credits each)	Ability enhancement courses (AEC) (2 credits each)	Value addition course (VAC) (2 credits each)	Total Credits
I	BTC 1.1: Phycology and microbiology (3) BTC 1.1(P): Phycology and microbiology (1) BTC 1.2: Cell Biology (3) BTC 1.2(P): Cell Biology (1)	BTM 1: Phycology and microbiology(3) BTM 1(P): Phycology and microbiology(1)	MDC-1: EVS(4)	BTS 1: Nursery and Gardening (2)	AEC-1: English Communication (2)	VAC-1: Constitutional Values (2)	22
II	BTC 2.1: Archegoniates (3) BTC 2.1(P): Archegoniates (1) BTC 2.2: Gymnosperms and Paleobotany (3) BTC 2.2(P): Gymnosperms and Paleobotany (1)	BTM 2: Mycology and Phytopathology (3) BTM 2(P): Mycology and Phytopathology (1)	MDC-2: Programming using Python(4)	BTS 2: Floriculture(2)	AEC-2: Basic Functional English(2)	VAC-2: Consumer Rights(2)	22
Exit option with Undergraduate Certificate (44 Credits)							44
III	BTC 3.1: Morphology and Anatomy of angiosperms(3) BTC 3.1(P): Morphology and Anatomy of Angiosperms(1) BTC 3.2: Economic Botany(3) BTC 3.2(P): Economic Botany(1) BTC 3.3: Genetics(3) BTC 3.3(P): Genetics(1)	BTM 3: Morphology and Anatomy of angiosperms(3) BTM 3(P): Morphology and Anatomy of angiosperms(1)	MDC-3: Intellectual Property Rights(4)	BTS 3: Biofertilizers(2)			22
IV	BTC 4.1: Reproduction and embryology of Angiosperm(3) BTC 4.1(P): Reproduction and embryology of Angiosperm(1) BTC 4.2: Plant ecology and Phytogeography(3) BTC 4.2(P): Plant ecology and Phytogeography(1) BTC 4.3: Plant Systematics(3) BTC 4.3(P): Plant Systematics(1)	BTM 4: Plant Taxonomy(3) BTM 4(P): Plant Taxonomy(1)		BTS 4: Mushroom cultivation (2)	AEC-3: Poetry, Prose and Short Stories (2)	VAC-3: Work Ethics(2)	22
Exit option with Undergraduate Diploma (88 Credits)							88
V	BTC 5.1: Molecular Biology(3) BTC 5.1(P): Molecular Biology(1) BTC 5.2: Plant Physiology(3) BTC 5.2(P): Plant Physiology(1) BTC 5.3: Plant Biotechnology(3) BTC 5.3(P): Plant Biotechnology(1)	BTM 5: Plant Physiology(3) BTM 5(P): Plant Physiology (1)		BTS 5: Herbal Technology (2)	AEC-4: Novel and Drama (2)	VAC-4: India through the ages(2)	22
VI	BTC 6.1: Plant metabolism(3) BTC 6.1(P): Plant metabolism (1) BTC 6.2: Biomolecules (3) BTC 6.2(P): Biomolecules (1) BTC 6.3: Plant Diversity and Human Welfare (3) BTC 6.3(P): Plant Diversity and Human Welfare(1) BTC 6.4: Plant Breeding(3) BTC 6.4 (P): Plant Breeding(1)	BTM 6: Plant Metabolism(3) BTM 6(P): Plant Metabolism(1)		BTI 6: Internship (2)			22
Exit option with Bachelor of Science, B.Sc Botany (132 Credits)-UG Degree							132

Semester	Major or Discipline Specific Core Paper (4 credits each)	Interdisciplinary Minor Paper (4 credits each)	Multidisciplinary course (4 credits each)	Skill Enhancement courses (SEC) OR Internship/ Apprenticeship/Project/Communi ty Outreach (2 credits each)	Research Project/ Dissertation (12 Credits) OR 3 Theory Papers (12 Credits)	Total Credits
VII	BTC 7.1: Horticultural Practices and Post Harvest Technology (3) BTC 7.1(P): Horticultural Practices and Post Harvest Technology (1) BTC 7.2: Biostatistics and Bioinformatics(3) BTC 7.2(P): Biostatistics and Bioinformatics(1) RM 7: Research Methodology(3) RM 7(P): Research Methodology(1)	BTM 7.1: Horticultural Practices and Post Harvest Technology (3) BTM 7.1(P): : Horticultural Practices and Post Harvest Technology (1) BTM 7.2: Biostatistics and Bioinformatics(3) BTM 7.2(P): Biostatistics and Bioinformatics(1)			Research Project/ Dissertation will start	20
VIII	BTC 8.1: Microbiology, mycology and Plant Pathology(3) BTC 8.1(P): Microbiology, mycology and Plant Pathology(1)	BTM 8.1: Microbiology, mycology and Plant Pathology(3) BTM 8.1(P): Microbiology, mycology and Plant Pathology(1)			Research Project/Dissertation in major(12) OR BTM 8.2: Natural Resource Management (3) BTM 8.2(P): Natural Resource Management(1) BTC 8.2: Plant morphogenesis and Embryology(3) BTC 8.2(P): Plant morphogenesis and Embryology(1) BTC 8.3: Methods in Plant Sciences(3) BTC 8.3(P): Methods in Plant Sciences(1)	20
Bachelor of Science, B.Sc Botany (Honours)with Research (172 Credits)						172

DISCIPLINE SPECIFIC COURSES (DSC)

SEMESTER	PAPER CODE	TITLE OF THE PAPER	CREDITS
I	BTC 1.1	Phycology and Microbiology	3
	BTC 1.1(P)	Phycology and Microbiology	1
	BTC 1.2	Cell Biology	3
	BTC 1.2 (P)	Cell Biology	1
II	BTC 2.1	Archegoniates	3
	BTC 2.1 (P)	Archegoniates	1
	BTC 2.2	Gymnosperms and Paleobotany	3
	BTC 2.2 (P)	Gymnosperms and Paleobotany	1
III	BTC 3.1	Morphology and Anatomy of Angiosperms	3
	BTC 3.1 (P)	Morphology and Anatomy of Angiosperms	1
	BTC 3.2	Economic Botany	3
	BTC 3.2 (P)	Economic Botany	1
	BTC 3.3	Genetics	3
	BTC 3.3 (P)	Genetics	1
IV	BTC 4.1	Reproduction and Embryology of Angiosperms	3
	BTC 4.1 (P)	Reproduction and Embryology of Angiosperms	1
	BTC 4.2	Plant Ecology and Phytogeography	3
	BTC 4.2 (P)	Plant Ecology and Phytogeography	1
	BTC 4.3	Plant Systematics	3
	BTC 4.3 (P)	Plant Systematics	1
V	BTC 5.1	Molecular Biology	3
	BTC 5.1 (P)	Molecular Biology	1
	BTC 5.2	Plant Physiology	3
	BTC 5.2 (P)	Plant Physiology	1
	BTC 5.3	Plant Biotechnology	3
	BTC 5.3 (P)	Plant Biotechnology	1
VI	BTC 6.1	Plant Metabolism	3
	BTC 6.1 (P)	Plant Metabolism	1
	BTC 6.2	Biomolecules	3
	BTC 6.2 (P)	Biomolecules	1
	BTC 6.3	Plant Diversity and Human Welfare	3
	BTC 6.3 (P)	Plant Diversity and Human Welfare	1
	BTC 6.4	Plant Breeding	3
	BTC 6.4 (P)	Plant Breeding	1
VII	BTC 7.1	Horticultural Practices and Post Harvest Technology	3
	BTC 7.1(P)	Horticultural Practices and Post Harvest Technology	1
	BTC 7.2	Biostatistics and Bioinformatics	3
	BTC 7.2(P)	Biostatistics and Bioinformatics	1
	RM 7	Research Methodology	3
	RM 7(P)	Research Methodology	1

SEMESTER	PAPER CODE	TITLE OF THE PAPER	CREDITS
VIII	BTC 8.1	Microbiology, Mycology and Plant Pathology	3
	BTC 8.1(P)	Microbiology, Mycology and Plant Pathology	1
		3 Theory Papers in lieu of Research Project/Dissertation (For Honors Students not undertaking Research Projects)	
	BTM 8.2	Natural Resource Management	3
	BTM 8.2(P)	Natural Resource Management	1
	BTC 8.2	Plant Morphogenesis and Embryology	3
	BTC 8.2(P)	Plant Morphogenesis and Embryology	1
	BTC 8.3	Methods in Plant Sciences	3
	BTC 8.3(P)	Methods in Plant Sciences	1

MULTIDISCIPLINARY/INTRODUCTORY COURSES

SEMESTER	PAPER CODE	TITLE OF THE PAPER	CREDITS
I	MDC-1	Environmental Studies	4
II	MDC-2	Programming using Python	4
III	MDC-3	Intellectual Property Rights (IPR)	4

MINOR PAPERS

SEMESTER	PAPER CODE	TITLE OF THE PAPER	CREDITS
I	BTM 1	Phycology and microbiology	3
	BTM 1(P)	Phycology and microbiology	1
II	BTM 2	Mycology and Phytopathology	3
	BTM 2(P)	Mycology and Phytopathology	1
III	BTM 3	Morphology and Anatomy of Angiosperms	3
	BTM 3(P)	Morphology and Anatomy of Angiosperms	1
IV	BTM 4	Plant Taxonomy	3
	BTM 4(P)	Plant Taxonomy	1
V	BTM 5	Plant Physiology	3
	BTM 5(P)	Plant Physiology	1
VI	BTM 6	Plant Metabolism	3
	BTM 6(P)	Plant Metabolism	1
VII	BTM 7.1	Horticultural Practices and Post Harvest Technology	3
	BTM 7.1(P)	Horticultural Practices and Post Harvest Technology	1
	BTM 7.2	Biostatistics and Bioinformatics	3
	BTM 7.2(P)	Biostatistics and Bioinformatics	1
VIII	BTM 8.1	Microbiology, Mycology and Plant Pathology	3
	BTM 8.1 (P)	Microbiology, Mycology and Plant Pathology	1
	BTM 8.2	Natural Resource Management	3
	BTM 8.2(P)	Natural Resource Management	1

SKILL ENHANCEMENT COURSES (SEC)

SEMESTER	PAPER CODE	TITLE OF THE PAPER	CREDITS
I	BTS 1	Nursery and Gardening	2
II	BTS 2	Floriculture	2
III	BTS 3	Biofertilizers	2
IV	BTS 4	Mushroom Cultivation	2
V	BTS 5	Herbal Technology	2

VALUE ADDED COURSES (VAC)

SEMESTER	PAPER CODE	TITLE OF THE PAPER	CREDITS
I	VAC 1	Constitutional Values	2
II	VAC 2	Consumer Rights	2
IV	VAC 3	Work Ethics	2
V	VAC 4	India through the ages	2

**BOTANY SYLLABUS FOR B.Sc/ B.Sc Honours
DISCIPLINE SPECIFIC CORE PAPERS**

Semester-I

NAME OF THE PAPER (CODE) : PHYCOLOGY AND MICROBIOLOGY (BTC 1.1)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **Phycology and Microbiology**:

CO 1	To be well versed in all the different organisms of the microbial world.
CO 2	To be well aware about viruses.
CO 3	To learn about the general bacterial world
CO 4	To know about the general account and classification of algae.
CO 5	To learn about the different life cycles of economically important algae and locally available species of algae

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to microbial world (CO 1)	Microbial nutrition, growth and metabolism. Economic importance of viruses with reference to their role in research and medicine. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).	CSO 1.1: To define the term micro-organisms. (K) CSO 1.2: To explain on microbial nutrition, growth and metabolism. (U) CSO 1.3: To illustrate the economic importance of viruses with reference to vaccine production, research and medicine. (A) CSO 1.4: To explain the diagnostics of micro-organisms as causal organisms of plant diseases. (U) CSO 1.5: To illustrate the economic importance of bacteria with reference to agriculture and industry. (A)	7	16	
UNIT 2 Viruses (CO 2)	Discovery, general characteristics; classification (Baltimore); replication (general account), Structure of DNA virus (T-phage), lytic and	CSO 2.1: To define viruses. (K) CSO 2.2: To explain the discovery, physiochemical and biological characteristics of viruses. (U)	8	18	

	lysogenic cycle; RNA virus (TMV), Retrovirus (HIV).	<p>CSO 2.3: To illustrate about the classification, general structure with special reference to viroids and prions. (A)</p> <p>CSO 2.4: To explain the general account of replication. (U)</p> <p>CSO 2.5: To illustrate about DNA virus (T-phage), lytic and lysogenic cycle, RNA virus (TMV), Retrovirus (HIV). (A)</p>			
UNIT 3 Bacteria (CO 3)	Discovery, general characteristics; Types-archaeobacteria, eubacteria; Cell structure; shapes of bacteria; classification of bacteria (Bergey's); Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction).	<p>CSO 3.1: To define bacteria. (K)</p> <p>CSO 3.2: To explain the discovery and general characteristics of bacteria. (U)</p> <p>CSO 3.3: To explain the different types of bacteria-archaeobacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts). (U)</p> <p>CSO 3.4: To explain the detailed cell structure, shapes, classification and nutritional types of bacteria. (U)</p> <p>CSO 3.5: To illustrate the different modes of reproduction in bacteria. (A)</p>	8	18	
UNIT 4 Algae (CO 4)	General characteristics; Ecology and occurrence; range of thallus organization; vegetative structure and cell components- cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; methods of reproduction; Classification; criteria, system of Fritsch. Economic importance of algae.	<p>CSO 4.1: To define algae. (K)</p> <p>CSO 4.2: To explain the general characteristics, ecology and distribution of algae. (U)</p> <p>CSO 4.3: To illustrate the range of thallus organization, cell structure and components; cell wall, pigment system, reserve food and flagella. (A)</p> <p>CSO 4.4: To explain the different methods of reproduction in algae. (U)</p> <p>CSO 4.5: To explain the different systems of classifications and</p>	10	22	

		criteria of algae. (U) CSO 4.6: To explain the significant contributions of important phycologists and economic importance of algae. (U)			
UNIT 5 Cyanophyta, Xanthophyta, Chlorophyta, Charophyta, Phaeophyta and Rhodophyta. (CO 5)	General characteristics; occurrence; morphology; Reproduction and life-cycle of <i>Nostoc</i> , <i>Vaucheria</i> , <i>Chlamydomonas</i> , <i>Volvox</i> , <i>Oedogonium</i> , <i>Chara</i> , <i>Ectocarpus</i> , <i>Fucus</i> and <i>Polysiphonia</i> . Evolutionary significance of <i>Prochloron</i> .	CSO 5.1: To explain the ecology, occurrence, range of thallus organization, cell structure, reproduction, morphology and life cycle of <i>Nostoc</i> and <i>Vaucheria</i> . (U) CSO 5.2: To explain the general characteristics, occurrence, cell structure, reproduction, morphology and life cycle of <i>Chlamydomonas</i> , <i>Oedogonium</i> and <i>Chara</i> . (U) CSO 5.3: To describe the evolutionary significance of <i>Prochloron</i> . (K) CSO 5.4: To explain the general characteristics, occurrence, cell structure, reproduction, morphology and life cycle of <i>Ectocarpus</i> and <i>Fucus</i> . (U)	12	26	

NAME OF THE PAPER	: PHYCOLOGY AND MICROBIOLOGY
Code	: BTC 1.1 (P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

Microbiology

1. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule.
3. Gram staining of gram positive and gram negative bacteria.
4. Endospore staining with malachite green using the (endospores taken from soil bacteria).

Phycology

1. Study of vegetative and reproductive structures of *Nostoc*, *Chlamydomonas* (electron micrographs), *Volvox*, *Oedogonium*, *Chara*, *Vaucheria*, *Ectocarpus*, *Fucus* and *Polysiphonia*, *Prochloron* through electron micrographs, temporary preparations and permanent slides.
2. Study of locally available algae species.

Suggested Readings

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
2. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGrawHill International.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
6. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.

NAME OF THE PAPER (CODE) : CELL BIOLOGY (BTC 1.2)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **CELL BIOLOGY**:

CO 1	To learn about cell, types of cell and origin.
CO 2	To be well versed in cell membrane and plasma membrane.
CO 3	To understand in detail the different cell organelles.
CO 4	To understand the endomembrane system.
CO 5	To inculcate the understanding of cell division.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 The Cell (CO 1)	Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory).	CSO 1.1: To define cell. (K) CSO 1.2: To explain cell as a unit of structure and function. (U) CSO 1.3: To explain and differentiate the characteristics of prokaryotic and eukaryotic cells. (U+A) CSO 1.4: To explain the origin of eukaryotic cell with reference to endosymbiotic theory. (U)	6	14	
UNIT 2 Cell Wall and Plasmamembrane (CO 2)	Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluidmosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.	CSO 2.1: To explain the chemistry, structure and function of plant cell wall. (U) CSO 2.2: To explain about membrane function. (U) CSO 2.3: To explain the fluid mosaic model. (U) CSO 2.4: To explain and identify the chemical composition of membranes. (U+A) CSO 2.5: To explain about Membrane transport – Passive, active and facilitated transport. (U)	8	18	

		CSO 2.6: To explain and differentiate between endocytosis and exocytosis. (U+A)			
UNIT 3 Cell organelles (CO 3)	Nucleus: Structure- nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus. Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament. Chloroplast, mitochondria and peroxisomes: Structural organization, function; and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.	CSO 3.1: To explain the structure of nucleus, molecular organization of chromatin and nucleolus. (U) CSO 3.2: To explain the role and structure of microtubules, microfilaments and intermediary filament. (U) CSO 3.3: To explain the structure, function and semiautonomous nature of mitochondria and chloroplast. (U) CSO 3.4: To explain and illustrate about peroxisomes. (U+A)	12	26	
UNIT 4 Endomembrane system (CO 4)	Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins and lipids; Golgi Apparatus – organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes.	CSO 4.1: To explain the structure, protein targeting, protein folding and processing of endoplasmic reticulum. (U) CSO 4.2: To explain about smooth endoplasmic reticulum, lipid synthesis and export of protein and lipids. (U) CSO 4.3: To explain and illustrate the organization, protein glycosylation, protein sorting and export from Golgi apparatus and lysosomes. (U+A)	10	22	
UNIT 5 Cell division (CO 5)	Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle- checkpoints, role of protein kinases.	CSO 5.1: To explain and elaborate on the different phases of eukaryotic cell cycle. (U) CSO 5.2: To explain	9	20	

		and differentiate between mitosis and meiosis. (U +A) CSO 5.3: To explain on the regulation of cell cycle- checkpoints, role of protein kinases. (U)			
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NAME OF THE PAPER : CELL BIOLOGY
Code : BTC 1.2 (P)
Number of Credit : 01
Number of Hours of Lecture : 30

Practicals

1. Study of plant cell structure with the help of epidermal peel mount of Onion/*Rhoeo/Crinum*.
2. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
3. Measurement of cell size by the technique of micrometry.
4. Counting the cells per unit volume with the help of haemocytometer. (Yeast/pollen grains).
5. Study of cell and its organelles with the help of electron micrographs.
6. Cytochemical staining of: DNA- Feulgen and cell wall in the epidermal peel of onion using Periodic Schiff's (PAS) staining technique.
7. Study the phenomenon of plasmolysis and deplasmolysis.
8. Study the effect of organic solvent and temperature on membrane permeability.
9. Study different stages of mitosis and meiosis.

Suggested Readings

1. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
2. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
3. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Semester-II

NAME OF THE PAPER (CODE) : ARCHEGONIATES (BTC 2.1)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **ARCHEGONIATES**:

CO 1	To develop in-depth knowledge on archegoniates.
CO 2	To learn and understand about bryophytes.
CO 3	To study and learn type studies of bryophytes.
CO 4	To learn and understand about pteridophytes.
CO 5	To study and learn type studies of pteridophytes.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to Archegoniates	Unifying features of archegoniates; Transition to land habit; Alternation of generations.	CSO 1.1: To define the term archegoniate. (K) CSO 1.2: To explain about the unifying features of archegoniates. (U) CSO 1.3: To explain about the transition of archegoniates to land habit. (U) CSO 1.4: To describe and illustrate in detail about alternation of generation in archegoniates. (K+A)	4	10	
UNIT 2 Bryophyta (CO 2)	General characteristics; Adaptations to land habit; classification (up to Order; ICN), range of thallus organization, life cycle of bryophyte; Reproduction and evolutionary trends in <i>Riccia</i> , <i>Marchantia</i> , <i>Anthoceros</i> and	CSO 2.1: To explain the general characteristics, adaptations to land habit and classification of bryophytes. (U) CSO 2.2: To explain the range of thallus organization of bryophytes. (U) CSO 2.3: To explain	10	22	

	<p><i>Funaria</i> (developmental stages not included). Ecological and economic importance of bryophytes with special reference to <i>Sphagnum</i>.</p>	<p>and illustrate the reproduction and evolutionary trends in <i>Riccia</i>, <i>Marchantia</i>, <i>Anthoceros</i> and <i>Funaria</i>. (U+A) CSO 2.4: To explain the ecological and economic importance of bryophytes with special reference to <i>Sphagnum</i>. (U)</p>			
<p>UNIT 3 Type studies- Bryophyta (CO 3)</p>	<p>Hepaticopsida – Classification; Occurrence; Morphology, Anatomy and reproduction of <i>Marchantia and Riccia</i>. Anthocerotopsida - Classification; Occurrence; Morphology, Anatomy and reproduction of <i>Anthoceros</i>. Bryopsida - Classification; Occurrence; Morphology, Anatomy and reproduction of <i>Sphagnum</i> and <i>Funaria</i>.</p>	<p>CSO 3.1: To explain the classification, morphology, anatomy and reproduction of <i>Riccia</i>. (U) CSO 3.2: To explain the classification, morphology, anatomy and reproduction of <i>Marchantia</i>. (U) CSO 3.3: To explain the classification, morphology, anatomy and reproduction of <i>Pellia</i>. (U) CSO 3.4: To explain the classification, morphology, anatomy and reproduction of <i>Porella</i>. (U) CSO 3.5: To explain the classification, morphology, anatomy and reproduction of <i>Anthoceros</i>. (U) CSO 3.6: To explain the classification, morphology, anatomy and reproduction of <i>Sphagnum</i>. (U) CSO 3.7: To explain the classification, morphology, anatomy and reproduction of <i>Funaria</i>. (U)</p>	10	22	

<p>UNIT 4 Pteridophyta (CO 4)</p>	<p>General characteristics; Classification (up to Order; ICN); Life Cycle of Pteridophytes, Apogamy, Apospory, heterospory; Telome theory; Stellar evolution; Ecological and economic importance.</p>	<p>CSO 4.1: To explain the general characteristics and classification of pteridophytes. (U) CSO 4.2: To explain and illustrate the life cycle of pteridophytes. (U+A) CSO 4.3: To explain apogamy, apospory, and heterospory of pteridophytes. (U) CSO 4.4: To explain about Telome theory, stellar evolution, ecological and economic importance of pteridophytes. (U)</p>	<p>11</p>	<p>24</p>	
<p>UNIT 5 Type studies- Pteridophyta (CO 5)</p>	<p>Psilophyta - Classification; Occurrence; morphology, anatomy and reproduction of <i>Psilotum</i>. Lepidophyta – Classification; Occurrence; morphology, anatomy and reproduction of <i>Selaginella</i>. Calamophyta - Classification; Occurrence; morphology, anatomy and reproduction of <i>Equisetum</i>. Pterophyta - Classification; Occurrence; morphology, anatomy and reproduction of <i>Pteris</i>.</p>	<p>CSO 5.1: To explain the classification, morphology, anatomy and reproduction of <i>Psilotum</i>. (U) CSO 5.2: To explain the classification, morphology, anatomy and reproduction of <i>Selaginella</i>. (U) CSO 5.3: To explain the classification, morphology, anatomy and reproduction of <i>Equisetum</i>. (U) CSO 5.4: To explain the classification, morphology, anatomy and reproduction of <i>Pteris</i>. (U)</p>	<p>10</p>	<p>22</p>	

NAME OF THE PAPER	: ARCHEGONIATES
Code	: BTC 2.1 (P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. *Riccia* – Morphology of thallus.
2. *Marchantia*- Morphology of thallus, whole mount of rhizoids & Scales, vertical section of thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).
3. *Anthoceros*- Morphology of thallus, dissection of sporophyte (to show stomata, spores, pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).
4. *Sphagnum*- Morphology of plant, whole mount of leaf (permanent slide only).
5. *Funaria*- Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule and protonema.
6. *Psilotum*- Study of specimen, transverse section of synangium (permanent slide).
7. *Selaginella*- Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).
8. *Equisetum*- Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
9. *Pteris*- Morphology, transverse section of rachis, vertical section of sporophyll, whole mount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).

Suggested Readings

1. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
2. Parihar, N.S. (1991). An introduction to Embryophyta: Vol. I. Bryophyta. Central Book Depot. Allahabad.
3. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.
4. Vanderpoorten, A. & Goffinet, B. (2009) Introduction to Bryophytes. Cambridge University Press.

NAME OF THE PAPER (CODE) : GYMNOSPERMS AND PALEOBOTANY (BTC 2.2)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **GYMNOSPERMS AND PALEOBOTANY**:

CO 1	To learn in detail about gymnosperms.
CO 2	To understand gymnosperms through type studies.
CO 3	To develop basic concept about early land plants.
CO 4	To enable students gain knowledge about paleobotany.
CO 5	To enable students to be well versed with geological time scale.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Gymnosperms (CO 1)	General characteristics, distribution, classification (up to Genus), Phylogenetic relationship of gymnosperm; Affinities of Gymnosperm; Ecological and economic importance.	CSO 1.1: To explain the general characteristics, distribution and classification of gymnosperms. (U) CSO 1.2: To explain and relate the phylogenetic relationship of gymnosperms. (U+A) CSO 1.3: To explain the affinities of gymnosperms. (U) CSO 1.4: To explain ecological and economic importance of gymnosperms. (U)	8	18	
UNIT 2 Type studies of gymnosperms (CO 2)	Cycadophyta- Salient features; Classification, Occurrences, Morphology, anatomy and reproduction of <i>Cycas</i> . (Developmental details not to be included). Coniferophyta – Salient features; Classification,	CSO 2.1: To explain the salient features; Classification, Occurrences, Morphology, anatomy and reproduction of <i>Cycas</i> . (U) CSO 2.2: To explain the salient features; Classification, Occurrences, Morphology, anatomy and reproduction of	10	22	

	Occurrences, Morphology, Anatomy and Reproduction of <i>Pinus</i> and <i>Gnetum</i> (Developmental details not to be included).	<i>Pinus.</i> (U) CSO 2.3: To explain the salient features; Classification, Occurrences, Morphology, anatomy and reproduction of <i>Gnetum.</i> (U)			
UNIT 3 Early land plants (CO 3)	Morphology, Anatomy and Reproduction of <i>Cooksonia</i> , <i>Rhynia</i> and <i>Psilophyton</i> .	CSO 3.1: To explain the morphology, Anatomy and Reproduction of <i>Cooksonia.</i> (U) CSO 3.2: To explain the morphology, Anatomy and Reproduction of <i>Rhynia.</i> (U) CSO 3.3: To explain the morphology, Anatomy and Reproduction of <i>Psilophyton.</i> (U)	9	20	
UNIT 4 Paleobotany (CO 4)	Definition and scope of paleobotany; Fossil – Definition and Nomenclature; Types of fossils; Types of fossil plants; Fossilisation process; Mode of preservation; Importance of fossil.	CSO 4.1: To define paleobotany and explain the scope of paleobotany. (K+U) CSO 4.2: To define fossil and explain its nomenclature. (K+U) CSO 4.3: To explain about types of fossils and types of fossil plants. (U) CSO 4.4: To explain about fossilisation process; mode of preservation; Importance of fossil. (U)	8	18	
UNIT 5 Geological time scale (CO 5)	Introduction; Geological time scale with biological events, Timeline divisions; continental drift; The Gondwana System;	CSO 5.1: To explain about geological time scale with biological events. (U) CSO 5.2: To explain and illustrate about	10	22	

	Gondwana flora; General account of dominant fossil flora of the ages; mass extinction.	timeline divisions and continental drift. (U+A) CSO 5.3: To explain about Gondwana system and its flora. (U) CSO 5.4: To explain about the dominant fossil flora of the ages and mass extinction. (U)			
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NAME OF THE PAPER : **GYMNOSPERMS AND PALEOBOTANY**
Code : **BTC 2.2 (P)**
Number of Credit : **01**
Number of Hours of Lecture : **30**

Practicals

1. *Cycas*- Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll, transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide).
2. *Pinus*- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), transverse section of Needle, transverse section of stem, longitudinal section of / transverse section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), longitudinal section of female cone, tangential longitudinal section & radial longitudinal sections stem (permanent slide).
3. *Gnetum*- Morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide)
4. *Ginkgo biloba* - Morphology (stem, male & female cones), transverse section of stem and leaf vertical section of ovule.
5. Study of early land plants - *Cooksonia*, *Rhynia* and *Psilophyton* (Micrograph/ permanent slide)
6. Study of different types of fossils (micrograph/museum specimen)

Suggested Readings

1. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
2. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.

Semester-III

NAME OF THE PAPER (CODE) :MORPHOLOGY AND ANATOMY OF ANGIOSPERMS (BTC 3.1)

Number of Credit : 03

Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **MORPHOLOGY AND ANATOMY OF ANGIOSPERMS:**

CO 1	To gain knowledge on the structures and development of different parts of the plant body.
CO 2	To learn about the tissue system in plants.
CO 3	To gain insights on meristematic tissues of plants.
CO 4	To be well versed with the vascular cambium, secondary growth and wood.
CO 5	To learn about adaptive and protective system in plants.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction, Structure and Development of Plant Body (CO 1)	Applications in systematics, forensics and pharmacognosy. Internal organization of plant body: The three tissue systems, types of cells and tissues. Development of plant body: Polarity, Cytodifferentiation and organogenesis during embryogenic development.	CSO 1.1: To explain the application of angiosperms in systematic, forensics and pharmacognosy. (U) CSO 1.2: To explain and identify the internal organization of plant body of angiosperms. (U+A) CSO 1.3: To explain the tissue systems, types of cells and tissues. (U) CSO 1.4: To explain and illustrate the development of plant body. (U+A) CSO 1.5: To explain about polarity, cytodifferentiation and organogenesis during embryogenic development. (U)	8	18	
UNIT 2	Classification of tissues;	CSO 2.1: To define	9	20	

<p>Tissues (CO 2)</p>	<p>Simple and complex tissues (no phylogeny); cytodifferentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.</p>	<p>tissues. (K) CSO 2.2: To explain the classification of tissues, simple and complex tissues. (U) CSO 2.3: To explain cytodifferentiation of tracheary elements and sieve elements, pits and plasmodesmata. (U) CSO 2.4: To explain about wall ingrowths and transfer cells, adcrustations and incrustations and ergastic substances. (U) CSO 2.5: To explain on hydathodes, cavities, lithocysts and laticifers. (U)</p>			
<p>UNIT 3 Apical meristems (CO 3)</p>	<p>Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory); Types of vascular bundles; Structure of dicot and monocot stem. Diversity and structure of monocot and dicot leaf. Structure of dicot and monocot leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Rootcap; Structure of dicot and monocot root.</p>	<p>CSO 3.1: To explain on the evolution of concept of organization of shoot apex. (U) CSO 3.2: To define and explain the types of vascular bundles. (K+U) CSO 3.3: To explain the structure of dicot and monocot stem. (U) CSO 3.4: To explain the origin, development, arrangement and diversity in size and shape of leaves. (U) CSO 3.5: To explain the structure of dicot and monocot leaf as well as Kranz anatomy. (U) CSO 3.6: To explain the organization of root apex, quiescent centre and root cap. (U) CSO 3.7: To explain the structure of dicot</p>	<p>12</p>	<p>26</p>	

		and monocot root. (U) CSO 3.8: To explain about endodermis, exodermis and origin of lateral root. (U)			
UNIT 4 Vascular Cambium and Wood (CO 4)	Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Axially and radially oriented elements; Types of rays and axial parenchyma; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology.	CSO 4.1: To explain the structure, function and seasonal activity of cambium. (U) CSO 4.2: To explain and illustrate about secondary growth in root and stem. (U+A) CSO 4.3: To describe in detail about axially and radially oriented elements. (K) CSO 4.4: To explain the types of rays and axial parenchyma. (U) CSO 4.5: To illustrate on cyclic aspects and reaction of wood. (A) CSO 4.6: To describe about sapwood and heartwood, ring and diffuse porous wood, early and late wood. (K) CSO 4.7: To explain about tyloses and dendrochronology. (U) CSO 4.8: To explain about the development and composition of periderm, rhytidome and lenticels. (U)	10	22	
UNIT 5 Adaptive and Protective Systems (CO 5)	Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni and multicellular, glandular and non glandular, two examples of each), stomata (classification); Adcrustation and incrustation;	CSO 5.1: To explain on the epidermal tissue system, cuticle, epicuticular waxes and trichomes. (U) CSO 5.2: To describe about the classification of stomata. (K) CSO 5.3: To illustrate on adcrustation and incrustation. (A)	6	14	

	Anatomical adaptations of xerophytes, hydrophytes and epiphytes.	CSO 5.4: To elucidate on anatomical adaptations of xerophytes and hydrophytes. (A)			
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NAME OF THE PAPER :MORPHOLOGY AND ANATOMY OF ANGIOSPERMS

Code : BTC 3.1 (P)

Number of Credit : 01

Number of Hours of Lecture : 30

Practical

1. Apical meristem of root, shoot and vascular cambium.
2. Distribution and types of parenchyma, collenchyma and sclerenchyma.
3. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibers.
4. Wood: ring porous; diffuse porous; tyloses; heart- and sapwood.
5. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibers.
6. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
Root: monocot, dicot, secondary growth.
7. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels.
8. Adaptive Anatomy: xerophytes, hydrophytes, epiphytes
9. Secretory tissues: cavities, lithocysts and laticifers.

Suggested Readings

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
4. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.

NAME OF THE PAPER (CODE) : ECONOMIC BOTANY (BTC 3.2)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **ECONOMIC BOTANY:**

CO 1	To learn about the origin of cultivation and agroecosystem.
CO 2	To learn about important cereals, legumes, spices and beverages.
CO 3	To be well versed about plant sources of sugar, starch, oils and fats.
CO 4	To learn about natural rubber and fibers.
CO 5	To learn about drug-yielding and timber plants.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Origin of Cultivated Plants and agroecosystem (CO 1)	Concept of Centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; Evolution of new crops/ varieties, importance of germplasm diversity. Agro-ecosystem in Nagaland: Jhum cultivation, terrace cultivation, water harvesting methods, irrigation methods and cropping system.	CSO 1.1: To explain on the concept of centres of origin of cultivated plants and their importance with reference to Vavilov's work. (U) CSO 1.2: To illustrate examples of major plant introductions, crop domestication and loss of genetic diversity, evolution of new crop or varieties. (A) CSO 1.3: To Illustrate the importance of germplasm diversity. (A) CSO 1.4: To define and explain about agro-ecosystem. (K+U) CSO 1.5: To explain illustrate on jhum cultivation, terrace cultivation, water harvesting methods, irrigation methods and cropping system with reference to Nagaland. (U+A)	9	20	
UNIT 2 Cereals, Legumes, Spices and Beverages (CO 2)	Cereals: Wheat and Rice (origin, morphology, processing & uses); Brief account of millets. Legumes: Origin, morphology and uses of Chick pea, Pigeon pea. Importance to man and ecosystem. Spices: Listing of important spices, their family and part used. Economic importance with special reference	CSO 2.1: To explain on the origin, morphology, processing and uses of wheat and rice. (U) CSO 2.2: To explain a brief account of millets. (U) CSO 2.3: To illustrate on the origin, morphology and uses of Chick pea, Pigeon pea and fodder legumes and their importance to man and ecosystem. (A) CSO 2.4: To create and study list of important spices, their family and parts used. (A) CSO 2.5: To explain economic importance with special reference to large cardamom, Ginger, Turmeric,	13	28	

	to large cardamom, Ginger, Turmeric, clove, King Chilli and black pepper Beverage: Tea, Coffee (morphology, processing & uses)	clove, King Chilli and black pepper. (U) CSO 2.6: To explain the morphology, processing and uses of tea and coffee. (U)			
UNIT 3 Sources of sugars and starches, Sources of oils and fats (CO 3)	Sugar: Morphology and processing of sugarcane, products and by-products of sugarcane industry. Starch: Potato – morphology, propagation & uses. Fats and oils: General description, classification, extraction, their uses and health implications of groundnut, coconut, soybean, mustard. Essential Oils: General account, extraction methods, comparison with fatty oils & their uses.	CSO 3.1: To explain the morphology and processing of sugarcane, products and by-products of sugarcane industry. (U) CSO 3.2: To describe the morphology, propagation and uses of potato. (K) CSO 3.3: To explain the general description, classification, extraction, uses and health implications of groundnut, coconut, soybean and mustard. (U) CSO 3.4: To describe essential oils, their general account and illustrate extraction methods, comparison with fatty oils and their uses. (K+A)	9	20	
UNIT 4 Natural Rubber and fibers (CO 4)	Para-rubber: tapping, processing and uses. Fibers: Classification based on the origin of fibers; Cotton, Coir and Jute (morphology, extraction and uses).	CSO 4.1: To explain on para-rubber, tapping, processing and uses. (U) CSO 4.2: To illustrate classification based on the origin of fibres. (A) CSO 4.3: To explain the morphology, extraction and uses of cotton, coir and jute. (U)	5	12	
UNIT 5 Drug-yielding plants, Natural dyes and Timber plants (CO 5)	Drug Yielding Plants: Therapeutic and habit-forming drugs with special reference to <i>Cinchona</i> , <i>Digitalis</i> , <i>Papaver</i> and <i>Cannabis</i> ; Tobacco (Morphology, processing, uses and health hazards). Timber: General account with special reference to teak, pine and <i>Terminalia</i> . Natural dyes: General account of <i>Hibiscus sabdarifa</i> and <i>Strobilanthes flaccidifolius</i> .	CSO 5.1: To explain on therapeutic and habit-forming drugs with special reference to <i>Cinchona</i> , <i>Digitalis</i> , <i>Papaver</i> and <i>Cannabis</i> . (U) CSO 5.2: To explain the morphology, processing, uses and health hazards of tobacco. (U) CSO 5.3: To draw a general account with special reference to teak, pine and <i>Terminalia</i> . (K) CSO 5.4: To explain on general account of <i>Hibiscus sabdarifa</i> and <i>Strobilanthes flaccidifolius</i> . (U)	9	20	

NAME OF THE PAPER	: ECONOMIC BOTANY
Code	: BTC 3.2 (P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. **Cereals:** Wheat and Rice (habit sketch, L. S/T.S. grain, starch grains, micro-chemical tests).
2. **Legumes:** Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. **Sources of sugars and starches:** Sugarcane (habit sketch; cane juice- micro-chemical tests), Potato (habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, micro-chemical tests).
4. **Spices:** Habit of Black pepper, Ginger and Clove (sections).
5. **Beverages:** Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. **Sources of oils and fats:** Coconut, Mustard–plant specimen, seeds; tests for fats in crushed seeds.
7. **Essential oil-yielding plants:** Habit sketch of *Rosa*, *Vetiveria*, *Santalum* and *Eucalyptus* (Specimen/ photographs).
8. **Rubber:** Specimen, photograph/model of tapping, samples of rubber products.
9. **Drug-yielding plants:** Specimens of *Digitalis*, *Papaver* and *Cannabis*.
10. **Tobacco:** Specimen and products of Tobacco.
11. **Woods:** *Tectona*, *Pinus*: Specimen, Section of young stem.
12. **Fiber-yielding plants:** Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber).
13. **Natural Dyes:** *Hibiscus sabdarifa* and *Strobilanthes flaccidifolius* (specimen, parts of plant used as dye)

Suggested Readings

1. Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
2. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.
3. Chrispeels, M.J. and Sadava, D.E. (1994).Plants, Genes and Agriculture. Jones & Bartlett _Publishers.

NAME OF THE PAPER (CODE) : GENETICS (BTC 3.3)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **GENETICS**:

CO 1	To learn about Mendelian genetics and its extension.
CO 2	To learn about extrachromosomal inheritance.
CO 3	To gain knowledge about linkage and chromosome mapping.
CO 4	To learn about the structure of gene and mutation.
CO 5	To be sensitized about population and evolutionary genetics.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Mendelian genetics and its extension (CO 1)	Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Numerical; Polygenic inheritance.	CSO 1.1: To explain the history and Principles of inheritance of Mendelism. (U) CSO 1.2: To explain the chromosome theory of inheritance, autosomes and sex chromosomes. (U) CSO 1.3: To illustrate and work out probability and pedigree analysis. (A) CSO 1.4: To explain on incomplete and complete dominance, multiple alleles, lethal alleles, epistasis and pleiotropy. (U) CSO 1.5: To describe recessive and dominant traits, penetrance and expressivity. (K) CSO 1.6: To estimate and evaluate genetical numerical. (A) CSO 1.7: To explain about polygenic inheritance. (U)	10	22	

<p align="center">UNIT 2</p> <p>Extrachromosomal Inheritance (CO 2)</p>	<p>Chloroplast mutation: Variegation in Four o'clock plant; mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective heredity-Kappa particles in <i>Paramecium</i>.</p>	<p>CSO 2.1: To illustrate chloroplast mutation with reference to variegation in Four o'clock plant. (A) CSO 2.2: To explain mitochondrial mutation in yeast. (U) CSO 2.3: To explain maternal effects in the shell coiling of snail. (U) CSO 2.4: To explain on infective heredity with reference to Kappa particles in <i>Paramecium</i>. (U)</p>	<p align="center">5</p>	<p align="center">12</p>	
<p align="center">UNIT 3</p> <p>Linkage, crossing over and chromosome mapping (CO 3)</p>	<p>Linkage and crossing over- Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping; Sex Linkage.</p>	<p>CSO 3.1: To define linkage and crossing over. (K) CSO 3.2: To explain cytological basis of crossing over. (U) CSO 3.3: To work out and estimate recombination frequencies, two factors and three factors crosses. (A) CSO 3.4: To explain about interference and coincidence. (U) CSO 3.5: To estimate and work out numerical based on gene mapping and explain on sex linkage. (A)</p>	<p align="center">10</p>	<p align="center">22</p>	
<p align="center">UNIT 4</p> <p>Fine structure of gene, Variation in chromosome number and structure; Gene mutations (CO 4)</p>	<p>Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus. Deletion, Duplication,</p>	<p>CSO 4.1: To make a comparison between classical and molecular concepts of gene. (A) CSO 4.2: To explain about cis-trans complementation test for functional</p>	<p align="center">10</p>	<p align="center">22</p>	

	<p>Inversion, Translocation, Position effect, Euploidy and Aneuploidy</p> <p>Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: CIB method. Role of Transposons in mutation. DNA repair mechanisms.</p>	<p>allelism. (U)</p> <p>CSO 4.3: To explain the structure of Phage T4, rII Locus. (U)</p> <p>CSO 4.4: To illustrate on deletion, duplication, inversion, translocation, position effect, euploidy and aneuploidy. (A)</p> <p>CSO 4.5: To explain the types of mutation and molecular basis of mutation. (U)</p> <p>CSO 4.6: To explain on mutagens and detection methods of mutations. (U)</p> <p>CSO 4.7: To explain the role of transposons in mutation. (U)</p> <p>CSO 4.8: To illustrate on DNA repair mechanisms. (A)</p>			
<p>UNIT 5</p> <p>Population and Evolutionary Genetics (CO 5)</p>	<p>Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.</p>	<p>CSO 5.1: To explain on allele frequencies and genotype frequencies. (U)</p> <p>CSO 5.2: To describe in detail about Hardy-Weinberg Law and role of natural selection. (K)</p> <p>CSO 5.3: To explain on mutation and genetic drift. (U)</p> <p>CSO 5.4: To explain about genetic variation and speciation. (U)</p>	10	22	

NAME OF THE PAPER	: GENETICS
Code	: BTC 3.3 (P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Meiosis through temporary squash preparation.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
3. Chromosome mapping using point test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex-linked traits.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
6. Blood Typing: ABO groups & Rh factor.
7. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.
8. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
9. Study of human genetic traits: Sickle cell anaemia, Xeroderma Pigmentosum, Albinism, red-green Colour blindness, Widow's peak, rolling of tongue, Hitchhiker's thumb and attached ear lobe.

Suggested Readings

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.

Semester-IV

NAME OF THE PAPER (CODE) : REPRODUCTION AND EMBRYOLOGY OF ANGIOSPERMS (BTC 4.1)

Number of Credit : 03

Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **REPRODUCTION AND EMBRYOLOGY OF ANGIOSPERMS**:

CO 1	To learn the various reproductive and developmental biology of angiosperms.
CO 2	To study about anther and pollen biology.
CO 3	To gain in depth knowledge on ovules.
CO 4	To learn about pollination, fertilization and self incompatibility.
CO 5	To learn about embryo, endosperm, seed, polyembryony and apomixes.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to Angiosperms; Reproductive development (CO 1)	History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope. Induction of flowering; flower as a modified determinate shoot, genetics and molecular aspect of flowering.	CSO 1.1: To discuss on the history of reproductive biology with reference to the contribution of some prominent personalities in the field. (U) CSO 1.2: To explain on the scope of reproductive biology. (U) CSO 1.3: To illustrate on the process of induction of flowering and explain about flower as a modified determinate shoot. (A) CSO 1.4: To discuss the genetic and molecular aspects of flower development. (U)	6	14	
UNIT 2 Anther and pollen biology (CO 2)	Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure; Palynology and scope	CSO 2.1: To describe about the structure and function of anther wall. (K) CSO 2.2: To explain about microsporogenesis, callose deposition and its significance. (U) CSO 2.3: To illustrate on the	9	20	

	(a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.	process of microgametogenesis. (A) CSO 2.4: To explain about pollen wall structure, male germ unit and NPC system. (U) CSO 2.5: To elucidate on palynology and its scope. (U) CSO 2.6: To explain about pollen wall proteins, pollen viability, storage and germination. (U) CSO 2.7: To explain about abnormal features such as pseudomonads, polyads, massulae and pollinia. (U)			
UNIT 3 Ovule (CO 3)	Structure; Types; Special structures—endothelium, obturator, aril, caruncle and hypostase; Female gametophyte—megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of <i>Polygonum</i> type).	CSO 3.1: To explain about the structure and types of ovules. (U) CSO 3.2: To describe special structures like endothelium, obturator, aril, caruncle and hypostase. (K) CSO 3.3: To explain about female gametophyte, megasporogenesis and megagametogenesis. (U) CSO 3.4: To illustrate on the organization and ultra structure of mature embryo sac. (A)	6	14	
UNIT 4 Pollination and fertilization, Self incompatibility (CO 4)	Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization; Methods to overcome self-incompatibility: mixed pollination, bud pollination, stub pollination; Intra-ovarian and <i>in vitro</i> pollination; Modification of stigma surface, parasexual hybridization.	CSO 4.1: To explain the types of pollination and its significance. (U) CSO 4.2: To describe about the adaptations involved in pollination and the structure of stigma and style. (K) CSO 4.3: To illustrate on the path of pollen tube in pistil and double fertilization. (A) CSO 4.4: To discuss basic concepts on interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI. (U) CSO 4.5: To explain about the different methods to overcome self incompatibility. (U) CSO 4.6: To discuss about mixed pollination, bud	12	26	

		<p>pollination, stub pollination, intra-ovarian and <i>in vitro</i> pollination. (U)</p> <p>CSO 4.7: To illustrate on modification of stigma surface, parasexual hybridization, cybrids and <i>in vitro</i> fertilization. (A)</p>			
<p>UNIT 5 Embryo, Endosperm and Seed; Polyembryony and apomixes (CO 5)</p>	<p>Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo development in <i>Paeonia</i>. Seed structure, importance and dispersal mechanisms. Introduction; Classification; Causes and applications.</p>	<p>CSO 5.1: To explain on the structure and types of embryo. (U)</p> <p>CSO 5.2: To describe the general pattern of development of dicot and monocot embryo and endosperm. (K)</p> <p>CSO 5.3: To illustrate the structure and function of suspensor and embryo-endosperm relationship. (A)</p> <p>CSO 5.4: To discuss about the nutrition of embryo, unusual features and embryo development in <i>Paeonia</i>. (U)</p> <p>CSO 5.5: To explain the structure, importance and dispersal mechanisms of seeds. (U)</p> <p>CSO 5.6: To define polyembryony and apomixes and discuss its classification, causes and applications. (K+U)</p>	12	26	

NAME OF THE PAPER	:REPRODUCTION AND EMBRYOLOGY OF ANGIOSPERMS
Code	: BTC 4.1(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular) through photographs and schematic representation.
2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs, fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazoliumtest.germination: Calculation of percentage germination in different media using hanging drop method.
3. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).
4. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
5. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
6. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

Suggested Readings

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

NAME OF THE PAPER (CODE) : PLANT ECOLOGY AND PHYTOGEOGRAPHY (BTC 4.2)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **PLANT ECOLOGY AND PHYTOGEOGRAPHY**:

CO 1	To learn the basic concepts and importance of soil and water to plant ecology.
CO 2	To gain knowledge about light, temperature and biotic interactions.
CO 3	To be well versed in population ecology and plant communities.
CO 4	To learn the concept of ecosystem and its functional aspects.
CO 5	To understand the concept of phytogeography.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction; Soil and Water (CO 1)	Definition; Basic concepts; Levels of organization; Inter-relationships between the living world and the environment, homeostasis. Soil: Origin; Formation; Composition; Physical; Chemical and Biological components; Soil profile. Water: States of water in the environment; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water table.	CSO 1.1: To explain the basic concepts, levels of organization, inter-relationships between the living world and the environment. (U) CSO 1.2: To explain on the components and dynamism of ecology and homeostasis. (U) CSO 1.3: To illustrate on the importance, origin, formation, composition, physical, chemical and biological components of soil. (A) CSO 1.4: To discuss about soil profile and role of climate in soil development. (U) CSO 1.5: To explain the importance of water and states of water in the environment. (U) CSO 1.6: To describe about atmospheric	10	22	

		moisture and precipitation types. (K) CSO 1.7: To explain about hydrological cycle, water in soil and water table. (U)			
UNIT 2 Light, temperature; Biotic interactions (CO 2)	Adaptations of plants to light, temperature and fire variation; Theory of tolerance; Basic source of energy, autotrophy, heterotrophy; symbiosis, commensalism, parasitism.	CSO 2.1: To define abiotic and biotic factors. (K) CSO 2.2: To explain about the variations, adaptations of plants to their variation. (U) CSO 2.3: To discuss about trophic organization, basic source of energy in ecology. (U) CSO 2.4: To explain about autotrophy, heterotrophy, symbiosis, commensalism and parasitism. (U) CSO 2.5: To discuss on food chains and webs, ecological pyramids, biomass and standing crop. (U)	7	16	
UNIT 3 Population ecology and Plant communities (CO 3)	Characteristics of Population Ecology, Ecological Speciation; Habitat and niche; Ecotone and edge effect; Characters: analytical and synthetic; Dynamics: succession – processes, types, climax community.	CSO 3.1: To explain the characteristics and dynamics of population ecology. (U) CSO 3.2: To illustrate on ecological speciation and concept of ecological amplitude. (A) CSO 3.3: To define and explain habitat and niche. (K+U) CSO 3.4: To explain the analytical and synthetic characters of habitat. (U) CSO 3.5: To explain and define ecotone and	12	26	

		edge effect. (K+U) CSO 3.6: To discuss succession and climax concepts. (U)			
UNIT 4 Ecosystems and Functional aspects of ecosystem (CO 4)	Trophic organisation; Food chains and Food webs; Ecological pyramids. Biomass, standing crop. Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.	CSO 4.1: To explain the structure and processes of ecosystem and trophic organisation. (U) CSO 4.2: To discuss about foodchains, food webs and ecological pyramids. (U) CSO 4.3: To explain the principles and models of energy, production and productivity and ecological efficiencies. (U) CSO 4.4: To define biogeochemical cycles and explain on cycling of carbon, nitrogen and phosphorus. (K+U)	10	22	
UNIT 5 Phytogeography (CO 5)	Principles; Phytogeographical division of India; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Endemism, Local Vegetation.	CSO 5.1: To define phytogeography and explain its principles. (K+U) CSO 5.2: To discuss about continental drift, theory of tolerance and endemism. (U) CSO 5.3: To give a brief description of major terrestrial biomes. (K) CSO 5.4: To discuss on phytogeographical division of India and local vegetation. (U)	6	14	

NAME OF THE PAPER	: PLANT ECOLOGY AND PHYTOGEOGRAPHY
Code	: BTC 4.2(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH of various soil and water samples (pH meter, universal indicator/Lovibond comparator and pH paper)
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
4. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
5. (a). Study of morphological adaptations of hydrophytes and xerophytes (four each).
(b). Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanch*) Epiphytes, Predation (Insectivorous plants).
6. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
7. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.
8. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
9. Field visit to familiarise students with ecology of different sites.

Suggested Readings

1. Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5th edition.
2. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
3. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
4. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.
5. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.

NAME OF THE PAPER (CODE) : PLANT SYSTEMATICS (BTC 4.3)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **PLANT SYSTEMATICS**:

CO 1	To understand to the basics of plant taxonomy and significance of plant systematic.
CO 2	To learn about taxonomic hierarchy and Botanical Nomenclature.
CO 3	To be well versed on the different systems of classifications.
CO 4	To learn about numerical taxonomy.
CO 5	To gain knowledge on phylogeny of angiosperms.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Significance of Plant systematic (CO 1)	Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences from palynology, cytology, phytochemistry and molecular data. Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys:Single access and Multi-access.	CSO 1.1: To define plant systematic and explain on plant identification, classification and nomenclature. (K+U) CSO 1.2: To illustrate on the evidences from palynology, cytology, phytochemistry and molecular data. (A) CSO 1.3: To explain about field inventory and functions of herbarium. (U) CSO 1.4: To discuss on important herbaria and botanical gardens of the world and India as well as on virtual herbarium and e-flora. (U) CSO 1.5: To illustrate on taxonomic documentation and taxonomic keys. (A)	12	26	
UNIT 2 Taxonomic hierarchy and Botanical Nomenclature	Concept of taxa (family, genus, species); Categories and taxonomic	CSO 2.1: To explain the concept of taxa, categories and taxonomic hierarchy. (U)	8	18	

(CO 2)	<p>hierarchy; Species concept (taxonomic, biological, evolutionary). Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.</p>	<p>CSO 2.2: To explain about the species concept. (U) CSO 2.3: To illustrate on the principles and rules of ICN. (A)</p>			
UNIT 3 Systems of classification (CO 3)	<p>Classification systems of Bentham and Hooker (upto series) and Engler and Prantl (upto series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.</p>	<p>CSO 3.1: To discuss on the major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, A.P. de Candolle. Bessey, Hutchinson, Takhtajan and Cronquist. (U) CSO 3.2: To illustrate on classification systems of Bentham and Hooker and Engler and Prantl. (A) CSO 3.3: To outline in brief the Angiosperm Phylogeny Group (APG III) classification. (K)</p>	8	18	
UNIT 4 Biometrics, numerical taxonomy and cladistics (CO 4)	<p>Characters; Variations; OTUs, character weighting and coding; Cluster analysis; Phenograms, cladograms (definitions and differences).</p>	<p>CSO 4.1: To explain on the characters and variations of numerical taxonomy. (U) CSO 4.2: To illustrate on OTUs, character weighting and coding. (A) CSO 4.3: To explain on cluster analysis, phenograms and cladograms. (U)</p>	8	18	
UNIT 5	Terms and concepts	CSO 5.1: To explain	9	20	

Phylogeny of Angiosperms (CO 5)	(primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Co-evolution of angiosperms and animals.	the terms and concepts of primitive and advanced characters, homology and analogy, parallelism and convergence, monophyly, paraphyly, polyphyly and clades. (U) CSO 5.2: To discuss on the origin and evolution of angiosperms. (U) CSO 5.3: To explain the co-evolution of angiosperms and animals. (U) CSO 5.4: To work out on methods of illustrating evolutionary relationship. (A)			
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NAME OF THE PAPER : PLANT SYSTEMATICS
Code : BTC 4.3(P)
Number of Credit : 01
Number of Hours of Lecture : 30

Practicals

- Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):

Ranunculaceae	-	<i>Ranunculus,</i>	<i>Delphinium</i>
Brassicaceae	-	<i>Brassica, Alyssum</i>	<i>/ Iberis</i>
Myrtaceae	-	<i>Eucalyptus,</i>	<i>Callistemon</i>
Umbelliferae	-	<i>Coriandrum /Anethum / Foeniculum</i>	
Asteraceae	-	<i>Sonchus/Launaea, Vernonia/Ageratum, Eclipta/Tridax</i>	
Solanaceae	-	<i>Solanum nigrum/Withania</i>	
Lamiaceae	-	<i>Salvia/Ocimum</i>	
Euphorbiaceae	-	<i>Euphorbia hirta/E.milii, Jatropha</i>	
Liliaceae	-	<i>Asphodelus/Lilium/Allium</i>	
Poaceae	-	<i>Triticum/Hordeum/Avena</i>	
- Field visit (local) – Subject to grant of funds from the university.
- Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

Suggested Readings

1. Singh, (2012). *Plant Systematics: Theory and Practice* Oxford & IBH Pvt. Ltd., New Delhi. 3rdedition.
2. Jeffrey, C. (1982). *An Introduction to Plant Taxonomy*. Cambridge University Press, Cambridge.
3. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). *Plant Systematics-A Phylogenetic Approach*. Sinauer Associates Inc., U.S.A. 2nd edition.
4. Maheshwari, J.K. (1963). *Flora of Delhi*. CSIR, New Delhi.
5. Radford, A.E. (1986). *Fundamentals of Plant Systematics*. Harper and Row, New York.

Semester-V

NAME OF THE PAPER (CODE) : MOLECULAR BIOLOGY (BTC 5.1)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **MOLECULAR BIOLOGY**:

CO 1	To learn about nucleic acids, DNA, RNA, Central dogma and genetic code.
CO 2	To understand the replication of DNA.
CO 3	To learn the detailed transcription process.
CO 4	To be sensitized on the processing and modification of RNA.
CO 5	To gain knowledge and understanding on translation process.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Nucleic acids: Carriers of genetic information; The Structures of DNA and RNA / Genetic Material; Central dogma and genetic code (CO 1)	Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase). DNA Structure: Watson and Crick model, Salient features, Types of DNA, Types of genetic material, RNA Structure. Chromatin structure - Euchromatin, Heterochromatin - Constitutive and Facultative heterochromatin. The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features)	CSO 1.1: To discuss the historical perspective of DNA as a genetic material. (U) CSO 1.2: To explain about DNA as the carrier of genetic information with reference to selected experiments. (U) CSO 1.3: To illustrate about the DNA structure according to Miescher and Watson and Crick. (A) CSO 1.4: To explain the historic perspective of DNA structure. (U) CSO 1.5: To explain the salient features of double helix and types of DNA, types of genetic material, denaturation and renaturation and cot curves of DNA. (U) CSO 1.6: To illustrate the organization of DNA in prokaryotes, viruses and eukaryotes (A). CSO 1.7: To explain	11	24	

		<p>about RNA structure, mitochondria and chloroplast DNA. (U)</p> <p>CSO 1.8: To discuss in detail about nucleosome, chromatin structure, euchromatin and heterochromatin. (U)</p> <p>CSO 1.9: To study about key experiments establishing the central dogma and learn the salient features of genetic code. (K+A)</p>			
<p>UNIT 2 The replication of DNA (CO 2)</p>	<p>Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, Semiconservative and semi discontinuous replication; Various models of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA; Enzymes involved in DNA replication.</p>	<p>CSO 2.1: To explain the chemistry of DNA synthesis. (U)</p> <p>CSO 2.2: To discuss the general principles of bidirectional, semi conservative and semi discontinuous replication and RNA priming. (U)</p> <p>CSO 2.3: To explain about various models of DNA replication including rolling circle, theta mode of replication, replication of linear ds-DNA and replication of the 5'end of linear chromosome. (U)</p> <p>CSO 2.4: To analyse enzymes involved in DNA replication. (A)</p>	10	22	
<p>UNIT 3 Transcription (CO 3)</p>	<p>Transcription in prokaryotes and eukaryotes. Principles of transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in <i>E.coli</i>. Eukaryotes: transcription factors, heat shock proteins,</p>	<p>CSO 3.1: To explain transcription in prokaryotes and eukaryotes. (U)</p> <p>CSO 3.2: To explain the principles of transcriptional regulation. (U)</p> <p>CSO 3.3: To discuss on the regulation of lactose metabolism and tryptophan synthesis in <i>E.</i></p>	8	18	

	steroids and peptide hormones.	<i>coli.</i> (U) CSO 3.4: To illustrate on transcription factors, heat shock proteins, steroids and peptide hormones. (A) CSO 3.5: To explain about gene silencing. (U)			
UNIT 4 Processing and modification of RNA (CO 4)	Split genes-concept of introns and exons, removal of introns, Splicing pathways, group I and group II intron splicing, alternative splicing, eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes; RNA editing and mRNA transport.	CSO 4.1: To explain about split genes, concept of introns and exons, removal of introns. (U) CSO 4.2: To illustrate on spliceosome machinery, splicing pathways, group I and group II intron splicing. (A) CSO 4.3: To discuss on alternative splicing of eukaryotic mRNA processing. (U) CSO 4.4: To explain on ribozymes, RNA editing and mRNA transport. (U)	8	18	
UNIT 5 Translation (CO 5)	Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyltRNA synthetases; various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Inhibitors of protein synthesis; Post-translational modifications of proteins.	CSO 5.1: To explain about structure and assembly of ribosome and mRNA. (U) CSO 5.2: To explain about charging of tRNA, aminoacyl tRNAsynthetases.(U) CSO 5.3: To illustrate on the various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides. (A) CSO 5.4: To discuss about fidelity of translation and inhibitors of protein synthesis. (U) CSO 5.5: To explain on post-translational modification of proteins. (U)	8	18	

NAME OF THE PAPER	: MOLECULAR BIOLOGY
Code	: BTC 5.1(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Preparation of LB medium and raising *E.coli*.
2. Isolation of genomic DNA from *E.coli*.
3. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
4. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
5. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
6. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)

Suggested Readings

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
4. Russell, P. J. (2010). i-Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition

NAME OF THE PAPER (CODE) : PLANT PHYSIOLOGY (BTC 5.2)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **PLANT PHYSIOLOGY**:

CO 1	To be introduced to and understand about plant water relations.
CO 2	To learn about nutrition in plants.
CO 3	To understand about translocation in plants.
CO 4	To be sensitized about plant growth regulators.
CO 5	To learn and understand the physiology of flowering.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Plant-water relations (CO 1)	Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap–cohesion-tension theory. Transpiration and factors affecting transpiration, mechanism of stomatal movement.	CSO 1.1: To explain water potential and its components. (U) CSO 1.2: To illustrate on water absorption by roots and aquaporins. (A) CSO 1.3: To explain pathway of water movement, symplast, apoplast and transmembrane pathways. (U) CSO 1.4: To describe about root pressure and guttation. (K) CSO 1.5: To explain ascent of sap and cohesion-tension theory. (U) CSO 1.6: To discuss about transpiration and factors affecting transpiration, anti transpirants and mechanism of stomatal movement.(U)	10	22	
UNIT 2 Mineral nutrition (CO 2)	Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents.	CSO 2.1: To explain about essential and beneficial elements, macro and micronutrients. (U) CSO 2.2: To describe the methods and use of nutrient solutions. (K) CSO 2.3: To explain on criteria of essentiality and mineral deficiency	10	22	

		symptoms. (U) CSO 2.4: To illustrate on essential elements and chelating agents. (A)			
UNIT 3 Nutrient Uptake Translocation in the phloem (CO 3)	Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport. Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.	CSO 3.1: To illustrate on soil as a nutrient reservoir. (A) CSO 3.2: To discuss on transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption and role of ATP. (U) CSO 3.3: To explain about carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport and antiport. (U) CSO 3.4: To discuss about experimental evidence in support of phloem as the site of sugar translocation. (U) CSO 3.5: To demonstrate Pressure-flow model, phloem loading and unloading and source-sink relationship. (A)	10	22	
UNIT 4 Plant growth regulators (CO 4)	Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid.	CSO 4.1: To discuss on the discovery, chemical nature and structure of auxins, gibberellins, abscisic acid, ethylene, brassinosteroids and jasmonic acid. (U) CSO 4.2: To explain the bioassay and physiological roles of auxins, gibberellins, abscisic acid, ethylene, brassinosteroids and jasmonic acid. (U)	5	12	
UNIT 5 Physiology of flowering; Phytochrome, cryptochromes and phototropins (CO 5)	Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy. Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER)	CSO 5.1: To define and explain photoperiodism. (K+U) CSO 5.2: To illustrate on flowering stimulus, florigen concept, vernalization and seed dormancy. (A) CSO 5.3: To explain the	10	22	

	and high irradiance responses (HIR), mode of action.	discovery, chemical nature and role of light pigments on photomorphogenesis. (U) CSO 5.4: To describe about low energy response, high irradiance responses and the mode of action. (K)			
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NAME OF THE PAPER : **PLANT PHYSIOLOGY**
Code : **BTC 5.2(P)**
Number of Credit : **01**
Number of Hours of Lecture : **30**

Practicals

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).
7. To study the effect of different concentrations of IAA on *Avena* coleoptile elongation (IAA Bioassay).

Demonstration experiments

1. To demonstrate suction due to transpiration.
2. Fruit ripening/Rooting from cuttings (Demonstration).

Suggested Readings

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

NAME OF THE PAPER (CODE) : PLANT BIOTECHNOLOGY (BTC 5.3)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **PLANT BIOTECHNOLOGY**:

CO 1	To learn the concept of plant tissue culture.
CO 2	To learn about Recombinant DNA Technology.
CO 3	To gain knowledge on gene cloning.
CO 4	To learn about methods of gene transfer.
CO 5	To gain in depth knowledge on applications of biotechnology

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Plant Tissue Culture (CO 1)	Historical perspective; Composition of media; role of Vitamins and hormones; Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).	CSO 1.1: To outline on the historical perspective of plant tissue culture. (K) CSO 1.2: To discuss on the composition of media, nutrient and hormone requirements. (U) CSO 1.3: To explain about totipotency, organogenesis and embryogenesis. (U) CSO 1.4: To illustrate on protoplast isolation, culture and fusion. (A) CSO 1.5: To explain on the various important applications of tissue culture. (U)	12	26	
UNIT 2 Recombinant DNA technology (CO 2)	Restriction Endonucleases (Types I-IV, biological role and application); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors	CSO 2.1: To explain the history, types, biological role and application of restriction endonucleases. (U) CSO 2.2: To discuss linear and circular restriction mapping. (U) CSO 2.3: To explain on prokaryotic cloning vectors, lambda phage, M13 phagemid, cosmid,	8	18	

	(YAC).	shuttle vector and eukaryotic vectors. (U)			
UNIT 3 Gene Cloning (CO 3)	Recombinant DNA, Bacterial Transformation and selection of recombinant clones, Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; Colony hybridization; PCR	CSO 3.1: To explain about recombinant DNA, bacterial transformation and selection of recombinant clones. (U) CSO 3.2: To illustrate on PCR mediated gene cloning, gene construct, construction of genomic and cDNA libraries. (A) CSO 3.3: To explain about screening DNA libraries to obtain gene of interest by genetic selection. (U) CSO 3.4: To discuss on complementation, colony hybridization and PCR. (U)	8	18	
UNIT 4 Methods of gene transfer (CO 4)	<i>Agrobacterium</i> -mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes (Luciferase, GUS, GFP).	CSO 4.1: To explain on <i>Agrobacterium</i> -mediated gene transfer. (U) CSO 4.2: To illustrate on direct gene transfer by electroporation, microinjection and microprojectile bombardment. (A) CSO 4.3: To discuss on selection of transgenics-selectable markers and reporter genes. (U)	8	18	
UNIT 5 Applications of Biotechnology (CO 5)	Pest resistant (Bt-cotton); herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Role of transgenics in bioremediation	CSO 5.1: To explain on application of biotechnology on pest resistant, herbicide resistant plants and transgenic crops with improved quality traits. (U) CSO 5.2: To discuss on improved horticultural varieties and role of	9	20	

	(Superbug); Gently Engineered Products– Human Growth Hormone; Biosafety concerns.	transgenics in bioremediation. (U) CSO 5.3: To explain about edible vaccines, industrial enzymes and genetically engineered products-human growth hormone. (U) CSO 5.4: To discuss on Humulin and biosafety concerns. (U)			
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NAME OF THE PAPER : PLANT BIOTECHNOLOGY

Code : BTC 5.3(P)

Number of Credit : 01

Number of Hours of Lecture : 30

Practicals

1. Preparation of MS medium.
2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
3. Isolation of protoplasts.
4. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
5. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.
6. Isolation of plasmid DNA.
7. Gel electrophoresis of plasmid DNA.

Suggested Readings

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
2. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
3. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
4. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.
5. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.

Semester-VI

NAME OF THE PAPER (CODE) : PLANT METABOLISM (BTC 6.1)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **PLANT METABOLISM**:

CO 1	To be introduced to and understand the concept of metabolism.
CO 2	To understand about carbon assimilation in plants
CO 3	To learn about carbohydrate metabolism and carbon oxidation in plants.
CO 4	To learn about ATP synthesis and signal transduction in plants
CO 5	To understand and learn about lipid and nitrogen metabolism.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Concept of metabolism (CO 1)	Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and Isozymes).	CSO 1.1: To describe the concept of metabolism. (K) CSO 1.2: To explain about anabolic and catabolic pathways. (U) CSO 1.3: To illustrate on the regulation of metabolism and role of regulatory enzymes. (A)	5	12	
UNIT 2 Carbon assimilation (CO 2)	Photosynthetic pigments (chlorophylls and accessory pigments), photosynthetic electron transport, antenna molecules and reaction centres, photochemical reactions, PSI, PSII, Q cycle, photorespiration, C ₄ pathways; Crassulacean acid metabolism.	CSO 2.1: To explain on photosynthetic pigments and their roles. (U) CSO 2.2: To discuss on antenna molecules and reaction centres of photosynthetic pigments. (U) CSO 2.3: To illustrate on photochemical reactions and photosynthetic electron transport. (A) CSO 2.4: To explain on PSI, PSII and Q cycle. (U)	10	22	

		CSO 2.5: To discuss on CO ₂ reduction, C ₄ pathways, CAM pathway and factors affecting CO ₂ reduction. (U)			
UNIT 3 Carbohydrate metabolism; Carbon Oxidation (CO 3)	Synthesis and catabolism of sucrose and starch. Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration.	CSO 3.1: To explain on synthesis and catabolism of sucrose and starch. (U) CSO 3.2: To explain glycolysis, fate of pyruvate, regulation of glycolysis and oxidative pentose phosphate pathway. (U) CSO 3.3: To explain on oxidative decarboxylation of pyruvate and regulation of PDH and NADH shuttle. (U) CSO 3.4: To explain TCA cycle, amphibolic role, anaplerotic reactions and regulation of the cycle. (U) CSO 3.5: To illustrate mitochondrial electron transport and oxidative phosphorylation. (A) CSO 3.6: To explain cyanide-resistant respiration and factors affecting respiration. (U)	10	22	
UNIT 4 ATP-Synthesis and Mechanism of signal transduction (CO 4)	Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (Oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker's experiment,	CSO 4.1: To explain the mechanism of ATP synthesis, substrate level phosphorylation and chemiosmotic mechanism. (U) CSO 4.2: To illustrate on ATP synthase,	10	22	

	Jagendorf's experiment; role of uncouplers. Receptor-ligand interactions; Second messenger concept, Calcium calmodulin.	Boyers conformational model, Racker's experiment and Jagendorf's experiment. (A) CSO 4.3: To discuss the role of uncouplers, receptor-ligand interactions, second messenger concept and calcium calmodulin. (U) CSO 4.4: To explain on MAP kinase cascade. (U)			
UNIT 5 Lipid and Nitrogen metabolism (CO 5)	Synthesis and breakdown of triglycerides, β -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination, α oxidation. Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Ammonia assimilation and transamination.	CSO 5.1: To explain the synthesis and breakdown of triglycerides. (U) CSO 5.2: To discuss on β -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination. (U) CSO 5.3: To explain α -oxidation. (U) CSO 5.4: To explain on nitrate assimilation, biological nitrogen fixation. (U) CSO 5.5: To illustrate on physiology and biochemistry of nitrogen fixation, ammonia assimilation and transamination. (A)	10	22	

NAME OF THE PAPER	: PLANT METABOLISM
Code	: BTC 6.1(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Chemical separation of photosynthetic pigments.
2. To study the effect of light intensity on the rate of photosynthesis.
3. Effect of carbon dioxide on the rate of photosynthesis.
4. To compare the rate of respiration in different parts of a plant.
5. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.
6. Demonstration of fluorescence by isolated chlorophyll pigments.
7. Demonstration of absorption spectrum of photosynthetic pigments.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.

NAME OF THE PAPER (CODE) : BIOMOLECULES (BTC 6.2)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **BIOMOLECULES**:

CO 1	To understand and study biomolecules in the biological world.
CO 2	To understand nomenclature, classification, structures and functions of carbohydrates, lipids and fatty acids
CO 3	To learn about amino acids, nucleic acids, RNA and DNA.
CO 4	To learn about the concept of bioenergetics.
CO 5	To understand enzymes, its types, classification, structure and activity.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to Biomolecules (CO 1)	Types and significance of chemical bonds; Structure and properties of water; pH and buffers.	CSO 1.1: To define biomolecules and explain the types and significance of chemical bonds. (K+U) CSO 1.2: To explain about the structure and properties of water, pH and buffers. (U)	7	16	
UNIT 2 Biomolecules I (CO 2)	Carbohydrates: Nomenclature and classification ; Monosaccharides ; Disaccharides ; Oligosaccharides and polysaccharides. Lipids: Definition and major classes of storage and structural lipids; Fatty acids structure and functions; Essential fatty acids; Triacyl glycerols structure, functions and properties; Phosphoglycerides.	CSO 2.1: To explain the nomenclature, classification (monosaccharides, disaccharides, oligosaccharides and polysaccharides) of carbohydrates. (U) CSO 2.2: To define lipids and explain the major classes of storage and structural lipids. (K+U) CSO 2.3: To explain the structure of fatty acids and functions. (U) CSO 2.4: To define essential fatty acids and explain the structure, function and properties of triacyl glycerols. (K+U) CSO 2.5: To explain about phosphoglycerides. (U)	10	22	
UNIT 3 Biomolecules II (CO 3)	Proteins: Structure of amino acids; Levels of protein structure-primary, secondary, tertiary	CSO 3.1: To explain the structure of amino acids, levels of protein structure; protein denaturation and biological roles of proteins. (U)	10	22	

	<p>and quarternary; Protein denaturation and biological roles of proteins. Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.</p>	<p>CSO 3.2: To explain the structure of nitrogenous bases, structure and functions of nucleotides, types of nucleic acids, structure of A, B and Z (U) CSO 3.3: To illustrate about the types of DNA (A) CSO 3.4: To explain and illustrate about the types of RNA and structure of tRNA. (U+A)</p>			
<p>UNIT 4 Bioenergenetics (CO 4)</p>	<p>Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as a energy currency molecule.</p>	<p>CSO 4.1: To explains the laws of thermodynamics and concept of free energy. (U) CSO 4.2: To explain about endergonic and exergonic reactions, coupled reactions and redox reactions. (U) CSO 4.3: To explain the structure of ATP and its role as energy currency molecule. (U)</p>	6	14	
<p>UNIT 5 Enzymes (CO 5)</p>	<p>Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theory), Michaelis – Menten equation, enzyme inhibition and factors affecting enzyme activity.</p>	<p>CSO 5.1: To define enzymes and explain the structure of enzyme (holoenzyme, apoenzyme, cofactors, coenzyme and prosthetic group). (K+U) CSO 5.2: To explain the classification of enzymes, features of active site, substrate specificity and mechanism of enzyme action. (U) CSO 5.3: To explain and work out Michaelis-Menten Equation. (K+A) CSO 5.4: To explain about enzyme inhibition and factors affecting enzyme activity. (U)</p>	12	26	

NAME OF THE PAPER	: BIOMOLECULES
Code	: BTC 6.2(P)
Number of Credit	: 01
Number of Hours of Lecture	: 3

Practicals

1. Testing food samples for the presence of biomolecules.
2. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
3. Buffer solution preparations and pH measurement.
4. Tests on amino acids.
5. Separation of sugars by paper chromatography.
6. Isolation of casein from milk.

Suggested Readings

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by ChurchillLivingstone
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman
4. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company
Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H.Freeman and Company.

NAME OF THE PAPER (CODE) : PLANT DIVERSITY AND HUMAN WELFARE
(BTC 6.3)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **PLANT DIVERSITY AND HUMAN WELFARE**:

CO 1	To acquire detailed knowledge on plant diversity and its scopes.
CO 2	To understand the implications of biodiversity loss and its management.
CO 3	To learn about management of plant biodiversity.
CO 4	To gain in depth knowledge of conservation of biodiversity.
CO 5	To learn on the role of plants in human welfare

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Plant diversity and its scope (CO 1)	Introduction to plant diversity: Genetic diversity, Species diversity, Plant diversity at the ecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes.	CSO 1.1: To explain about plant diversity: Genetic diversity, Species diversity. (U) CSO 1.2: To explain plant diversity at the ecosystem level. (U) CSO 1.3: To explain about Agrobiodiversity and cultivated plant taxa, wild taxa. (U) CSO 1.4: To explain about values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle, Methodologies for valuation, Uses of plants, Uses of microbes. (U)	12	26	
UNIT 2 Loss of Biodiversity (COM2)	Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss.	CSO 2.1: To explain about loss of genetic diversity, loss of species diversity, loss of ecosystem diversity, loss of agrobiodiversity. (U) CSO 2.2: To explain about projected scenario for biodiversity loss. (U)	8	18	
UNIT 3 Management of Plant Biodiversity (CO 3)	Organizations associated with biodiversity management- Methodology for	CSO 3.1: To explain about organizations associated with biodiversity management- Methodology for	10	22	

	execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.	execution-IUCN, UNEP, UNESCO, WWF, NBPGR. (U) CSO 3.2: To explain about biodiversity legislation and conservations. (U) CSO 3.3: To explain about biodiversity information management and communication. (U)			
UNIT 4 Conservation of Biodiversity (CO 4)	Conservation of genetic diversity, species diversity and ecosystem diversity, <i>In situ</i> and <i>ex situ</i> conservation, Social approaches to conservation, Biodiversity awareness programs, Sustainable development.	CSO 4.1: To explain about conservation of genetic diversity, species diversity and ecosystem diversity, <i>In situ</i> and <i>ex situ</i> conservation. (U) CSO 4.2: To explain about social approaches to conservation, biodiversity awareness programs, sustainable development. (U)	7	16	
UNIT 5 Role of plants in relation to Human Welfare (CO 5)	a) Importance of forestry their utilization and commercial aspects b) Avenue trees, c) Ornamental plants of India. d)Alcoholic beverages through ages e) Fermented foods f) Ethnobotanical medicines. Fruits and nuts: Important fruit crops their commercial importance. Wood and its uses.	CSO 5.1: To explain about the importance of forestry their utilization and commercial aspects. (U) CSO 5.2: To explain and illustrate about Avenue trees, ornamental plants of India,alcoholic beverages through ages, fermented foods and ethnobotanical medicines. (U+A) CSO 5.3: To explain about fruits and nuts: Important fruit crops their commercial importance. Wood and its uses. (U)	8	18	

NAME OF THE PAPER	: PLANT DIVERSITY AND HUMAN WELFARE
Code	: BTC 6.3(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Collecting and preserving plant specimens, preparation of herbarium sheets.
2. Study of plant diversity (gymnosperms and angiosperms) of the campus.
3. Study of some important ornamental plants of India/Nagaland
4. Study of some locally available fruits and nuts.
5. Field visit to Biodiversity hot spots.
6. Study of local fermented foods (microbes involved and process of fermentation)

Suggested Readings

1. Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
2. Sharma O.P., (2015.) Plants and Human Welfare. Pragathi Prakashan
3. S.K .Jain, 1995. Manual of Ethnobotany. Scientific publishers.
4. S. Sundar Rajan.,(2007.) College Botany Vol-V, Part 1:Taxonomy and Economic Botany Himalaya Publishing House.
5. Susil Kumar Mukharjee.,(2004.) College Botany Vol-III. New Central Book agency, London
6. P.Vasanth Kumar.,(2014.) Economic Botany.
7. Erach Bharucha., (1998.) Environmental Studies for UG Students. Universities Press, New Delhi.
8. Jain S. K.,(2000.) Human aspects of plant diversity. Economic Botany 54: 459 (article).
9. Maiti, P.K., Maiti, P.(2017.) Biodiversity : Perception, Peril and Preservation Prentice Hall India Pvt., Limited

NAME OF THE PAPER (CODE) : PLANT BREEDING (BTC 6.3)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **PLANT BREEDING**:

CO 1	To learn the basic concepts about the field of plant breeding.
CO 2	To be well versed in the methods of crop improvement.
CO 3	To gain knowledge in quantitative inheritance in plants.
CO 4	To understand about inbreeding depression and heterosis.
CO 5	To gain insights on crop improvement and breeding.

COURSE SPECIFIC OUTCOMES (CSOs)

Unit & Title	Unit Contents	Course Specific Outcomes (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Plant Breeding (CO 1)	Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.	CSO 1.1: To give an introduction and explain the objectives of plant breeding. (K+U) CSO 1.2: To illustrate on breeding systems and modes of reproduction in crop plants. (A) CSO 1.3: To discuss on important achievements and undesirable consequences of plant breeding. (U)	10	22	
UNIT 2 Methods of crop improvement (CO 2)	Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.	CSO 2.1: To explain on the centres of origin and domestication of crop plants and plant genetic resources. (U) CSO 2.2: To discuss on acclimatization of crop plants, selection methods for self pollinated, cross pollinated and vegetatively propagated plants. (U) CSO 2.3: To define hybridization and explain hybridization for self, cross and vegetatively propagated plants. (K+U) CSO 2.4: To illustrate the procedure, advantages and limitations of	10	22	

		hybridization for self, cross and vegetatively propagated plants. (A)			
UNIT 3 Quantitative inheritance (CO 3)	Concept, mechanism, examples of inheritance of Kernel colour in wheat, kernel colour in corn, Monogenic vs polygenic Inheritance	CSO 3.1: To explain the concept of quantitative inheritance. (U) CSO 3.2: To illustrate the mechanism with examples of inheritance of kernel colour in wheat and kernel colour in corn. (A) CSO 3.3: To make a comparison between monogenic and polygenic inheritance. (U+A)	10	22	
UNIT 4 Inbreeding depression and heterosis (CO 4)	History, genetic basis of inbreeding depression and heterosis; Applications.	CSO 4.1: To discuss on the history of inbreeding depression and heterosis. (U) CSO 4.2: To explain the genetic basis of inbreeding depression and heterosis. (U) CSO 4.3: To outline the applications of inbreeding depression and heterosis. (K)	5	12	
UNIT 5 Crop improvement and breeding (CO 5)	Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.	CSO 5.1: To illustrate the role of mutation in crop improvement. (A) CSO 5.2: To discuss polyploidy in crop improvement. (U) CSO 5.3: To explain on distant hybridization and role of biotechnology in crop improvement. (U)	10	22	

NAME OF THE PAPER	: PLANT BREEDING
Code	: BTC 6.4(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Project work (To be assigned to students)

1. Hybridization technique on selected plants
2. Plant tissue culture through root, stem and shoot cuttings or seeds.
3. Cultivation of crops and study of acclimatization and various environmental factors affecting its growth.
4. Study of qualitative inheritance in kernel color in wheat or corn.

Suggested Readings

1. Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7th edition.
2. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding. Oxford – IBH. 2nd edition 52
3. Acquaah, G. (2007). Principles of Plant Genetics & Breeding. Blackwell Publishing.

Semester-VII

NAME OF THE PAPER (CODE) : HORTICULTURE PRACTICES AND POST HARVEST TECHNOLOGY (BTC 7.1)

Number of Credit : 03

Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **HORTICULTURE PRACTICES AND POST HARVEST TECHNOLOGY**:

CO 1	To understand about the field of horticulture and its techniques.
CO 2	To learn about floriculture and ornamental plants.
CO 3	To learn about various vegetable and fruit crops.
CO 4	To learn about post-harvest technologies.
CO 5	To understand and learn about landscaping and garden design.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction and horticultural techniques (CO 1)	Scope and importance, Branches of horticulture; Role in rural economy and employment generation; Importance in food and nutritional security; Urban horticulture and ecotourism. Application of fertilizers and PGRs; Biofertilizers, biopesticides; Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics; Propagation Methods: asexual (grafting, cutting, layering, budding), sexual (seed propagation).	CSO 1.1: To explain about the scope and importance of horticulture and different branches of horticulture. (U) CSO 1.2: To discuss the role of horticulture in rural economy and employment generation. (U) CSO 1.3: To explain on the importance of horticulture in food and nutritional security. (U) CSO 1.4: To discuss on urban horticulture and ecotourism. (U) CSO 1.5: To explain on application of manure, fertilizers, nutrients and PGRs. (U) CSO 1.6: To discuss on weed control, bio fertilizers and bio pesticides. (U)	10	22	

		<p>CSO 1.7: To explain about the different methods of irrigation and hydroponics. (U)</p> <p>CSO 1.8: To discuss on asexual and sexual propagation methods. (U)</p> <p>CSO 1.9: To discuss on scope and limitations of horticulture. (U)</p>			
<p>UNIT 2 Floriculture and Ornamental plants (CO 2)</p>	<p>Cut flowers, bonsai, commerce (market demand and supply). Types, classification (annuals, perennials); Identification and salient features of some ornamental plants [rose, gladiolus, orchids, poppies, gerberas, tuberose, sages, cacti and succulents (opuntia, agave and spurges)] Ornamental flowering trees (Indian laburnum, gulmohar, Jacaranda, Lagerstroemia, fishtail, areca palms, coral tree).</p>	<p>CSO 2.1: To discuss about cut flowers and bonsai as well as their market demand and supply. (U)</p> <p>CSO 2.2: To explain about the importance of flower shows and exhibitions. (U)</p> <p>CSO 2.3: To explain about the different types and classification of flowers and ornamental plants. (U)</p> <p>CSO 2.4: To identify and explain the salient features of some ornamental plants. (A+U)</p> <p>CSO 2.5: To identify and explain the salient features of some ornamental flowering trees. (A+U)</p>	10	22	
<p>UNIT 3 Fruit and vegetable crops (CO 3)</p>	<p>Production, origin and distribution; Description of plants and their economic products; Management and marketing of vegetable and fruit crops; Identification of some fruits and vegetable varieties (citrus, banana, mango, chillies and cucurbits).</p>	<p>CSO 3.1: To explain about the production, origin and distribution of fruits and vegetable crops. (U)</p> <p>CSO 3.2: To illustrate on description of plants and their economic products. (A)</p> <p>CSO 3.3: To discuss on the management and marketing of fruits and vegetable crops. (U)</p> <p>CSO 3.4: To identify</p>	5	12	

		and study some fruits and vegetable varieties. (A)			
UNIT 4 Post-harvest technology (CO 4)	Importance of post-harvest technology in horticultural crops; Evaluation of quality traits; Harvesting and handling of fruits, vegetables and cut flowers; Principles, methods of preservation and processing; Methods of minimizing losses during storage and transportation; Food irradiation - advantages and disadvantages; food safety.	CSO 4.1: To explain on the importance of post harvest technology in horticultural crops. (U) CSO 4.2: To study about the evaluation of quality traits. (U+A) CSO 4.3: To explain about harvesting and handling of fruits, vegetables and cut flowers. (U) CSO 4.4: To illustrate on the principles and methods of preservation and processing of fruits and vegetables. (A) CSO 4.5: To discuss on the methods of minimizing losses during storage and transportation. (U) CSO 4.6: To explain about food irradiation, its advantages and disadvantages and food safety. (U)	10	22	
UNIT 5 Landscaping and garden design (CO 5)	Planning and layout (parks and avenues); gardening traditions - Ancient Indian, European, Mughal and Japanese Gardens; Urban forestry; policies and practices.	CSO 5.1: To discuss on planning and layout of parks and avenues. (U) CSO 5.2: To explain about gardening traditions with reference to ancient Indian, European, Mughal and Japanese gardens. (U) CSO 5.3: To explain about urban forestry, policies and practices. (U)	10	22	

NAME OF THE PAPER : **HORTICULTURE PRACTICES AND POST HARVEST TECHNOLOGY**
Code : **BTC 7.1(P)**
Number of Credit : **01**
Number of Hours of Lecture : **30**

Practicals

1. Field trip

Field visits to gardens, standing crop sites, nurseries, vegetable gardens and horticultural fields at IARI or other suitable locations.

OR

2. Project work (to be assigned to the students)

- a) Hydroponics
- b) Post harvest techniques
- c) Floriculture/Olericulture/Pomology (Market demand and sales)
- d) Landscaping & Gardens

Suggested Readings

- 1. Singh, D. & Manivannan, S. (2009). Genetic Resources of Horticultural Crops. Ridhi International, Delhi, India.
- 2. Swaminathan, M.S. and Kochhar, S.L. (2007). Groves of Beauty and Plenty: An Atlas of Major Flowering Trees in India. Macmillan Publishers, India.
- 3. NIIR Board (2005). Cultivation of Fruits, Vegetables and Floriculture. National Institute of Industrial Research Board, Delhi.
- 4. Kader, A.A. (2002). Post-Harvest Technology of Horticultural Crops. UCANR Publications, USA.56
- 5. Capon, B. (2010). Botany for Gardeners. 3rd Edition. Timber Press, Portland, Oregon.

NAME OF THE PAPER (CODE) : BIOSTATISTICS AND BIOINFORMATICS (BTC 7.2)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **BIOSTATISTICS AND BIOINFORMATICS**:

CO 1	To develop in-depth knowledge of biostatistics and data collection.
CO 2	To learn and understand about central tendency and statistical inference.
CO 3	To learn about bioinformatics and databases.
CO 4	To gain knowledge about Biological Sequence Databases and Sequence Alignment and Molecular Phylogeny
CO 5	To learn about applications of bioinformatics.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Biostatistics and Collection of primary and secondary data (CO 1)	Definition-Statistical methods- basic principles. Variables- measurements, functions, limitations and uses of statistics. Types and methods of data collection procedures-merits and demerits, Classification- tabulation and presentation of data- sampling methods.	CSO 1.1: To define biostatistics. (K) CSO 1.2: To explain about statistical methods and basic principles. (U) CSO 1.3: To illustrate on variables- measurements, functions, limitations and uses of statistics. (A) CSO 1.4: To explain the types and methods of data collection procedures. (U) CSO 1.5: To discuss the merits and demerits of the types of data collection. (U) CSO 1.6: To illustrate on classification, tabulation and presentation of data. (A) CSO 1.7: To explain about sampling methods. (U)	7	16	
UNIT 2 Measures of	Mean, Median, Mode, Geometric mean-	CSO 2.1: To define and solve problems of	10	22	

<p>Central Tendency and Statistical inference (CO 2)</p>	<p>merits and demerits. Measures of dispersion-range, standard deviation, mean deviation, quartile deviation-merits and demerits. Hypothesis-simple hypothesis-student't' test-Chi square test. Introduction to software tools for statistical analysis.</p>	<p>mean, median, mode and geometric mean. (K+A) CSO 2.2: To discuss the merits and demerits of mean, median, mode and geometric mean. (U) CSO 2.3: To define and work out problems on range, standard deviation, mean deviation and quartile deviation. (K+A) CSO 2.4: To discuss the merits and demerits of range, standard. (U) CSO 2.5: To define and explain about hypothesis. (K+U) CSO 2.6: To evaluate and work out problems on student't'-test. (A) CSO 2.7: To work out problems on chi-square test. (A)</p>			
<p>UNIT 3 Introduction to Bioinformatics and Databases in Bioinformatics (CO 3)</p>	<p>Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics: Biological Databases, Classification format of Biological Databases.</p>	<p>CSO 3.1: To define and explain the branches of Bioinformatics. (K+U) CSO 3.2: To explain about the aim, scope and research area of bioinformatics. (U) CSO 3.3: To discuss on biological databases and classification format of biological databases. (U)</p>	10	22	
<p>UNIT 4 Biological Sequence</p>	<p>National Centre for Biotechnology (NCBI): Tools and</p>	<p>CSO 4.1: To explain about National Centre for Biotechnology</p>	13	28	

<p>Databases and Sequence Alignment and Molecular Phylogeny (CO 4)</p>	<p>Databases of NCBI, Database Retrieval Tools, Sequence submission to NCBI, Basic Local Alignment Search Tool (BLAST), Nucleotide Database. Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTAL W. Methods of Phylogeny, Software for Phylogenetics Analyses.</p>	<p>(NCBI): Tools and Databases of NCBI, Database Retrieval Tools, Sequence submission to NCBI. (U) CSO 4.2: To study and illustrate about Basic Local Alignment Search Tool (BLAST), Nucleotide Database. (U+A) CSO 4.3: To explain on the concept on alignment and Multiple Sequence Alignment (MSA), MSA by CLUSTAL W. (U) CSO 4.4: To explain and illustrate about methods of Phylogeny, Software for Phylogenetics Analyses. (U+A)</p>			
<p>UNIT 5 Application of Bioinformatics (CO 5)</p>	<p>Structural Bioinformatics in Drugs Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drugs Design, Microbial genome application, Crop improvement</p>	<p>CSO 5.1: To explain and illustrate about structural bioinformatics in drugs discovery, Quantitative structure-activity relationship (QSAR) techniques in Drugs Design. (U+A) CSO 5.2: To discuss on Microbial genome application, Crop improvement. (U)</p>	5	12	

NAME OF THE PAPER	: BIOSTATISTICS AND BIOINFORMATICS
Code	: BTC 7.2(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Collection of data.
2. Calculation of central tendency.
3. Testing of statistical hypothesis.
4. Nucleic Acid and Protein Databases.
5. Sequence retrieval from Databases.
6. Sequence alignment.
7. Sequence homology and Gene Annotation.
8. Construction of phylogenetic tree

Suggested Readings

1. Andreas D. Baxevanis and B. F. Francis Ouellette Bioinformatics (2001). A Practical Guide to the Analysis of Genes and Proteins, Second Edition 2nd Edition; Willey&Sons.
2. Bailey, N.T.J. 1995. Statistical methods of Biology 3rd edition, Cambridge University Press
3. Bioinformatics and Biostatistics James M. Bower and Hamid Bolouri (2011).Computational Modeling of Genetic and Biochemical Networks. MIT Pubs
4. Daniel, W. W. (2007). Biostatistics- A Foundation for Analysis in the Health Sciences, Wiley.
5. Daniel, W.W., (1978.) Biostatistics: A foundation for analysis in health sciences 2nd edition. John Wiley, NY.
6. Dutta, N. K. (2004). Fundamentals of Biostatistics, Kanishka Publishers.
7. Eynon B.P. and T.W. Anderson, Minitab guide to Statistics.
8. Gurumani N. (2005) .An Introduction to Biostatistics, MJP Publishers.
9. Jayarama Reddy (2011)Fundamentals of Bioinformatics.SS Education Series: 1st edition 2011
10. Jayarama Reddy (2017) Bioinformatics and Biostatistics, Publishers- Geetha Book House, Bengaluru, ISBN:(9789352679515)
11. Jayarama Reddy (2017) Bioinformatics and Biostatistics, Publishers- Geetha Book House, Bengaluru.
12. Khan, I.A. and Khanum, (1994.)Fundamentals of Biostatistics, Ukaaz Publications Hyderabad.
13. Mark Borodovsky and Svetlana Ekisheva (2006). Problems and Solutions in Biological Sequence Analysis Cambridge University Press; 1st edition
14. Pagano, M. & Gauvreau, K. (2007). Principles of Biostatistics.
15. Pavel A. Pevzner, Phillip Compeau (2015). Bioinformatics Algorithms. Active Learning Publishers, 2015
16. Rao, K. V. (2007). Biostatistics - A Manual of Statistical Methods for use in Health Nutrition and Anthropology.
17. Remington, R.D. and Schork, M.A. (1970.) Statistics with applications to the Biological and health sciences, Prentice Hall Inc. NY.

NAME OF THE PAPER (CODE) : RESEARCH METHODOLOGY (RM 7)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **RESEARCH METHODOLOGY:**

CO 1	To learn the basic concept of research, research methods and types of research.
CO 2	To learn about various laboratory practices.
CO 3	To be well versed in data collection, documentation and biological problems.
CO 4	To learn about different methods of plant study and micro techniques.
CO 5	To be acquainted with the art of scientific writing and presentation.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Basic concepts of research (CO 1)	Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative)	CSO 1.1: To define research and types of research. (K) CSO 1.2: To explain about research methods as well as methodology. (U) CSO 1.3: To discuss about literature review and its consolidations. (U) CSO 1.4: To discuss on library research, field research and laboratory research. (U)	7	16	
UNIT 2 Laboratory practices (CO 2)	Common calculations in botany laboratories. Understanding the details on the label of reagent bottles. Molarity and normality of common acids and bases. Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about	CSO 2.1: To explain about common calculations in botany laboratories. (U) CSO 2.2: To explain the details on the label of reagent bottles and molarity, normality of common acids and bases. (U) CSO 2.3: To explain on preparation of solutions, dilutions, percentage solutions, molar, molal and normal solutions. (U)	7	16	

	common toxic chemicals and safety measures in their handling.	CSO 2.4: To explain the techniques of handling micropipettes and give knowledge about common toxic chemicals and safety measures in their handling. (U)			
UNIT 3 Data collection, documentation and Biological problems (CO 3)	Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography. History; Key biology research areas, Model organisms in biology (A Brief overview): Genetics, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics-Transcriptional regulatory network	CSO 3.1: To explain about maintaining a laboratory record, tabulations and generation of graphs. (U) CSO 3.2: To explain on imaging of tissue specimens and application of scale bars and discuss the art of field photography. (U) CSO 3.3: To discuss on history, key biology research areas and model organisms in biology. (U) CSO 3.4: To briefly explain about genetics, physiology, biochemistry, molecular biology, cell biology, genomics and proteomics. (U)	10	22	
UNIT 4 Methods to study plant cell/tissue structure (CO 4)	Whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning; Tissue preparation: living vs fixed, physical vs chemical fixation, coagulating fixatives, non-coagulant fixatives; tissue dehydration using graded solvent series;	CSO 4.1: To explain about whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning. (U) CSO 4.2: To discuss on tissue preparation: living vs fixed, physical vs chemical fixation, coagulating fixatives, non-coagulant fixatives, tissue dehydration	15	32	

	<p>Paraffin and plastic infiltration; Preparation of thin and ultrathin sections.</p> <p>Staining procedures, classification and chemistry of stains. Staining equipment. Reactive dyes and fluorochromes (including genetically engineered protein labeling with GFP and other tags). Cytogenetic techniques with squashed plant materials.</p>	<p>using graded solvent series. (U)</p> <p>CSO 4.3: To explain about paraffin and plastic infiltration and preparation of thin and ultrathin sections. (U)</p> <p>CSO 4.4: To discuss on staining procedures, classification and chemistry of stains. (U)</p> <p>CSO 4.5: To explain on staining equipments, reactive dyes and fluorochromes. (U)</p> <p>CSO 4.6: To discuss on cytotenetic techniques and squashed plant materials. (U)</p>			
<p>UNIT 5</p> <p>The art of scientific writing and its presentation (CO 5)</p>	<p>Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Powerpoint presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism.</p>	<p>CSO 5.1: To explain about numbers, units, abbreviations and nomenclature used in scientific writing. (U)</p> <p>CSO 5.2: To discuss on writing references, power point presentations, poster presentation. (U)</p> <p>CSO 5.3: To explain on scientific writing and ethics. (U)</p> <p>CSO 5.4: To describe about copyright-academic misconduct/plagiarism. (K)</p>	6	14	

NAME OF THE PAPER	: RESEARCH METHODOLOGY
Code	: RM 7(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Experiments based on chemical calculations.
2. Plant microtechnique experiments.
3. The art of imaging of samples through microphotography and field photography.
4. Poster presentation on defined topics.
5. Technical writing on topics assigned.
6. Field survey/Field sampling.

Suggested Readings

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Ruzin, S.E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.
4. Garg, B. L.Karadia R. Agrawal, F. and Agrawal U. K., (2002). An Introduction to Research Methodology, RBSAPublishers
5. Kothari C. R.,(1990.) Research Methodology: Methods and Techniques New Age International418p.
6. Sinha S. C. and Dhiman A. K., (2002.) Research Methodology Ess Publications 2 Columes.
7. Trochim W. M. K., (2005.) Research Methods: The Concise Knowledge Base Atomic Dog Publishing.270P
8. Wadehra B. L., (2000.) Law Relating to Patents, Trade Marks, Copyright Design and Geographical Indications, Universal LawPublishing
9. Research Methodology: Principle, Methods and Practices-Joshua O.Miluwi and Hina Rashid
10. How to Write and publish a Research Paper- Seventh Edition-Robert Day And Barbara Gastle..

Semester-VIII

NAME OF THE PAPER (CODE) : MICROBIOLOGY, MYCOLOGY AND PLANT PATHOLOGY (BTC 8.1)

Number of Credit : 03

Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **MICROBIOLOGY, MYCOLOGY AND PLANT PATHOLOGY**:

CO 1	To gain knowledge on plant diseases, its defence and host-pathogen interaction.
CO 2	To learn about the immune system in plants.
CO 3	To learn about mycology and fungal forms.
CO 4	To be well versed in plant pathology.
CO 5	To study various plant diseases.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Diseases and Defence: Host-Pathogen interaction (CO 1)	Host-microbe relationship (Symbiosis, Commensalism, Mutualism & Parasitism) Infection Patterns; Pathogenicity; Virulence Classification of Diseases (Epidemic, Endemic, Pandemic & Sporadic) Epidemiology Diseases in population Reservoirs of infection	CSO 1.1: To explain about Host-microbe relationship. (U) CSO 1.2: To discuss on infection patterns, pathogenicity and virulence. (U) CSO 1.3: To explain about classification of diseases, epidemiology and diseases in population. (U) CSO 1.4: To explain about reservoirs of infection. (U)	7	16	
UNIT 2 Diseases and Defence: Immune system (CO 2)	Introduction to immunology Innate & Acquired Immune Response Antigen; Antibody Structure, Types & Properties Haematopoiesis Cells involved in immune system Immunity in Plants	CSO 2.1: To introduce immunology and discuss on innate and acquired immune response. (U) CSO 2.2: To explain about antigen, antibody structure, types and properties. (U) CSO 2.3: To discuss on haematopoiesis, cells involved in immune system and immunity in plants. (U)	8	18	
UNIT 3 Introduction to mycology and fungal forms (CO 3)	Characteristics, habit, habitat, somatic structures, reproduction and present status of fungi; Classification of fungi by Ainsworth, 1973, and Alexopoulos et al. 1996,	CSO 3.1: To explain about the characteristics, habit, habitat, somatic structures, reproduction and present status of fungi. (U) CSO 3.2: To discuss about the classification of fungi by Ainsworth, Alexopoulos	14	30	

	<p>Phylogenetic classification of fungi by McLaughlin et al 2001, Hibbett et al 2007, and Kirk et.al, 2008. Economic importance of fungi.</p> <p>Salient features, classification and life cycles of Myxomycota, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina with suitable examples.</p> <p>Mycotoxins: useful and harmful effects.</p>	<p>phylogenetic classification by McLaughlin, Hubbet and Kirk. (U)</p> <p>CSO 3.3: To discuss on the economic importance of fungi. (U)</p> <p>CSO 3.4: To explain the salient features, classification and life cycles of myxomycota, mastigomycotina, zygomycotina, ascomycotina, basidiomycotina and deuteromycotina. (U)</p> <p>CSO 3.5: To discuss about mycotoxins, its useful and harmful effects. (U)</p>			
<p>UNIT 4 Plant Pathology (CO 4)</p>	<p>History, concepts and scope of plant pathology; classification of plant diseases; Disease cycle and disease development; Pathogenicity test and Koch's postulates, effect disease on physiology of host, defence mechanisms in plants. Methods of plant disease management.</p> <p>Locally available plant diseases</p>	<p>CSO 4.1: To explain the history, concepts and scope of plant pathology. (U)</p> <p>CSO 4.2: To explain the classification of plant diseases, disease cycle and disease development. (U)</p> <p>CSO 4.3: To discuss about pathogenicity test and Koch's postulates. (U)</p> <p>CSO 4.4: To explain the effect of disease on physiology of host, defence mechanisms in plants and methods of plant disease management. (U)</p>	7	16	
<p>UNIT 5 Study of Plant Diseases (COM5)</p>	<p>Disease cycle and control measures of following diseases:</p> <p>Mycoplasma diseases: Grassy shoot of sugar cane, Yellow Dwarf in rice,</p> <p>Viral diseases: Bunchy top of banana, Cotton leaf curl disease,</p> <p>Bacterial diseases: Bacterial leaf blight of paddy, Black rot of crucifers,</p> <p>Fungal Diseases: Late blight of Potato, Coffee rust, Wood rotting.</p>	<p>CSO 5.1: To explain about disease cycle and control measures of:</p> <p>Mycoplasma diseases</p> <p>Viral diseases</p> <p>Bacterial diseases</p> <p>Fungal diseases (U)</p>	9	20	

NAME OF THE PAPER	: MICROBIOLOGY, MYCOLOGY AND PLANT PATHOLOGY
Code	: BTC 8.1(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Micrometry
2. Haemocytometer
3. Isolation, Culture and Staining Techniques of Fungi
4. Identification of Fungi using Fungal Floras
5. Type Study: *Stemonites*, *Saprolegnia*, *Albugo*, *Phytophthora*, *Mucor*, *Aspergillus*, *Pencillium*, *Morchella*, *Hemileia*, *Ustilago*, *Lycoperdon*, *Dictyophora*, *Curvularia*, *Alternaria*, *Fusarium*, *Pestalotia*, *Pleurotus*, *Amanita*, *Lenzites*, *Polyporus*, *Trametes* *Ganoderma*. (use recent classification)
6. Study of some Bacterial, Viral, Mycoplasma Diseases in Plants (based on availability)
7. Antibacterial/Fungal essay by Disc Diffusion method.
8. Type study of locally available plant diseases.

Suggested Readings

1. Ajoy Paul, (2016.) Text book of Immunology. Books and Allied Pvt. Ltd. Kolkatta.
2. Alexopoulos, C.J., Mims, C.W and Blackwell (1996) Introductory Mycology, 6th edition, Wiley Eastern Ltd., New Delhi.
3. Aneja, K.R. (1993) Experiments in Microbiology, plant pathology and tissue culture, Wishwa Prakashan, New Delhi.
4. Burnet, F.M. and Stanely, W.M. (1970) Biochemical biological and biophysical properties Vol-I general virology 3rd edition Academic Press, NY, London.
5. Conrat, F.H.; Kimball, P.C. and Jay, L. (1988) Virology, Prentice Hall, Englewood Cliff, New Jersey.
6. Deacon, J.W., (2006.) Fungal Biology., Blackwell Publishers, USA.
7. N.J. Dimmock, A.J. Easton, K.N. Leppard, (2007.) Modern Virology, VI Edition, Blackwell Publishing Company.
8. Kodo, C.I. and Agarwal, H.O. (1972) Principles and techniques in Plant Virology, Van Nostrand, Reinhold company
9. Pelczar, M.J. (Jr.) Chan, E.C.S. and Kreig, N.R. (1988) Microbiology, 5th edition McGraw Hall book company, Singapore.

NAME OF THE PAPER (CODE) : PLANT MORPHOGENESIS AND EMBRYOLOGY (BTC 8.2)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **PLANT MORPHOGENESIS AND EMBRYOLOGY**:

CO 1	To attain knowledge in plant morphogenesis and organogenesis.
CO 2	To learn about polarity and flower.
CO 3	To gain knowledge on microsporangium and ovule.
CO 4	To understand the process of fertilization and sexual incompatibility in plants.
CO 5	To learn about embryo and endosperm.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Morphogenetic studies and organogenesis in plants (CO 1)	Aim, scope and historical account of Plant Morphogenesis Morphogenesis in vivo (Field concepts and meristemoid); Experimental studies on shoot apex, root apex and differentiated organs. (5 hrs) Formation of leaves; types of phyllotaxy (Self study –1 hrs); transformation of vegetative apex into reproductive apex. Nature of organs: Theories on nature of shoot (Phytonic and axial theories) and flower (Monaxial, pluriaxial, suigeneris and acarpy: appendicular and axial theories of inferior ovaries).	CSO 1.1: To discuss on aim, scope and historical account of plant morphogenesis. (U) CSO 1.2: To explain about morphogenesis in vivo and experimental studies on shoot apex, root apex and differentiated organs. (U) CSO 1.3: To explain about formation of leaves and types of phyllotaxy. (U) CSO 1.4: To discuss about transformation of vegetative apex into reproductive apex. (U) CSO 1.5: To explain on Nature of organs: Theories on nature of shoot and flower. (U)	10	22	
UNIT 2 Polarity and Flower (CO 2)	Contemporary understanding at different levels of	CSO 2.1: To discuss about contemporary understanding at	8	18	

	<p>organization and in different organisms (self study-3 hr) Differentiation – patterns of differentiation, vascular differentiation, role of growth hormones in vascular differentiation Serial evocation of genes and floral development; genetic analysis of floral development ABCDE model (Arabidopsis), flower regulatory genes (MADS box genes).</p>	<p>different levels of organization and in different organisms. (U) CSO 2.2: To explain about differentiation – patterns of differentiation, vascular differentiation, role of growth hormones in vascular differentiation. (U) CSO 2.3: To explain about Serial evocation of genes and floral development; genetic analysis of floral development ABCDE model (Arabidopsis), flower regulatory genes (MADS box genes). (U)</p>			
<p>UNIT 3 Microsporangium and Ovule (CO 3)</p>	<p>Development and structure; differentiation of anther wall and their role. Microsporogenesis: General account, ultrastructure and physiology; role of callose. Male gametophyte: Development and structure; formation of male gametes, sperm dimorphism, male germ unit. Discussion of research papers with specific examples of development. Pollen abnormalities - pollen sporophytes, Nemec phenomenon, pollen development in Cyperaceae (Self study-2 hrs) A general account of</p>	<p>CSO 3.1: To explain about development and structure; differentiation of anther wall and their role. (U) CSO 3.2: To discuss on microsporogenesis: general account, ultrastructure and physiology; role of callose. (U) CSO 3.3: To explain on male gametophyte: Development and structure; formation of male gametes, sperm dimorphism, male germ unit. (U) CSO 3.4: To discuss on research papers with specific examples of development. (U) CSO 3.5: To explain on pollen abnormalities - pollen sporophytes, Nemec</p>	10	22	

	<p>ontogeny, types and diversity in structure. Megasporogenesis: General account, Ultra structure and physiology. Female gametophyte Diversity in organization; ultra structure of female gametophyte, embryosac haustoria. Types, Development and reserve food materials.</p>	<p>phenomenon, pollen development in Cyperaceae. (U) CSO 3.6: To explain on ontogeny, types and diversity in structure. (U) CSO 3.7: To explain on megasporogenesis: General account, ultra structure and physiology. (U) CSO 3.8: To discuss about female gametophyte, diversity in organization; ultra structure of female gametophyte, embryosac haustoria. (U) CSO 3.9: To explain about types, development and reserve food materials. (U)</p>			
<p>UNIT 4 Fertilization and Sexual incompatibility (CO 4)</p>	<p>Structure of stigma and style, role of stigmatic exudates; pollen germination in vivo ;pollen tube entry into the stigma ; pollen tube growth ; entry of pollen tube into female gametophyte ; double fertilization ; hetero fertilization and single fertilization., in vitro fertilization, Polyspermy. Self incompatibility, genetic basis, barriers to fertilization, physiology and biochemistry of incompatibility.</p>	<p>CSO 4.1: To explain on structure of stigma and style and role of stigmatic exudates. (U) CSO 4.2: To discuss about pollen germination in vivo ; pollen tube entry into the stigma ; pollen tube growth ; entry of pollen tube into female gametophyte. (U) CSO 4.3: To explain about double fertilization; hetero fertilization and single fertilization, in vitro fertilization, Polyspermy. (U) CSO 4.4: To explain about self incompatibility, genetic basis, barriers to fertilization, physiology and</p>	9	20	

		biochemistry of incompatibility. (U)			
UNIT 5 Embryo and Endosperm (CO 5)	Classification based on early development of embryo; structure, Composition of embryo. Early embryogenesis in <i>Capsella</i> (Dicot) and <i>Najas</i> (Monocot). Chimeral embryos. Polyembryony, apomixis in <i>hib</i> embryo endosperm relationship, Endosperm haustoria.	CSO 5.1: To explain about classification based on early development of embryo; structure and composition of embryo. (U) CSO 5.2: To discuss about early embryogenesis in <i>Capsella</i> (Dicot) and <i>Najas</i> (Monocot). (U) CSO 5.3: To explain about chimeral embryos. (U) CSO 5.4: To explain about polyembryony, apomixes, and embryo endosperm relationship and endosperm haustoria. (U)	8	18	

NAME OF THE PAPER : PLANT MORPHOGENESIS AND EMBRYOLOGY
Code : BTC 8.2(P)
Number of Credit : 01
Number of Hours of Lecture : 30

Practicals

Plant Morphogenesis:

1. Study of shoot apices by dissections using aquatic plants (*Ceratophyllum & Hydrilla*).
2. Study of cytohistochemical zonation in the shoot apical meristem in sectioned and double stained micropreparation of a suitable plant. Study of development of bisected shoot apices.
3. Study of L.S. of roots from permanent micropreparation to understand the organization of root apicalmeristem and its derivatives
4. Study of alternate and distichous, alternate and superposed, opposite and superposed, opposite anddecussate leaf arrangement.
5. Diagrammatic representation on theories of shoot and flower, Regeneration experiment with stem cuttings to show polarity.

Embryology:

1. Study of the following stages from permanent micro preparation: Anther wall, Microsporogenesis.Pollen mitosis; pollen in cyperaceae; Isolation of male gametes.
2. Pollen germination in *Balsam*, *Vinca*, *Datura*, *Delonix*, *Peltophorum* and the effect of sucrose, Boron andCalcium on germination.
3. Types of placentation, Types of ovules and ovular parts.
4. Megasporogenesis and female gametophyte (Polygonum type)
5. Study of endosperm: types, endosperm haustoria
6. Embryo - Mature dicot and monocot embryos. Mounting of globular, cordate and torpedo shaped embryos in suitable seeds.

Suggested Readings

1. Bhojwani S.S. Bhatnagar S.P. and P.K. Dantu, (2015). The embryology of angiosperms, 6th Ed., Vikas Pub. New Delhi.
2. Davis G.L. (1966). Systematic embryology of Angiosperms, John Wiley & Sons, Inc. New York.
3. Easu K. (1977). Anatomy of seed plants 2nd ed. Wiley Eastern New Delhi.
4. Johansen, D.A. (1950). Plant embryology, Chronica Botanica Co., Waltham, mass.
5. Johri B.M. (ed) (1984). Embryology of Angiosperms, Springer - verlag, Berlin.
6. Lyndon R.F (1990). Plant Development - The cellular basis, Unwin Hyman, London.
7. Maheswari P. (1950). An introduction to the embryology of Angiosperms, McGraw Hill, New York.
8. Maheshwari P (ed.) (1963). Recent advances in embryology, Int. Soc. Pl. Morphol. New York.
9. Raghvan V. (1976) Experimental embryogenesis in vascular plants, Cambridge University, Cambridge.
10. Raghavan V.R.(2000). Developmental biology of flowering plants. Springer publications.
11. Sinnot E.W. (1960). Plant morphogenesis. Mc Graw Hill Book Company, INC, New York.
12. Steeves T.A. and Sussex I.M. (1989). Patterns in plant development, 2nd ed. Cambridge University Press, Cambridge.
13. Steward, F.C. (1968). Growth and Organization in plants, Addison - Wesley Pub. Co. U.S.A.
14. Johri B.M. (1982). Experimental embryology of vascular plants. Springer Verlag, Berlin.
15. Wardlaw (1968). Morphogenesis in plants, Methuen and Co.
16. Wareing P.F. and I.D.J. Phillips, (1978). The control of growth and differentiation in plants. Pergamonpress, New York.
17. Mc Lean R.C. and W.R. Ivimey-Cook, (1951). Text book of theoretical botany, Vol. I. Longmans, Green and Co Ltd.
18. Weigel (1995). The genetics of flower development from floral induction to ovule morphogenesis. Annual review of Genetics. Vol.29.
19. Bernier G. (1988). The control of floral evocation and morphogenesis. Ann.Rev.Pl. Physiol. & Mol.Biol.Vol.39., 175-219.
20. Sharma, H.P.(2009). Plant embryology classical and experimental. Narosa Publishing House, New Delhi.

NAME OF THE PAPER (CODE) : METHODS IN PLANT SCIENCES (BTC 8.3)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **METHODS IN PLANT SCIENCES**:

CO 1	To develop a sound knowledge in microscopy, its history and types.
CO 2	To develop a very good understanding on microtomy and centrifugation
CO 3	To understand the various separation and purification techniques.
CO 4	To gain sound knowledge on biophysics.
CO 5	To learn about research methodology.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Microscopy, History, Introduction and types of microscopes (CO 1)	History of Microscopy. Properties of light in relation to microscopy - Wavelength, resolution, reflection, transmission, absorption, refraction, diffraction. Aberrations in Microscopy (spherical, chromatic and field curvature). Lenses used in compound microscope – Abbe’s condenser system, objective lenses, ocular lenses and mirror. Principle, construction and uses of bright field microscopy, dark field microscopy, stereomicroscopy, Nomarski (DIC) microscopy, inverted microscopy, polarization microscopy , fluorescent microscopy, electron microscopy (TEM, SEM), atomic force microscope, Camera lucida, photomicrography (Self-study- 1 hr) and image analysis.	CSO 1.1: To explain about history of Microscopy, properties of light in relation to microscopy - Wavelength, resolution, reflection, transmission, absorption, refraction, diffraction and aberrations in microscopy. (U) CSO 1.2: To discuss about lenses used in compound microscope – Abbe’s condenser system, objective lenses, ocular lenses and mirror. (U) CSO 1.3: To explain about principle, construction and uses of bright field microscopy, dark field microscopy, stereomicroscopy, Nomarski (DIC) microscopy, inverted microscopy, polarization microscopy , fluorescent microscopy, electron microscopy (TEM, SEM), and atomic force microscope. (U) CSO 1.4: To explain about camera lucida,	10	22	

		photomicrography and image analysis. (U)			
UNIT 2 Microtomy and Centrifugation (CO 2)	Microtomy and ultra microtomy techniques, fixatives, clearing agents, dehydrants, stains, staining schedules, freeze fracturing, freeze etching; cryopreservation. Principle and types of centrifuges and rotors; techniques of centrifugation, brief about of cell fractionation (self-study- 1 hr). Spectroscopy: Visible, UV, IR, NMR, AAS, XRD. Radiobiology: radioisotope techniques (GM counter, scintillation and autoradiography).	CSO 2.1: To explain about microtomy and ultra microtomy techniques, fixatives, clearing agents, dehydrants, stains, staining schedules, freeze fracturing, freeze etching; cryopreservation. (U) CSO 2.2: To discuss about principle and types of centrifuges and rotors; techniques of centrifugation, brief about of cell fractionation. (U) CSO 2.3: To explain about Spectroscopy: Visible, UV, IR, NMR, AAS, XRD. (U) CSO 2.4: To discuss about radiobiology: radioisotope techniques (GM counter, scintillation and autoradiography). (U)	8	18	
UNIT 3 Separation and purification techniques (CO 3)	Electrophoresis (agarose and PAGE), isoelectric focussing. Chromatography, types and applications: History and introduction (self-study – 1 hr). Paper chromatography (ascending, descending, 2D), TLC, HPTLC, Column chromatography, Gel filtration, affinity, ion exchange, Gas chromatography, HPLC and hydrophobic interaction chromatography.	CSO 3.1: To explain about Electrophoresis (agarose and PAGE), isoelectric focussing. (U) CSO 3.2: To discuss about Chromatography, types and applications: History and introduction. (U) CSO 3.3: To explain and illustrate about paper chromatography (ascending, descending, 2D), TLC, HPTLC, Column chromatography, Gel filtration, affinity, ion exchange, Gas chromatography, HPLC and hydrophobic interaction	8	18	

		chromatography. (U+A)			
UNIT 4 Biophysics (CO 4)	Intra and intermolecular interactions: atomic structure, chemical bonding (ionic, covalent, hydrogen and coordinate bonds). Van der Waals interactions and London forces of dispersion Colloids: Properties, dispersion system, classification of colloids (sol, gel, suspension and emulsion). Tyndall effect and Brownian movement. Applications of colloids. (Self-study-2 hrs). Photoluminescence: Principles and applications of phosphorescence, fluorescence and bioluminescence. Biomechanics: Principles and applications of biomechanics, nano-technology and protein engineering.	CSO 4.1: To explain about intra and intermolecular interactions: atomic structure, chemical bonding (ionic, covalent, hydrogen and coordinate bonds). (U) CSO 4.2: To discuss about Van der Walls interactions and London forces of dispersion Colloids: Properties, dispersion system, classification of colloids (sol, gel, suspension and emulsion). (U) CSO 4.3: To explain about tyndall effect and Brownian movement and applications of colloids. (U) CSO 4.4: To discuss about photoluminescence: principles and applications of phosphorescence, fluorescence and bioluminescence. (U) CSO 4.5: To explain about biomechanics: Principles and applications of biomechanics, nano-technology and protein engineering. (U)	12	26	
UNIT 5 Research Methodology (CO 5)	Components of a research paper. Writing references using Mendeley and Endnotes.	CSO 5.1: To explain about components of a research paper. (U) CSO 5.2: To discuss about writing references using Mendeley and Endnotes. (U)	7	16	

NAME OF THE PAPER	: METHODS IN PLANT SCIENCES
Code	: BTC 8.3(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Writing references using Mendeley and Endnotes. Photomicrography and image analysis.
2. Working and applications of dissection microscope, stereomicroscope and light microscope; Cameralucida.
3. Phase contrast Microscope and Inverted microscope. Microtome.
4. Tissue maceration to identify VAM fungal colonization.
5. Centrifuges: types of rotors, centrifugation techniques (cell fractionation, density gradient, differential)
6. Extraction of pigments using Soxhlet apparatus.
7. Chromatography: paper, TLC, column chromatography.
8. Determination of absorption maxima of compounds extracted from plants.
9. Extraction of proteins and preparation of reagents for SDS-PAGE.
10. Separation of proteins using SDS-PAGE.
11. Revision and attestation of records.

Suggested Readings

1. R. Cotterill (2002), Biophysics – An Introduction, John Wiley & Sons.
2. Pranav Kumar (2017), Fundamentals and Techniques of Biophysics and Molecular Biology, Second Edition, Pathfinder Publications, New Delhi.
3. Gerald Karp (2007), Cell Biology, Seventh Edition, John Wiley & Sons.
4. C.E. Banwell, C.N., and McCash E.M. 1994. Fundamentals of Molecular spectroscopy, (4th edition), TataMcGraw - Hill, Publishing Co. Ltd
5. Narayanan, P. (2000). Essential of Biophysics. New Agri. International Publishers.
6. Berlyn, G.P. & Miksche, J.P. (1976). Botanical Microtechnique and cytochemistry, Iowa State Univ. Press.
7. De Robertis, E.O.P., & De Robertis, E.M.R. Jr. (1987). Cell and molecular biology, 8th ed., B.I. Wasberly Pvt.Ltd., New Delhi.
8. Dhopte, A, M. (2002). Principles and Techniques for plant scientists, Agrobios (India).
9. Grey, P. (ed.) (1973) Encyclopedia of microscopy and Microtechnique, van Nostrand Reinhold Co., New York.
10. Jensen, W.A. (1962). Botanical histochemistry, Freeman & Co., San-Fransisco.
11. Johansen, D.A. (1940). Botanical Microtechnique, McGraw Hill, New York.
12. Kaul, A.D., Singh, N., Sonkusare, A., Kumar, P. & Wadhwa, S.S. (1997). Design of an Atomic forcemicroscope for topographic studies, Curr. Sci. 73 (9): 738 - 743.
13. Purvis, M.J., Collins, D.C., & Wallis, D. (1966). Laboratory techniques in Botany (2nd ed.) Butterworths, London Running.
14. M.P., Clark, S.E. & Mayerowitzz, E.M. (1995). Confocal microscopy of shoot apex, in methods in cell biology, Vol. 49, pp. 355 - 366, Academic Press, New York.
15. Sanderson, J.B. (1994). Biological microtechniques, BIOS Sci. Pub., London.

.INTERDISCIPLINARY MINOR (IDM)

Semester-I

NAME OF THE PAPER (CODE) : PHYCOLOGY AND MICROBIOLOGY (BTM 1)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **PHYCOLOGY AND MICROBIOLOGY**:

CO 1	To be well versed in all the different organisms of the microbial world.
CO 2	To be well aware about viruses.
CO 3	To learn about the general bacterial world.
CO 4	To know about the general account and classification of algae.
CO 5	To learn about the different life cycles of economically important algae and locally available species of algae.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to microbial world (CO 1)	Microbial nutrition, growth and metabolism. Economic importance of viruses with reference to their role in research and medicine. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).	CSO 1.1: To define the term micro-organisms. (K) CSO 1.2: To explain on microbial nutrition, growth and metabolism. (U) CSO 1.3: To illustrate the economic importance of viruses with reference to vaccine production, research and medicine. (A) CSO 1.4: To explain the diagnostics of micro-organisms as causal organisms of plant diseases. (U) CSO 1.5: To illustrate the economic importance of bacteria with reference to agriculture and industry. (A)	7	16	
UNIT 2 Viruses (CO 2)	Discovery, general characteristics;	CSO 2.1: To define viruses. (K)	8	18	

	classification (Baltimore); replication (general account), Structure of DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV), Retrovirus (HIV).	<p>CSO 2.2: To explain the discovery, physiochemical and biological characteristics of viruses. (U)</p> <p>CSO 2.3: To illustrate about the classification, general structure with special reference to viroids and prions. (A)</p> <p>CSO 2.4: To explain the general account of replication. (U)</p> <p>CSO 2.5: To illustrate about DNA virus (T-phage), lytic and lysogenic cycle, RNA virus (TMV), Retrovirus (HIV). (A)</p>			
UNIT 3 Bacteria (CO 3)	Discovery, general characteristics; Types-archaeobacteria, eubacteria; Cell structure; shapes of bacteria; classification of bacteria (Bergey's); Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction).	<p>CSO 3.1: To define bacteria. (K)</p> <p>CSO 3.2: To explain the discovery and general characteristics of bacteria. (U)</p> <p>CSO 3.3: To explain the different types of bacteria-archaeobacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts). (U)</p> <p>CSO 3.4: To explain the detailed cell structure, shapes, classification and nutritional types of bacteria. (U)</p> <p>CSO 3.5: To illustrate the different modes of reproduction in bacteria. (A)</p>	8	18	
UNIT 4 Algae (CO 4)	General characteristics; Ecology and occurrence; range of thallus organization; vegetative structure and cell	<p>CSO 4.1: To define algae. (K)</p> <p>CSO 4.2: To explain the general characteristics, ecology and distribution of algae. (U)</p> <p>CSO 4.3: To illustrate the</p>	10	22	

	<p>components- cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; methods of reproduction; Classification; criteria, system of Fritsch. Economic importance of algae.</p>	<p>range of thallus organization, cell structure and components; cell wall, pigment system, reserve food and flagella. (A) CSO 4.4: To explain the different methods of reproduction in algae. (U) CSO 4.5: To explain the different systems of classifications and criteria of algae. (U) CSO 4.6: To explain the significant contributions of important phycologists and economic importance of algae. (U)</p>			
<p>UNIT 5 Cyanophyta, Xanthophyta, Chlorophyta, Charophyta, Phaeophyta and Rhodophyta. (CO 5)</p>	<p>General characteristics; occurrence; morphology; Reproduction and life-cycle of <i>Nostoc</i>, <i>Vaucheria</i>, <i>Chlamydomonas</i>, <i>Volvox</i>, <i>Oedogonium</i>, <i>Chara</i>, <i>Ectocarpus</i>, <i>Fucus</i> and <i>Polysiphonia</i>. Evolutionary significance of <i>Prochloron</i>.</p>	<p>CSO 5.1: To explain the ecology, occurrence, range of thallus organization, cell structure, reproduction, morphology and life cycle of <i>Nostoc</i> and <i>Vaucheria</i>. (U) CSO 5.2: To explain the general characteristics, occurrence, cell structure, reproduction, morphology and life cycle of <i>Chlamydomonas</i>, <i>Oedogonium</i> and <i>Chara</i>. (U) CSO 5.3: To describe the evolutionary significance of <i>Prochloron</i>. (K) CSO 5.4: To explain the general characteristics, occurrence, cell structure, reproduction, morphology and life cycle of <i>Ectocarpus</i> and <i>Fucus</i>. (U)</p>	12	26	

NAME OF THE PAPER	: PHYCOLOGY AND MICROBIOLOGY
Code	: BTM 1(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

Microbiology

1. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule.
3. Gram staining of gram positive and gram negative bacteria.
4. Endospore staining with malachite green using the (endospores taken from soil bacteria).

Phycology

1. Study of vegetative and reproductive structures of *Nostoc*, *Chlamydomonas* (electron micrographs), *Volvox*, *Oedogonium*, *Chara*, *Vaucheria*, *Ectocarpus*, *Fucus* and *Polysiphonia*, *Prochloron* through electron micrographs, temporary preparations and permanent slides.
2. Study of locally available algae species.

Suggested Readings

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
2. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGrawHill International.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
6. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.

Semester-II

NAME OF THE PAPER (CODE) : MYCOLOGY AND PHYTOPATHOLOGY (BTM 2)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **MYCOLOGY AND PHYTOPATHOLOGY**:

CO 1	To learn about true fungi, Chytridiomycota, Zygomycota and Oomycota.
CO 2	To learn about Ascomycota and Basidiomycota.
CO 3	To gain Knowledge on allied fungi and symbiotic associations.
CO 4	To learn about applied mycology.
CO 5	To understand about phytopathology.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to true fungi; Chytridiomycota, Zygomycota and Oomycota (CO 1)	General Characteristics; Thallus Organization; Cell Wall Composition; Nutrition; Classification. Chytridiomycota, Zygomycota and Oomycota: Characteristic features; Significance; Reproduction; Life cycle with reference to <i>Synchytrium</i> , <i>Rhizopus</i> and <i>Phytophthora</i> .	CSO 1.1: To explain the general characteristics of fungi and its affinities with plants and animals. (U) CSO 1.2: To explain the thallus organization, cell wall composition and nutrition of fungi. (U) CSO 1.3: To explain the classification of fungi. (U) CSO 1.4: To explain the Characteristic features; Significance; Reproduction; Life cycle with reference to <i>Synchytrium</i> , <i>Rhizopus</i> and <i>Phytophthora</i> . (U)	10	22	
UNIT 2 Ascomycota and Basidiomycota (CO 2)	Ascomycota: General characteristics; asexual and sexual fruiting bodies; Life cycle with reference to <i>Saccharomyces</i> ,	CSO 2.1: To explain the general characteristics, life cycle and classification with reference to <i>Saccharomyces</i> ,	10	22	

	<p><i>Aspergillus</i>, <i>Penicillium</i> and <i>Alternaria</i>. Basidiomycota: General characteristics; Life cycle with reference to <i>Puccinia</i>, <i>Agaricus</i>; Bioluminescence, Fairy Rings of Mushroom.</p>	<p><i>Aspergillus</i>, <i>Penicillium</i> and <i>Alternaria</i>. (U) CSO 2.2: To explain the general characteristics, ecology, life cycle and classification with reference to black stem rust on wheat (<i>Puccinia</i>), loose and covered smut (<i>Agaricus</i>). (U) CSO 2.3: To explain about bioluminescence and fairy rings of mushroom. (U)</p>			
<p>UNIT 3 Allied Fungi, and symbiotic associations (CO 3)</p>	<p>Slime molds: General characteristics; Status; Classification; Occurrence; Types of plasmodia; Types of fruiting bodies. Lichen: Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction. Mycorrhiza: Ectomycorrhiza, Endomycorrhiza and their significance.</p>	<p>CSO 3.1: To explain the general characteristics and status of slime moulds. (U) CSO 3.2: To explain the classification and occurrence of slime moulds. (U) CSO 3.3: To explain on the types of plasmodia and types of fruiting bodies. (U) CSO 3.4: To explain the occurrence, general characteristics, growth forms and range of thallus organization of lichens. (U) CSO 3.5: To explain the Nature of associations of algal and fungal partners; Reproduction. (U) CSO 3.6: To explain about Ectomycorrhiza, Endomycorrhiza and their significance. (U)</p>	10	22	
<p>UNIT 4 Applied Mycology (CO 4)</p>	<p>Role of fungi in biotechnology; Application of fungi in</p>	<p>CSO 4.1: To explain the role of fungi in biotechnology, food</p>	6	14	

	<p>food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.</p>	<p>industry and as a source of secondary metabolites. (U) CSO 4.2: To explain the application of fungi in agriculture as well as a source of mycotoxins. (U) CSO 4.3: To explain the role of fungi in biological control and in medical mycology. (U)</p>			
<p>UNIT 5 Phytopathology (CO 5)</p>	<p>Terms and concepts; General symptoms; Geographical distribution of diseases; Etiology; Symptomology; Host-Pathogen relationships; Disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine. Bacterial diseases- Citrus Canker Viral diseases – Tobacco Mosaic viruses. Fungal diseases – Early and late blight of potato; Black stem rust of wheat. Loose and covered smut (Symptoms only).</p>	<p>CSO 5.1: To define the terms and concepts of phytopathology. (K) CSO 5.2: To explain the general symptoms, geographical distribution of diseases and etiology. (U) CSO 5.3: To explain about symptomology, host-pathogen relationships, disease cycle and environmental relation of host and pathogen. (U) CSO 5.4: To explain about the prevention and control of plant diseases and role of quarantine. (U) CSO 5.5: To explain about bacterial diseases. (U) CSO 5.6: To explain about viral diseases. (U) CSO 5.7: To explain about fungal diseases. (U)</p>	9	20	

NAME OF THE PAPER	: MYCOLOGY AND PHYTOPATHOLOGY
Code	: BTM 2(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Introduction to the world of fungi (Unicellular, coenocytic/ septate mycelium, ascocarps & basidiocarps).
2. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. *Aspergillus* and *Penicillium*: Study of asexual stage from temporary mounts. Study of sexual stage from permanent slides/ photographs.
4. *Peziza*: sectioning through ascocarp.
5. *Alternaria*: Specimen/ photographs and temporary mounts.
6. *Puccinia*: Mounts of spores / Permanent slides
7. *Agaricus*: Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*, fairy rings and bioluminescent mushrooms to be shown.
8. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs)
9. Phytopathology: Herbarium specimens of Citrus Canker (bacterial diseases); TMV (Viral diseases); Early blight of potato, Black stem rust of wheat (Fungal diseases).

Suggested Readings

1. Agrios, G.N. (1997) Plant Pathology, 4th edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.
3. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.
4. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
5. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

Semester-III

NAME OF THE PAPER (CODE) : MORPHOLOGY AND ANATOMY OF ANGIOSPERMS (BTM 3)

Number of Credit : 03

Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **MORPHOLOGY AND ANATOMY OF ANGIOSPERMS**:

CO 1	To gain knowledge on the structures and development of different parts of the plant body.
CO 2	To learn about the tissue system in plants.
CO 3	To gain insights on meristematic tissues of plants.
CO 4	To be well versed with the vascular cambium, secondary growth and wood.
CO 5	To learn about adaptive and protective system in plants.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction, Structure and Development of Plant Body (CO 1)	Applications in systematics, forensics and pharmacognosy. Internal organization of plant body: The three tissue systems, types of cells and tissues. Development of plant body: Polarity, Cytodifferentiation and organogenesis during embryogenic development.	CSO 1.1: To explain the application of angiosperms in systematic, forensics and pharmacognosy. (U) CSO 1.2: To explain the internal organization of plant body of angiosperms. (U) CSO 1.3: To explain the tissue systems, types of cells and tissues. (U) CSO 1.4: To explain and illustrate the development of plant body. (U+A) CSO 1.5: To explain about polarity, cytodifferentiation and organogenesis during embryogenic development. (U)	8	18	
UNIT 2 Tissues (CO 2)	Classification of tissues; Simple and complex tissues (no phylogeny); cytodifferentiation of tracheary elements and sieve elements; Pits and	CSO 2.1: To define tissues. (K) CSO 2.2: To explain the classification of tissues, simple and complex	9	20	

	plasmodesmata; Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.	tissues. (U) CSO 2.3: To explain cytodifferentiation of tracheary elements and sieve elements, pits and plasmodesmata. (U) CSO 2.4: To explain about wall ingrowths and transfer cells, adcrustations and incrustations and ergastic substances. (U) CSO 2.5: To explain on hydathodes, cavities, lithocysts and laticifers. (U)			
UNIT 3 Apical meristems (CO 3)	Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory); Types of vascular bundles; Structure of dicot and monocot stem. Diversity and structure of monocot and dicot leaf. Structure of dicot and monocot leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Rootcap; Structure of dicot and monocot root.	CSO 3.1: To explain on the evolution of concept of organization of shoot apex. (U) CSO 3.2: To explain the types of vascular bundles. (U) CSO 3.3: To explain the structure of dicot and monocot stem. (U) CSO 3.4: To explain the origin, development, arrangement and diversity in size and shape of leaves. (U) CSO 3.5: To explain the structure of dicot and monocot leaf as well as Kranz anatomy. (U) CSO 3.6: To explain the organization of root apex, quiescent centre and root cap. (U) CSO 3.7: To explain the structure of dicot and monocot root. (U) CSO 3.8: To explain about endodermis, exodermis and origin of lateral root. (U)	12	26	
UNIT 4 Vascular Cambium and	Structure, function and seasonal activity of cambium; Secondary	CSO 4.1: To explain the structure, function and seasonal activity of	10	22	

Wood (CO 4)	growth in root and stem. Axially and radially oriented elements; Types of rays and axial parenchyma; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology.	cambium. (U) CSO 4.2: To explain about secondary growth in root and stem. (U) CSO 4.3: To describe in detail about axially and radially oriented elements. (K) CSO 4.4: To explain the types of rays and axial parenchyma. (U) CSO 4.5: To illustrate on cyclic aspects and reaction of wood. (A) CSO 4.6: To describe about sapwood and heartwood, ring and diffuse porous wood, early and late wood. (K) CSO 4.7: To explain about tyloses and dendrochronology. (U) CSO 4.8: To explain about the development and composition of periderm, rhytidome and lenticels. (U)			
UNIT 5 Adaptive and Protective Systems (CO 5)	Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni and multicellular, glandular and non-glandular, two examples of each), stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes, hydrophytes and epiphytes.	CSO 5.1: To explain on the epidermal tissue system, cuticle, epicuticular waxes and trichomes. (U) CSO 5.2: To describe about the classification of stomata. (K) CSO 5.3: To illustrate on adcrustation and incrustation. (A) CSO 5.4: To elucidate on anatomical adaptations of xerophytes and hydrophytes. (A)	6	14	

NAME OF THE PAPER	:MORPHOLOGY AND ANATOMY OF
	ANGIOSPERMS
Code	: BTM 3(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Apical meristem of root, shoot and vascular cambium.
2. Distribution and types of parenchyma, collenchyma and sclerenchyma.
3. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates;
4. xylem fibres.
5. Wood: ring porous; diffuse porous; tyloses; heart- and sapwood.
6. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
7. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
8. Root: monocot, dicot, secondary growth.
9. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels.
10. Adaptive Anatomy: xerophytes, hydrophytes, epiphytes
11. Secretory tissues: cavities, lithocysts and laticifers.

Suggested Readings

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
4. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.

Semester-IV

NAME OF THE PAPER (CODE) : PLANT TAXONOMY (BTM 4)

Number of Credit : 03

Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **PLANT TAXONOMY**:

CO 1	To learn the basics of plant taxonomy and significance of plant systematic.
CO 2	To learn about taxonomic hierarchy and taxonomic evidences.
CO 3	To be well versed on Botanical Nomenclature.
CO 4	To learn about classification systems.
CO 5	To gain knowledge on biometrics, numerical taxonomy and cladistics.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to plant taxonomy (CO 1)	Identification, Classification, Nomenclature. Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access	CSO 1.1: To define plant systematic and explain on plant identification, classification and nomenclature. (K+U) CSO 1.2: To explain about field inventory and functions of herbarium. (U) CSO 1.3: To discuss on important herbaria and botanical gardens of the world and India as well as on virtual herbarium and e-flora. (U) CSO 1.4: To illustrate on taxonomic documentation and taxonomic keys. (A)	8	18	
UNIT 2 Taxonomic evidences and Taxonomic hierarchy (CO 2)	Taxonomic evidences: Palynology, cytology, phytochemistry and molecular data. Ranks, categories and taxonomic groups	CSO 2.1: To illustrate on the evidences from palynology, cytology, phytochemistry and molecular data. (A) CSO 2.2: To explain about taxonomic hierarchy- Ranks, categories and taxonomic groups. (U)	12	26	
UNIT 3 Botanical nomenclature (CO 3)	Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of	CSO 3.1: To explain about the Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its	14	30	

	names, principle of priority and its limitations.	limitations. (U)			
UNIT 4 Classification (CO 4)	Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series).	CSO 4.1: To explain about types of classification-artificial, natural and phylogenetic. (U) CSO 4.2: To explain Bentham and Hooker (upto series), Engler and Prantl (upto series). (U)	6	14	
UNIT 5 Biometrics, numerical taxonomy and cladistics (CO 5)	Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).	CSO 5.1: To explain about characters; variations; OTUs, character weighting and coding. (U) CSO 5.2: To explain about cluster analysis; phenograms, cladograms. (U)	5	12	

NAME OF THE PAPER : **PLANT TAXONOMY**
Code : **BTM 4(P)**
Number of Credit : **01**
Number of Hours of Lecture : **30**

Practicals

- Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification): Brassicaceae - *Brassica*, *Alyssum* / *Iberis*; Asteraceae - *Sonchus*/*Launaea*, *Vernonia*/*Ageratum*, *Eclipta*/*Tridax*; Solanaceae - *Solanum nigrum*, *Withania*; Lamiaceae - *Salvia*, *Ocimum*; Liliaceae - *Asphodelus* / *Lilium* / *Allium*.
- Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

Suggested Readings

- Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
- Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
- Simpson, M.G. (2006). *Plant Systematics*. Elsevier Academic Press, San Diego, CA, U.S.A.
- Singh, G. (2012). *Plant Systematics: Theory and Practice*. Oxford & IBH Pvt. Ltd., New Delhi. 3rd editio

Semester- V

NAME OF THE PAPER (CODE) : PLANT PHYSIOLOGY (BTM 5)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **PLANT PHYSIOLOGY**:

CO 1	To be introduced to and understand about plant water relations.
CO 2	To learn about nutrition in plants.
CO 3	To understand about translocation in plants.
CO 4	To be sensitized about plant growth regulators.
CO 5	To learn and understand the physiology of flowering.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Plant-water relations (CO 1)	Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap– cohesion-tension theory. Transpiration and factors affecting transpiration, mechanism of stomatal movement.	CSO 1.1: To explain water potential and its components. (U) CSO 1.2: To illustrate on water absorption by roots and aquaporins. (A) CSO 1.3: To explain pathway of water movement, symplast, apoplast and transmembrane pathways. (U) CSO 1.4: To explain about root pressure and guttation. (U) CSO 1.5: To explain ascent of sap and cohesion-tension theory. (U) CSO 1.6: To discuss about transpiration and factors affecting transpiration, anti transpirants and mechanism of stomatal movement. (U)	10	22	
UNIT 2 Mineral nutrition (CO 2)	Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents.	CSO 2.1: To explain about essential and beneficial elements, macro and micronutrients. (U) CSO 2.2: To explain the methods and use of nutrient solutions. (U) CSO 2.3: To explain on criteria of essentiality and mineral deficiency symptoms. (U) CSO 2.4: To illustrate on essential elements and chelating agents. (A)	10	22	
UNIT 3 Nutrient Uptake	Soil as a nutrient reservoir, transport of ions across cell membrane, passive	CSO 3.1: To illustrate on soil as a nutrient reservoir. (A) CSO 3.2: To discuss on transport of ions across cell membrane, passive	10	22	

Translocation in the phloem (CO 3)	absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport. Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.	absorption, electrochemical gradient, facilitated diffusion, active absorption and role of ATP. (U) CSO 3.3: To explain about carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport and antiport. (U) CSO 3.4: To discuss about experimental evidence in support of phloem as the site of sugar translocation. (U) CSO 3.5: To illustrate Pressure-flow model, phloem loading and unloading and source-sink relationship. (A)			
UNIT 4 Plant growth regulators (CO 4)	Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Absciscic acid, Ethylene, Brassinosteroids and Jasmonic acid.	CSO 4.1: To discuss on the discovery, chemical nature and structure of auxins, gibberellins, absciscic acid, ethylene, brassinosteroids and jasmonic acid. (U) CSO 4.2: To explain the bioassay and physiological roles of auxins, gibberellins, absciscic acid, ethylene, brassinosteroids and jasmonic acid. (U)	5	12	
UNIT 5 Physiology of flowering; Phytochrome, cryptochromes and phototropins (CO 5)	Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy. Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.	CSO 5.1: To define and explain photoperiodism. (K+U) CSO 5.2: To illustrate on flowering stimulus, florigen concept, vernalization and seed dormancy. (A) CSO 5.3: To explain the discovery, chemical nature and role of light pigments on photomorphogenesis. (U) CSO 5.4: To describe about low energy response, high irradiance responses and the mode of action. (K)	10	22	

NAME OF THE PAPER	: PLANT PHYSIOLOGY
Code	: BTM 5(P)
Number of Credit	: 01
Number of Hours of Lecture	: 30

Practicals

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).
7. To study the effect of different concentrations of IAA on *Avena* coleoptile elongation (IAA Bioassay).

Demonstration experiments

1. To demonstrate suction due to transpiration.
2. Fruit ripening/Rooting from cuttings (Demonstration).

Suggested Readings

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

Semester-VI

NAME OF THE PAPER (CODE) : PLANT METABOLISM (BTM 6)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **PLANT METABOLISM**:

CO 1	To be introduced to and understand the concept of metabolism.
CO 2	To understand about carbon assimilation in plants.
CO 3	To learn about carbohydrate metabolism and carbon oxidation in plants.
CO 4	To learn about ATP synthesis and signal transduction in plants
CO 5	To understand and learn about lipid and nitrogen metabolism.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Concept of metabolism (CO 1)	Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and Isozymes).	CSO 1.1: To give an introduction on the concept of metabolism. (K) CSO 1.2: To explain about anabolic and catabolic pathways. (U) CSO 1.3: To illustrate on the regulation of metabolism and role of regulatory enzymes. (A)	5	12	
UNIT 2 Carbon assimilation (CO 2)	Photosynthetic pigments (chlorophylls and accessory pigments), photosynthetic electron transport, antenna molecules and reaction centres, photochemical reactions, PSI, PSII, Q cycle, photorespiration, C ₄ pathways; Crassulacean acid metabolism.	CSO 2.1: To explain on photosynthetic pigments and their roles. (U) CSO 2.2: To discuss on antenna molecules and reaction centres of photosynthetic pigments. (U) CSO 2.3: To illustrate on photochemical reactions and photosynthetic electron transport. (A) CSO 2.4: To explain on PSI, PSII and Q cycle. (U) CSO 2.5: To discuss on CO ₂ reduction, C ₄	10	22	

		pathways, CAM pathway and factors affecting CO ₂ reduction. (U)			
UNIT 3 Carbohydrate metabolism; Carbon Oxidation (CO 3)	Synthesis and catabolism of sucrose and starch. Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration.	CSO 3.1: To explain on synthesis and catabolism of sucrose and starch. (U) CSO 3.2: To explain glycolysis, fate of pyruvate, regulation of glycolysis and oxidative pentose phosphate pathway. (U) CSO 3.3: To explain on oxidative decarboxylation of pyruvate and regulation of PDH and NADH shuttle. (U) CSO 3.4: To explain TCA cycle, amphibolic role, anaplerotic reactions and regulation of the cycle. (U) CSO 3.5: To illustrate mitochondrial electron transport and oxidative phosphorylation. (A) CSO 3.6: To explain cyanide-resistant respiration and factors affecting respiration. (U)	10	22	
UNIT 4 ATP-Synthesis and Mechanism of signal transduction (CO 4)	Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (Oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers. Receptor-ligand interactions; Second messenger concept, Calcium calmodulin.	CSO 4.1: To explain the mechanism of ATP synthesis, substrate level phosphorylation and chemiosmotic mechanism. (U) CSO 4.2: To illustrate on ATP synthase, Boyers conformational model, Racker's experiment and Jagendorf's experiment. (A) CSO 4.3: To discuss the role of uncouplers, receptor-ligand interactions, second	10	22	

		messenger concept and calcium calmodulin. (U) CSO 4.4: To explain on MAP kinase cascade. (U)			
UNIT 5 Lipid and Nitrogen metabolism (CO 5)	Synthesis and breakdown of triglycerides, β -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination, α oxidation. Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Ammonia assimilation and transamination.	CSO 5.1: To explain the synthesis and breakdown of triglycerides. (U) CSO 5.2: To discuss on β -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination. (U) CSO 5.3: To explain α -oxidation. (U) CSO 5.4: To explain on nitrate assimilation, biological nitrogen fixation. (U) CSO 5.5: To illustrate on physiology and biochemistry of nitrogen fixation, ammonia assimilation and transamination. (A)	10	22	

NAME OF THE PAPER : PLANT METABOLISM
Code : BTM 6(P)
Number of Credit : 01
Number of Hours of Lecture : 30

Practicals

1. Chemical separation of photosynthetic pigments.
2. To study the effect of light intensity on the rate of photosynthesis.
3. Effect of carbon dioxide on the rate of photosynthesis.
4. To compare the rate of respiration in different parts of a plant.
5. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.
6. Demonstration of fluorescence by isolated chlorophyll pigments.
7. Demonstration of absorption spectrum of photosynthetic pigments.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.

Semester-VII

NAME OF THE PAPER (CODE) : HORTICULTURE PRACTICES AND POST-HARVEST TECHNOLOGY (BTM 7.1)

Number of Credit : 03

Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **HORTICULTURE PRACTICES AND POST-HARVEST TECHNOLOGY**:

CO 1	To understand about the field of horticulture and its techniques.
CO 2	To learn about floriculture and ornamental plants.
CO 3	To learn about various vegetable and fruit crops.
CO 4	To learn about post-harvest technologies.
CO 5	To understand and learn about landscaping and garden design.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction and horticultural techniques (CO 1)	Scope and importance, Branches of horticulture; Role in rural economy and employment generation; Importance in food and nutritional security; Urban horticulture and ecotourism. Application of fertilizers and PGRs; Biofertilizers, biopesticides; Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics; Propagation Methods: asexual (grafting, cutting, layering, budding), sexual (seed propagation).	CSO 1.1: To explain about the scope and importance of horticulture and different branches of horticulture. (U) CSO 1.2: To discuss the role of horticulture in rural economy and employment generation. (U) CSO 1.3: To explain on the importance of horticulture in food and nutritional security. (U) CSO 1.4: To discuss on urban horticulture and ecotourism. (U) CSO 1.5: To explain on application of manure, fertilizers, nutrients and PGRs. (U) CSO 1.6: To discuss on weed control, bio fertilizers and bio pesticides. (U) CSO 1.7: To explain about the different methods of irrigation and hydroponics. (U) CSO 1.8: To discuss on asexual and sexual propagation methods. (U) CSO 1.9: To discuss on scope and limitations oh horticulture. (U)	10	22	
UNIT 2 Floriculture and	Cut flowers, bonsai, commerce (market demand and supply).	CSO 2.1: To discuss about cut flowers and bonsai as well as their market demand and supply. (U)	10	22	

Ornamental plants (CO 2)	Types, classification (annuals, perennials); Identification and salient features of some ornamental plants [rose, gladiolus, orchids, poppies, gerberas, tuberose, sages, cacti and succulents (opuntia, agave and spurges)] Ornamental flowering trees (Indian laburnum, gulmohar, Jacaranda, Lagerstroemia, fishtail, areca palms, coral tree).	CSO 2.2: To explain about the importance of flower shows and exhibitions. (U) CSO 2.3: To explain about the different types and classification of flowers and ornamental plants. (U) CSO 2.4: To identify and explain the salient features of some ornamental plants. (A) CSO 2.5: To identify and explain the salient features of some ornamental flowering trees. (A)			
UNIT 3 Fruit and vegetable crops (CO 3)	Production, origin and distribution; Description of plants and their economic products; Management and marketing of vegetable and fruit crops; Identification of some fruits and vegetable varieties (citrus, banana, mango, chillies and cucurbits).	CSO 3.1: To explain about the production, origin and distribution of fruits and vegetable crops. (U) CSO 3.2: To illustrate on description of plants and their economic products. (A) CSO 3.3: To discuss on the management and marketing of fruits and vegetable crops. (U) CSO 3.4: To identify and study some fruits and vegetable varieties. (A)	5	12	
UNIT 4 Post-harvest technology (CO 4)	Importance of post-harvest technology in horticultural crops; Evaluation of quality traits; Harvesting and handling of fruits, vegetables and cut flowers; Principles, methods of preservation and processing; Methods of minimizing losses during storage and transportation; Food irradiation - advantages and disadvantages; food safety.	CSO 4.1: To explain on the importance of post harvest technology in horticultural crops. (U) CSO 4.2: To study about the evaluation of quality traits. (A) CSO 4.3: To explain about harvesting and handling of fruits, vegetables and cut flowers. (U) CSO 4.4: To illustrate on the principles and methods of preservation and processing of fruits and vegetables. (A) CSO 4.5: To discuss on the methods of minimizing losses during storage and transportation. (U) CSO 4.6: To explain about food irradiation, its advantages and disadvantages and food safety. (U)	10	22	
UNIT 5	Planning and layout (parks and avenues);	CSO 5.1: To discuss on planning and layout of parks and avenues. (U)	10	22	

Landscaping and garden design (CO 5)	gardening traditions - Ancient Indian, European, Mughal and Japanese Gardens; Urban forestry; policies and practices.	CSO 5.2: To explain about gardening traditions with reference to ancient Indian, European, Mughal and Japanese gardens. (U) CSO 5.3: To explain about urban forestry, policies and practices. (U)			
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NAME OF THE PAPER : HORTICULTURE PRACTICES AND POST-HARVEST TECHNOLOGY
Code : BTM 7.1(P)
Number of Credit : 01
Number of Hours of Lecture : 30

Practicals

1. Field trip

Field visits to gardens, standing crop sites, nurseries, vegetable gardens and horticultural fields at IARI or other suitable locations.

OR

2. Project work (to be assigned to the students)

- a) Hydroponics
- b) Post harvest techniques
- c) Floriculture/Olericulture/Pomology (Market demand and sales)
- d) Landscaping & Gardens

Suggested Readings

1. Singh, D. & Manivannan, S. (2009). Genetic Resources of Horticultural Crops. Ridhi International, Delhi, India.
2. Swaminathan, M.S. and Kochhar, S.L. (2007). Groves of Beauty and Plenty: An Atlas of Major Flowering Trees in India. Macmillan Publishers, India.
3. NIIR Board (2005). Cultivation of Fruits, Vegetables and Floriculture. National Institute of Industrial Research Board, Delhi.
4. Kader, A.A. (2002). Post-Harvest Technology of Horticultural Crops. UCANR Publications, USA.56
5. Capon, B. (2010). Botany for Gardeners. 3rd Edition. Timber Press, Portland, Oregon.

NAME OF THE PAPER (CODE) : BIOSTATISTICS AND BIOINFORMATICS (BTM 7.2)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **BIOSTATISTICS AND BIOINFORMATICS**:

CO 1	To develop in-depth knowledge of biostatistics and data collection.
CO 2	To learn and understand about central tendency and statistical inference.
CO 3	To learn about bioinformatics and databases.
CO 4	To gain knowledge about Biological Sequence Databases and Sequence Alignment and Molecular Phylogeny.
CO 5	To learn about applications of bioinformatics.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Biostatistics and Collection of primary and secondary data (CO 1)	Definition-Statistical methods- basic principles. Variables-measurements, functions, limitations and uses of statistics. Types and methods of data collection procedures-merits and demerits, Classification-tabulation and presentation of data-sampling methods.	CSO 1.1: To define biostatistics. (K) CSO 1.2: To explain about statistical methods and basic principles. (U) CSO 1.3: To illustrate on variables-measurements, functions, limitations and uses of statistics. (A) CSO 1.4: To explain the types and methods of data collection procedures. (U) CSO 1.5: To discuss the merits and demerits of the types of data collection. (U) CSO 1.6: To illustrate on classification, tabulation and presentation of data. (A) CSO 1.7: To explain about sampling methods. (U)	7	16	
UNIT 2 Measures of Central Tendency and Statistical inference (CO 2)	Mean, Median, Mode, Geometric mean-merits and demerits. Measures of dispersion-range, standard deviation, mean deviation, quartile deviation-merits and demerits. Hypothesis-	CSO 2.1: To define and solve problems of mean, median, mode and geometric mean. (K+A) CSO 2.2: To discuss the merits and demerits of mean, median, mode and geometric mean. (U)	10	22	

	<p>simple hypothesis-student't' test-Chi square test.</p> <p>Introduction to software tools for statistical analysis.</p>	<p>CSO 2.3: To define and work out problems on range, standard deviation, mean deviation and quartile deviation. (K+A)</p> <p>CSO 2.4: To discuss the merits and demerits of range, standard. (U)</p> <p>CSO 2.5: To define and explain about hypothesis. (K+U)</p> <p>CSO 2.6: To work out problems on student't'-test. (A)</p> <p>CSO 2.7: To work out problems on chi-square test. (A)</p>			
<p>UNIT 3 Introduction to Bioinformatics and Databases in Bioinformatics (CO 3)</p>	<p>Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics: Biological Databases, Classification format of Biological Databases.</p>	<p>CSO 3.1: To introduce and explain the branches of Bioinformatics. (K+U)</p> <p>CSO 3.2: To explain about the aim, scope and research area of bioinformatics. (U)</p> <p>CSO 3.3: To discuss on biological databases and classification format of biological databases. (U)</p>	10	22	
<p>UNIT 4 Biological Sequence Databases and Sequence Alignment and Molecular Phylogeny (CO 4)</p>	<p>National Centre for Biotechnology (NCBI): Tools and Databases of NCBI, Database Retrieval Tools, Sequence submission to NCBI, Basic Local Alignment Search Tool (BLAST), Nucleotide Database.</p> <p>Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTAL W. Methods of Phylogeny, Software for Phylogenetics Analyses.</p>	<p>CSO 4.1: To explain about National Centre for Biotechnology (NCBI): Tools and Databases of NCBI, Database Retrieval Tools, Sequence submission to NCBI. (U)</p> <p>CSO 4.2: To explain about Basic Local Alignment Search Tool (BLAST), Nucleotide Database. (U)</p> <p>CSO 4.3: To explain on the concept on alignment and Multiple Sequence Alignment (MSA), MSA by CLUSTAL W. (U)</p> <p>CSO 4.4: To explain about methods of Phylogeny, Software for Phylogenetics Analyses.</p>	13	28	

		(U+A)			
UNIT 5 Application of Bioinformatics (CO 5)	Structural Bioinformatics in Drugs Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drugs Design, Microbial genome application, Crop improvement	CSO 5.1: To explain about structural bioinformatics in drugs discovery, Quantitative structure-activity relationship (QSAR) techniques in Drugs Design. (U) CSO 5.2: To discuss on Microbial genome application, Crop improvement. (U)	5	12	

NAME OF THE PAPER : BIostatISTICS AND BIOINFORMATICS
Code : BTM 7.2(P)
Number of Credit : 01
Number of Hours of Lecture : 30

Practicals

1. Collection of data.
2. Calculation of central tendency.
3. Testing of statistical hypothesis.
4. Nucleic Acid and Protein Databases.
5. Sequence retrieval from Databases.
6. Sequence alignment.
7. Sequence homology and Gene Annotation.
8. Construction of phylogenetic tree.

Suggested Readings

1. Andreas D. Baxevanis and B. F. Francis Ouellette Bioinformatics (2001). A Practical Guide to the Analysis of Genes and Proteins, Second Edition 2nd Edition; Willey&Sons.
2. Bailey, N.T.J. 1995. Statistical methods of Biology 3rd edition, Cambridge University Press
3. Bioinformatics and Biostatistics James M. Bower and Hamid Bolouri (2011).Computational Modeling of Genetic and Biochemical Networks. MIT Pubs
4. Daniel, W. W. (2007). Biostatistics- A Foundation for Analysis in the Health Sciences, Wiley.
5. Daniel, W.W., (1978.) Biostatistics: A foundation for analysis in health sciences 2nd edition. John Wiley, NY.
6. Dutta, N. K. (2004). Fundamentals of Biostatistics, Kanishka Publishers.
7. Eynon B.P. and T.W. Anderson, Minitab guide to Statistics.
8. Gurumani N. (2005) .An Introduction to Biostatistics, MJP Publishers.
9. Jayarama Reddy (2011)Fundamentals of Bioinformatics.SS Education Series: 1st edition 2011
10. Jayarama Reddy (2017) Bioinformatics and Biostatistics, Publishers- Geetha Book House, Bengaluru, ISBN:(9789352679515)

Semester-VIII

NAME OF THE PAPER (CODE) : MICROBIOLOGY, MYCOLOGY AND PLANT PATHOLOGY (BTM 8.1)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **MICROBIOLOGY, MYCOLOGY AND PLANT PATHOLOGY**:

CO 1	To gain knowledge on plant diseases, its defence and host-pathogen interaction.
CO 2	To learn about the immune system in plants.
CO 3	To learn about mycology and fungal forms.
CO 4	To be well versed in plant pathology.
CO 5	To study various plant diseases.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Diseases and Defence: Host-Pathogen interaction (CO 1)	Host-microbe relationship (Symbiosis, Commensalism, Mutualism & Parasitism) Infection Patterns; Pathogenicity; Virulence Classification of Diseases (Epidemic, Endemic, Pandemic & Sporadic) Epidemiology Diseases in population Reservoirs of infection	CSO 1.1: To explain about Host-microbe relationship. (U) CSO 1.2: To discuss on infection patterns, pathogenecity and virulence. (U) CSO 1.3: To explain about classification of diseases, epidemiology and diseases in population. (U) CSO 1.4: To explain about reservoirs of infection. (U)	7	16	
UNIT 2 Diseases and Defence: Immune system (CO 2)	Introduction to immunology Innate & Acquired Immune Response Antigen; Antibody Structure, Types & Properties Haematopoiesis Cells involved in immune system Immunity in Plants	CSO 2.1: To introduce immunology and discuss on innate and acquired immune response. (K+U) CSO 2.2: To explain about antigen, antibody structure, types and properties. (U) CSO 2.3: To discuss on haematopoiesis, cells involved in immune system and immunity in plants. (U)	8	18	
UNIT 3 Introduction to mycology	Characteristics, habit, habitat, somatic structures, reproduction	CSO 3.1: To explain about the characteristics, habit, habitat, somatic structures,	14	30	

and fungal forms (CO 3)	and present status of fungi; Classification of fungi by Ainsworth,1973, and Alexopoulos et al. 1996, Phylogenetic classification of fungi by Mclaughlin et al 2001, Hibbett et al 2007, and Kirk et.al, 2008. Economic importance of fungi. Salient features, classification and life cycles of Myxomycota, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina with suitable examples. Mycotoxins: useful and harmful effects.	reproduction and present status of fungi. (U) CSO 3.2: To discuss about the classification of fungi by Ainsworth, Alexopoulos phylogenetic classification by Mclaughlin, Hubbet and Kirk. (U) CSO 3.3: To discuss on the economic importance of fungi. (U) CSO 3.4: To explain the salient features, classification and life cycles of myxomycota, mastigomycotina, zygomycotina, ascomycotina, basidiomycotina and deuteromycotina. (U) CSO 3.5: To discuss about mycotoxins, its useful and harmful effects. (U)			
UNIT 4 Plant Pathology (CO 4)	History, concepts and scope of plant pathology; classification of plant diseases; Disease cycle and disease development; Pathogenicity test and Koch's postulates effect disease on physiology of host, defence mechanisms in plants. Methods of plant disease management. Locally available plant diseases.	CSO 4.1: To explain the history, concepts and scope of plant pathology. (U) CSO 4.2: To explain the classification of plant diseases, disease cycle and disease development. (U) CSO 4.3: To discuss about pathogenecity test and Koch's postulates. (U) CSO 4.4: To explain the effect of disease on physiology of host, defence mechanisms in plants and methods of plant disease management. (u)	7	16	
UNIT 5 Study of Plant Diseases (CO 5)	Disease cycle and control measures of following diseases: Mycoplasma diseases: Grassy shoot of sugar cane, Yellow Dwarf in rice, Viral diseases: Bunchy top of banana, Cotton	CSO 5.1: To explain about disease cycle and control measures of: a) Mycoplasma diseases b) Viral diseases c) Bacterial diseases d) Fungal diseases (U)	9	20	

	leaf curl disease, Bacterial diseases: Bacterial leaf blight of paddy, Black rot of crucifers, Fungal Diseases: Late blight of Potato, Coffee rust, Wood rotting.				
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NAME OF THE PAPER : **MICROBIOLOGY, MYCOLOGY AND PLANT PATHOLOGY**
Code : **BTM 8.1(P)**
Number of Credit : **01**
Number of Hours of Lecture : **30**

Practicals

1. Micrometry
2. Haemocytometer
3. Isolation, Culture and Staining Techniques of Fungi
4. Identification of Fungi using Fungal Floras
5. Type Study: *Stemonites*, *Saprolegnia*, *Albugo*, *Phytophthora*, *Mucor*, *Aspergillus*, *Pencillium*, *Morchella*, *Hemileia*, *Ustilago*, *Lycoperdon*, *Dictyophora*, *Curvularia*, *Alternaria*, *Fusarium*, *Pestalotia*, *Pleurotus*, *Amanita*, *Lenzites*, *Polyporus*, *Trametes* *Ganoderma*. (use recent classification)
6. Study of some Bacterial, Viral, Mycoplasma Diseases in Plants (based on availability)
7. Antibacterial/Fungal essay by Disc Diffusion method.
8. Type study of locally available plant diseases.

Suggested Readings

1. Ajoy Paul, (2016.) Text book of Immunology. Books and Allied Pvt. Ltd. Kolkatta.
2. Alexopoulos, C.J., Mims, C.W and Blackwell (1996) Introductory Mycology, 6th edition, Wiley Eastern Ltd., New Delhi.
3. Aneja, K.R. (1993) Experiments in Microbiology, plant pathology and tissue culture, Wishwa Prakashan, New Delhi.
4. Burnet, F.M. and Stanely, W.M. (1970) Biochemical biological and biophysical properties Vol-I general virology 3rd edition Academic Press, NY, London.
5. Conrat, F.H.; Kimball, P.C. and Jay, L. (1988) Virology, Prentice Hall, Englewood Cliff, New Jersey.
6. Deacon, J.W., (2006.) Fungal Biology., Blackwell Publishers, USA.
7. N.J. Dimmock, A.J. Easton, K.N. Leppard, (2007,) Modern Virology, VI Edition, Blackwell Publishing Company.
8. Kodo, C.I. and Agarwal, H.O. (1972) Principles and techniques in Plant Virology, Van Nostrand, Reinhold company
9. Pelczar, M.J. (Jr.) Chan, E.C.S. and Kreig, N.R. (1988) Microbiology, 5th edition McGraw Hall book company, Singapore.

NAME OF THE PAPER (CODE) : NATURAL RESOURCE MANAGEMENT (BTM 8.2)
Number of Credit : 03
Number of Hours of Lecture : 45

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **NATURAL RESOURCE MANAGEMENT**:

CO 1	To understand the concept of natural resources and sustainable utilization.
CO 2	To be well versed with the utilization of land and water resources.
CO 3	To learn about biological resources.
CO 4	To learn about forests and energy resources.
CO 5	To be sensitized on resource management and conservation.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Natural resources and Sustainable utilization (CO 1)	Natural Resources: Definition and types. Sustainable utilization: Concept, approaches (economic, ecological and socio-cultural) with special reference to sustainable practices in Nagaland, WCED.	CSO 1.1: To define natural resources and explain its types. (K+U) CSO 1.2: To discuss the concepts and approaches with special reference to sustainable practices in Nagaland. (U)	7	16	
UNIT 2 Land and Water (CO 2)	Utilization (agricultural, pastoral, horticultural, Silvicultural); Soil degradation and management. Fresh water (rivers, lakes, groundwater, watershed); Marine; Estuarine; Wetlands; Threats and management strategies.	CSO 2.1: To illustrate on the different types of land utilization. (A) CSO 2.2: To discuss on soil degradation and management. (U) CSO 2.3: To explain on fresh water resources, marine, estuarine and wetlands. (U) CSO 2.4: To discuss about the threats and management strategies. (U)	12	26	
UNIT 3 Biological Resources (CO 3)	Biodiversity- Definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan). Ecosystem services.	CSO 3.1: To define biodiversity and explain its types. (K+U) CSO 3.2: To study the significance of biodiversity. (K) CSO 3.3: To discuss the threats, management and strategies of biodiversity. (U) CSO 3.4: To explain on bioprospecting and Intellectual Property Right. (U) CSO 3.5: To discuss on CBD and National Biodiversity Action Plan. (U)	9	20	
UNIT 4 Forests and	Definition, Cover and its significance (with special reference to India); Major	CSO 4.1: To define forest and explain on forest cover and its significance with reference to India.	9	20	

Energy (CO 4)	and minor Forestproducts; Depletion; Management. Renewable and non-renewable sources of energy.	(K+U) CSO 4.2: To discuss on major and minor forest products. (U) CSO 4.3: To explain on the depletion and management of forest. (U) CSO 4.4: To explain about renewable and non-renewable sources of energy. (U)			
UNIT 5 Contemporary practices in resource management and National and international efforts in resource management and conservation (CO 5)	EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management.	CSO 5.1: To explain about Environmental Impact Assessment, GIS and Participatory Resource Appraisal. (U) CSO 5.2: To discuss about ecological footprint with emphasis on carbon footprint. (U) CSO 5.3: To explain about resource accounting and waste management. (U)	8	18	

NAME OF THE PAPER : NATURAL RESOURCE MANAGEMENT
Code : BTM 8.2(P)
Number of Credit : 01
Number of Hours of Lecture : 30

Practicals

1. Estimation of solid waste generated by a domestic system (biodegradable and nonbiodegradable) and its impact on land degradation.
2. Collection of data on forest covers of specific area.
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological footprint.
5. Ecological modeling.
6. Field report.

Suggested Readings

1. Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.
2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.

SKILL ENHANCEMENT COURSES (SEC)

Semester-I

NAME OF THE PAPER (CODE) : NURSERY AND GARDENING (BTS 1)
Number of Credit : 02
Number of Hours of Lecture : 30

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **NURSERY AND GARDENING**:

CO 1	To gain in depth knowledge about nursery.
CO 2	To gain knowledge and understand about seed and vegetative propagation.
CO 3	To learn about gardening, sowing/raising of seeds and seedlings.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Nursery (CO 1)	Definition, objectives and scope and building up of infrastructure for nursery, planning and seasonal activities - Planting - direct seeding and transplants.	CSO 1.1: To define nursery and explain its objectives and scope. (K+U) CSO 1.2: To explain the building up of infrastructure for nursery, planning and seasonal activities. (U) CSO 1.3: To explain about planting - direct seeding and transplants. (U)	4	8	
UNIT 2 Seed and Vegetative propagation (CO 2)	Structure and types - Seed dormancy; causes and methods of breaking dormancy - Seed storage: Seed banks, factors affecting seed viability, genetic erosion – Seed production technology - seed testing and certification. Air-layering, cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings - Hardening of plants - green house - mist	CSO 2.1: To explain about structure and types of seeds. (U) CSO 2.2: To explain seed dormancy; causes and methods of breaking dormancy. (U) CSO 2.3: To explain about seed storage: Seed banks, factors affecting seed viability, genetic erosion. (U) CSO 2.4: To explain about seed production technology - seed testing and certification. (U) CSO 2.5: To explain about air-layering,	12	20	

	chamber, shed root, shade house and glass house.	cutting, selection of cutting, collecting season, treatment of cutting, rooting medium and planting of cuttings. (U) CSO 2.6: To explain about hardening of plants - green house - mist chamber, shed root, shade house and glass house. (U)			
UNIT 3 Gardening, Sowing/raising of seeds and seedlings (CO 3)	Definition, objectives and scope - different types of gardening - landscape and home gardening - parks and its components - plant materials and design - computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting. Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - Storage and marketing procedures.	CSO 3.1: To define garden and explain its objectives and scopes. (K+U) CSO 3.2: To explain different types of gardening-landscape and home gardening. (U) CSO 3.3: To explain about parks and its components. (U) CSO 3.4: To explain about plant materials and design and computer applications in landscaping. (U) CSO 3.5: To explain about gardening operations- soil laying, manuring, watering, management of pests and diseases and harvesting. (U) CSO 3.6: To explain about transplanting of seedlings. (U) CSO 3.7: To explain the cultivation of different vegetables- cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots. (U) CSO 3.8: To explain about storage and marketing procedures. (U)	14	22	

Suggested Readings

1. Bose T.K. & Mukherjee, D., (1972). Gardening in India, Oxford & IBH Publishing Co., New Delhi.
2. Sandhu, M.K., (1989). Plant Propagation, Wile Eastern Ltd., Bangalore, Madras.
3. Kumar, N., (1997). Introduction to Horticulture, Rajalakshmi Publications, Nagercoil.
4. Edmond Musser & Andres, Fundamentals of Horticulture, McGraw Hill Book Co., New Delhi.
5. Agrawal, P.K. (1993). Hand Book of Seed Technology, Dept. of Agriculture and Cooperation, National Seed Corporation Ltd., New Delhi.
6. Janick Jules. (1979). Horticultural Science. (3rd Ed.), W.H. Freeman and Co., San Francisco, USA.

Semester-II

NAME OF THE PAPER (CODE) : FLORICULTURE (BTS 2)
Number of Credit : 02
Number of Hours of Lecture : 30

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **FLORICULTURE**:

CO 1	To learn about floriculture and ornamental plants.
CO 2	To gain knowledge on principles of garden design and landscaping.
CO 3	To be well versed about commercial floriculture.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to floriculture and Ornamental Plants (CO 1)	History of gardening; Importance and scope of floriculture and landscape gardening. Nursery Management and Routine Garden Operations: Sexual and vegetative methods of propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Shading; Stopping or pinching; Defoliation; Wintering; Mulching; Topiary; Role of plant growth regulators. Flowering annuals; Herbaceous perennials; Divine vines; Shade and ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms and Cycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai.	CSO 1.1: To explain the History of gardening; Importance and scope of floriculture and landscape gardening. (U) CSO 1.2: To explain about Nursery Management and Routine Garden Operations: Sexual and vegetative methods of propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Shading; Stopping or pinching; Defoliation; Wintering; Mulching; Topiary; Role of plant growth regulators. (U) CSO 1.3: To explain about Flowering annuals and Herbaceous perennials. (U) CSO 1.4: To explain about divine vines; Shade and ornamental trees. (U) CSO 1.5: To explain about Ornamental bulbous and foliage plants; Cacti and	14	22	

		<p>succulents; Palms and Cycads; Ferns and Selaginellas. (U)</p> <p>CSO 1.6: To explain about Cultivation of plants in pots; Indoor gardening; Bonsai. (U)</p>			
<p>UNIT 2 Principles of Garden Designs and landscaping (CO 2)</p>	<p>English, Italian, French, Persian, Mughal and Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India. Landscaping Places of Public Importance: Landscaping highways and Educational institutions.</p>	<p>CSO 2.1: To explain about English, Italian, French, Persian, Mughal and Japanese gardens. (U)</p> <p>CSO 2.2: To explain about Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. (U)</p> <p>CSO 2.3: To explain about some Famous gardens of India. (U)</p> <p>CSO 2.4: To explain about landscaping Places of Public Importance: Landscaping highways and Educational institutions. (U)</p>	8	14	
<p>UNIT 3 Commercial Floriculture (CO 3)</p>	<p>Factors affecting flower production; Production and packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation of Important cut flowers (Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolous, Marigold, Rose, Liliium, Orchids). Diseases and Pests of Ornamental Plants.</p>	<p>CSO 3.1: To explain about factors affecting flower production. (U)</p> <p>CSO 3.2: To explain about Production and packaging of cut flowers. (U)</p> <p>CSO 3.3: To explain about Flower arrangements; Methods to prolong vase life. (U)</p> <p>CSO 3.4: To explain about ultivation of important cut flowers. (U)</p> <p>CSO 3.5: To explain Diseases and Pests of Ornamental Plants. (U)</p>	8	14	

Suggested Readings

1. Randhawa, G.S. and Mukhopadhyay, A. 1986. Floriculture in India. Allied Publishers.

Semester-III

NAME OF THE PAPER (CODE) : BIOFERTILIZERS (BTS 3)
Number of Credit : 02
Number of Hours of Lecture : 30

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **BIOFERTILIZERS**:

CO 1	To understand the concept of biofertilizers.
CO 2	To learn about <i>Azospirillum</i> , <i>Azotobacter</i> , <i>Cyanobacteria</i> , <i>Azolla</i> and <i>Anabaena azollae</i> as biofertilizers.
CO 3	To understand Mycorrhizal association and organic farming.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to biofertilizers (CO 1)	General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.	CSO 1.1: To explain about the microbes used as biofertilizer – <i>Rhizobium</i> – isolation, identification, mass multiplication, carrier based inoculants. (U) CSO 1.2: To explain about Actinorrhizal symbiosis. (U)	4	8	
UNIT 2 <i>Azospirillum</i>, <i>Azotobacter</i>, <i>Cyanobacteria</i>, <i>Azolla</i> and <i>Anabaena azollae</i> as biofertilizers (CO 2)	<i>Azospirillum</i> : isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. <i>Azotobacter</i> : classification, characteristics – crop response to <i>Azotobacter</i> inoculum, maintenance and mass multiplication. <i>Cyanobacteria</i> (blue green algae), <i>Azolla</i> and <i>Anabaena azollae</i> association, nitrogen fixation, factors affecting growth, blue green algae and <i>Azolla</i> in rice cultivation.	CSO 2.1: To explain about <i>Azospirillum</i> as biofertilizer- isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. (U) CSO 2.2: To explain about <i>Azotobacter</i> as biofertilizer- classification, characteristics – crop response to <i>Azotobacter</i> inoculum, maintenance and mass multiplication. (U)	12	20	

		<p>CSO 2.3: To explain about Cyanobacteria (blue green algae), <i>Azolla</i> and <i>Anabaena azollae</i> association, nitrogen fixation, factors affecting growth. (U)</p> <p>CSO 2.4: To explain about blue green algae and <i>Azolla</i> in rice cultivation. (U)</p>			
<p>UNIT 3 Mycorrhizal Associations and Organic Farming (CO 3)</p>	<p>Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.</p> <p>Organic farming – Green manuring and organic fertilizers, Recycling of bio- degradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.</p>	<p>CSO 3.1: To explain about mycorrhizal association and types of mycorrhizal association. (U)</p> <p>CSO 3.2: To explain about taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants. (U)</p> <p>CSO 3.3: To explain about green manuring and organic fertilizers. (U)</p> <p>CSO 3.4: To explain about Recycling of bio- degradable municipal, agricultural and Industrial wastes. (U)</p> <p>CSO 3.5: To explain about biocompost making methods, types and method of vermicomposting – field application. (U)</p>	14	22	

Suggested Readings

1. Dubey, R.C., (2005). A Text book of Biotechnology S.Chand & Co, New Delhi.
2. Kumaresan, V. (2005). Biotechnology, Saras Publications, New Delhi.
3. John Jothi Prakash, E. (2004). Outlines of Plant Biotechnology. Emkay Publication, NewDelhi.
4. Sathe, T.V. (2004).Vermiculture and Organic Farming. Daya publishers.
5. Rao, N.S. (2000). Soil Microbiology, Oxford & IBH Publishers, New Delhi.
Vayas,S.C, Vayas, S. and Modi, H.A. (1998). Bio-fertilizers and organic Farming Akta Prakashan, Nadiad

Semester-IV

NAME OF THE PAPER (CODE) : MUSHROOM CULTIVATION (BTS 4)
Number of Credit : 02
Number of Hours of Lecture : 30

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **MUSHROOM CULTIVATION**:

CO 1	To learn about mushroom and its history.
CO 2	To gain in depth knowledge about cultivation technology, requirements and mushroom bed preparation.
CO 3	To learn about storage, preparation and mushroom food preparation.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction and history (CO 1)	Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India - <i>Volvariella volvacea</i> , <i>Pleurotus citrinopileatus</i> , <i>Agaricus bisporus</i> .	CSO 1.1: To define mushroom. (K) CSO 1.2: To illustrate on the nutritional and medicinal value of edible mushrooms. (A) CSO 1.3: To explain about types of poisonous and selected edible mushrooms available in India. (U)	5	10	
UNIT 2 Cultivation Technology, requirements and Mushroom bed preparation (CO 2)	Cultivation Technology: Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low-cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparation of spawn,	CSO 2.1: To explain the infrastructures involved in cultivation technology. (U) CSO 2.2: To discuss the use of locally available substrates, polythene bags, vessels, inoculation hook, inoculation loop, low cost stove, sieves, culture rack, water sprayer etc. (U) CSO 2.3: To illustrate on pure culture medium, sterilization, preparation of spawn	13	20	

	<p>multiplication. Paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation. Low cost technology, Composting technology in mushroom production.</p>	<p>and multiplication. (A) CSO 2.4: To explain mushroom bed preparation using paddy straw, sugarcane trash, maize straw and banana leaves. (U) CSO 2.5: To explain about factors affecting mushroom bed preparation. (U) CSO 2.6: To explain on low cost technology, composting technology in mushroom production. (U)</p>			
<p>UNIT 3 Storage, nutrition and Mushroom food preparation (CO 3)</p>	<p>Short-term storage (Refrigeration - upto 24 hours) Long term Storage (canning, pickels, papads), drying, storage in saltsolutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins. Food Preparation: Types of foods prepared from mushroom. Research Centres - National level and Regional level. Cost benefit ratio - Marketing in India and abroad, Export Value.</p>	<p>CSO 3.1: To explain short-term storage and long term storage of mushroom. (U) CSO 3.2: To discuss the methods of storage of mushroom. (U) CSO 3.3: To explain on the nutritive values of mushroom with reference to amino acids, mineral elements, carbohydrates, fibre content and vitamins. (U) CSO 3.4: To discuss on the different types of food prepared from mushroom. (U) CSO 3.5: To illustrate on Research Centres at National level and Regional level. (A) CSO 3.6: To explain the cost benefit. (U)</p>	12	20	

Suggested readings:

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991)
2. Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
3. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.

4. Tewari, Pankaj Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
5. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol. II.

Semester-V

NAME OF THE PAPER (CODE) : HERBAL TECHNOLOGY (BTS 5)
Number of Credit : 02
Number of Hours of Lecture : 30

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **HERBAL TECHNOLOGY**:

CO 1	To learn about herbal medicines.
CO 2	To gain knowledge on pharmacognosy and phytochemistry.
CO 3	To learn about analytical pharmacognosy and future prospects.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Herbal medicines (CO 1)	History and scope - definition of medical terms - role of medicinal plants in Siddha systems of medicine; cultivation - harvesting - processing - storage - marketing and utilization of medicinal plants.	CSO 1.1: To explain the history, scope and definition of medical terms. (U) CSO 1.2: To illustrate the role of medicinal plants in Siddha systems of medicine. (A) CSO 1.3: To explain the cultivation, harvesting, processing, storage, marketing and utilization of medicinal plants. (U)	6	10	
UNIT 2 Pharmacognosy and Phytochemistry (CO 2)	Systematic position medicinal uses of the following plants in curing various ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka. Active principles and methods of their testing	CSO 2.1: To define the term pharmacognosy. (K) CSO 2.2: To explain the systematic position, medicinal uses of Tulsi, ginger, fenugreek, Indian gooseberry and Ashoka in curing various ailments. (U)	12	20	

	- identification and utilization of the medicinal herbs; <i>Catharanthus roseus</i> (cardiotonic), <i>Withania somnifera</i> (drugs acting on nervous system), <i>Clerodendron phlomoides</i> (anti-rheumatic) and <i>Centella asiatica</i> (memory booster).	CSO 2.3: To define the term phytochemistry. (K) CSO 2.4: To explain the active principles and methods of testing of medicinal plants. (U) CSO 2.5: To illustrate the identification and utilization of the medicinal herbs such as <i>Catharanthus roseus</i> , <i>Withania somnifera</i> , <i>Clerodendron phlomoides</i> and <i>Centella asiatica</i> . (A)			
UNIT 3 Analytical pharmacognosy and future prospects (CO 3)	Drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds). Medicinal plant banks micro propagation of important species (<i>Withania somnifera</i> , neem and tulsi- Herbal foods-future of pharmacognosy)	CSO 3.1: To define drug adulteration. (K) CSO 3.2: To explain the types and methods of drug evaluation. (U) CSO 3.3: To explain biological testing of herbal drugs. (U) CSO 3.4: To explain phytochemical screening tests for secondary metabolites. (U) CSO 3.5: To explain about medicinal plant banks. (U) CSO 3.6: To discuss on micro propagation of <i>Withania somnifera</i> , neem and tulsi. (U) CSO 3.7: To discuss on herbal foods. (U) CSO 3.8: To illustrate on the future of pharmacognosy. (A)	12	20	

Suggested Readings

1. Glossary of Indian medicinal plants, R.N.Chopra, S.L.Nayar and I.C.Chopra, (1956). C.S.I.R, New Delhi.
2. The indigenous drugs of India, Kanny, Lall, Dey and Raj Bahadur, (1984). International Book_Distributors.

3. Herbal plants and Drugs Agnes Arber, (1999). Mangal Deep Publications.
4. Ayurvedic drugs and their plant source. V.V. Sivarajan and Balachandran Indra (1994). Oxford IBH _publishing Co.
5. Ayurveda and Aromatherapy. Miller, Light and Miller, Bryan, (1998). Banarsidass, Delhi.
6. Principles of Ayurveda, Anne Green, (2000). Thomsons, London.
7. Pharmacognosy, Dr.C.K.Kokate et al. (1999). Nirali Prakashan.

Semester-III

NAME OF THE PAPER (CODE) : INTELLECTUAL PROPERTY RIGHTS (MDC-3)
Number of Credit : 04
Number of Hours of Lecture : 60

COURSE OBJECTIVES (COs)

The following are the Course Objectives (COs) for the paper **INTELLECTUAL PROPERTY RIGHTS:**

CO 1	To learn about Intellectual Property Rights.
CO 2	To understand and be aware about patents
CO 3	To learn about copyrights and trademarks.
CO 4	To learn about Geographical indications.
CO 5	To gain in depth knowledge about industrial designs and information technology.

COURSE SPECIFIC OBJECTIVES (CSOs)

Unit & Title	Unit Contents	Course Specific Objectives (CSOs)	Lecture Hours	Marks	LOs
UNIT 1 Introduction to Intellectual Property Rights (CO 1)	Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, some important examples. IPR and WTO (TRIPS, WIPO).	CSO 1.1: To explain the concept, kinds and economic importance of IPR. (U) CSO 1.2: To discuss about IPR in India. (U) CSO 1.3: To explain about genesis, scope and some examples of IPR. (U) CSO 1.4: To explain about IPR and WTO. (U)	10	16	
UNIT 2 Patents (CO 2)	Objectives, Rights, Patent Act 1970 and	CSO 2.1: To explain on the objectives and rights of patents. (U)	14	24	

	its amendments. Procedure of obtaining patents, Working of patents, Rights and duties of Patentee, Assignment and license, Infringement, Remedies and Penalties.	CSO 2.2: To discuss on the Patent Act 1970 and its amendments. (U) CSO 2.3: To explain about procedure of obtaining patents, Working of patents, Rights and duties of Patentee, Assignment and license, Infringement. (U) CSO 2.4: To explain about remedies and penalties. (U)			
UNIT 3 Copyrights and Trademarks (CO 3)	Copyrights: Introduction, Works protected under copyright law, Rights, Transfer of copyrights, Infringement. Trademarks: Objectives, Types, Rights, Protection of Goodwill, Infringement, Passing off, Defences, Domain name.	CSO 3.1: To introduce copyrights and explain about works protected under copyright law. (K+U) CSO 3.2: To explain about rights, transfer of copyrights and infringement. (U) CSO 3.3: To explain the objectives, types, protection of goodwill of trademarks. (U) CSO 3.4: To discuss about the infringement, passing off, defenses and domain name of trademarks. (U)	12	20	
UNIT 4 Geographical Indications (CO 4)	Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position. Geographical indications granted to Nagaland State.	CSO 4.1: To explain about the objectives, and justification of geographical indications. (U) CSO 4.2: To discuss about the international position, multilateral treaties, national level and Indian position pertaining to geographical indications. (U) CSO 4.3: To discuss about geographical indication granted to Nagaland state. (U)	10	16	
UNIT 5 Industrial designs and Information	Industrial Designs: Objectives, Rights, Assignments,	CSO 5.1: To explain about objectives, rights, assignments,	14	24	

Technology (CO 5)	Infringements, Defences of Design Infringement Information Technology: Computer Software and Intellectual Property, Database and Data Protection, Protection of Semiconductor chips, Domain Name Protection.	infringements, defenses of design infringement. (U) CSO 5.2: To explain about computer software and intellectual property. (U) CSO 5.3: To discuss about Database and Data Protection, Protection of Semiconductor chips, Domain Name Protection. (U)			
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Suggested Readings

1. N.S. Gopalakrishnan & T.G. Agitha, (2009) Principles of Intellectual Property EasternBook Company, Lucknow.
2. Kerly's Law of Trade Marks and Trade Names (14th Edition) Thomson, Sweet & Maxweel.
3. Ajit Parulekar and Sarita D' Souza, (2006) Indian Patents Law – Legal & Business Implications; Macmillan India Ltd.
4. B.L.Wadehra (2000) Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd., India.
5. P. Narayanan (2010) Law of Copyright and Industrial Designs; Eastern law House, Delhi.