UNIVERSITY OF KALYANI

CBCS CURRICULUM FOR THREE YEARS UNDER-GRADUATE COURSE

IN

BOTANY (HONOURS)

COURSES EFFECTIVE FROM THE ACADEMIC SESSION

2018-19

SYLLABUS OF COURSES TO BE OFFERED

Core Courses, Generic Elective Courses, Skill Enhancement Courses & Ability Enhancement Courses

PREAMBLE

The University Grants Commission (UGC) has taken various measures by means of formulating regulations and guidelines and updating them, in order to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions in India. The various steps that the UGC has initiated are all targeted towards bringing equity, efficiency and excellence in the Higher Education System of country. These steps include introduction of innovation and improvements in curriculum structure and content, the teaching-learning process, the examination and evaluation systems, along with governance and other matters. The introduction of Choice Based Credit System is one such attempt towards improvement and bringing in uniformity of system with diversity of courses across all higher education institutes in the country. The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising of core, elective, skill enhancement or ability enhancement courses. The courses shall be evaluated following the grading system, is considered to be better than conventional marks system. This will make it possible for the students to move across institutions within India to begin with and across countries for studying courses of their choice. The uniform grading system shall also prove to be helpful in assessment of the performance of the candidates in the context of employment.

Outline of the Choice Based Credit System being introduced:

1. **Core Course (CC):** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2. **Elective Course:** Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the student's proficiency/skill is termed as an Elective Course.

   2.1 **Discipline Specific Elective Course (DSEC):** Elective courses that are offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

   2.2 **Generic Elective Course (GEC):** An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

3. **Ability Enhancement Courses/ Skill Enhancement Courses:**

   3.1 **Ability Enhancement Compulsory Course (AECC):** Ability enhancement courses are the courses based upon the content that leads to Knowledge enhancement. They (i) Environmental Science, (ii) English Communication) are mandatory for all disciplines.

   3.2 **Skill Enhancement Course (SEC):** These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

A. TOTAL Number of courses in UG-CBCS (B.Sc. BOTANY Honours):

Types of course	Core course (CC)	Elective course		Ability enhancement course		TOTAL
		Discipline specific elective course (DSE)	Generic elective course(GE)	Ability Enhancement compulsory course (AECC)	Skill Enhancement course (SEC)	
No. of course	14	4	4	2	2	26
Credit/course	6	6	6	2	2	140

Structure of B.Sc. Honours Botany under CBCS

Core Courses (CC) – 14 compulsory courses

1. Biomolecules and Cell Biology
2. Plant Morphology and Anatomy
3. Diversity of Microbes and Algae
4. Diversity of Fungi and Plant Pathology
5. Diversity of Bryophytes and Pteridophytes
6. Diversity of Gymnosperms and Palaeobotany
7. Reproductive Biology of Plants
8. Taxonomy of Angiosperms and Plant Systematics
9. Plant Ecology and Phytogeography
10. Economic Botany and Pharmacognosy
11. Plant Physiology
12. Plant Metabolism
13. Genetics
14. Plant Molecular Biology & Biotechnology

Discipline Specific Elective Courses (DSEC) – Any four out of eight courses offered, to be opted for in Semesters V and VI

Semester V (any two)

1. Analytical Techniques in Plant Sciences
2. Industrial and Environmental Microbiology
3. Stress Biology
4. Plant Breeding and Biometry

Semester VI (any two)

5. Biodiversity and Conservation
6. Coastal Biology
7. Research Methodology
8. Dissertation

Generic Elective Courses (GEC) – Courses offered to students of other Departments

1. Biodiversity of Microbes, Algae, Fungi and Archegoniate (Semester I)
2. Plant Ecology, Morphology and Taxonomy (Semester II)
3. Plant Cell, Anatomy and Embryology (Semester III)
4. Plant Physiology and Metabolism (Semester IV)

Ability Enhancement Compulsory Courses (AECC) – Two compulsory courses in Semesters I & II

1. English Communication
2. Environmental Science

Skill Enhancement Courses (SEC): Two courses in Semesters III and IV

Semester III (any one)

1. Biofertilizers
2. Plant Diversity and Human Welfare
3. Floriculture

Semester IV (any one)

1. Medicinal Botany
2. Mushroom Culture
3. Intellectual Property Rights

TABLE-1. DETAILS OF COURSES & CREDIT OF B.SC. BOTANY (HONOURS) UNDER CBCS

S. No.	**Particulars of Course**	**Credit Point**
1.	**Core Course: 14 Papers**	**Theory + Practical**
1.A.	Core Course: Theory (14 papers)	14x4 = 56
1.B.	Core Course (Practical/Tutorial)*(14 papers)	14x2 = 28
2.	**Elective Courses: (8 papers)**	
2.A.	A. Discipline specific Elective (DSE)(4 papers)	4x4 = 16
2.B.	DSE (Practical)* (4 papers)	4x2 =8
2C.	General Elective (GE) (Interdisciplinary) (4 papers)	4x4 = 16
2.D.	GE (Practical)* (4 papers)	4x2 =8
# Optional Dissertation/ Project Work in place of* one *DSE paper (6 credits) in 6th semester		
3. Ability Enhancement Courses		
A.	AECC(2 papers of 2 credits each) ENVS, English Communication/ MIL	2x2 = 4
B.	Skill Enhancement Course(SEC) (2 papers of 2 credits each)	2x2 = 4
	Total Credit:	**140**

TABLE-2: SEMESTER-WISE DISTRIBUTION OF COURSE & CREDITS IN B.SC. BOTANY HONOURS

Courses/ (Credits)	**Sem-I**	**Sem-II**	**Sem-III**	**Sem-IV**	**Sem-V**	**Sem-VI**	**Total No. of Courses**	**Total**
CC (6)	2	2	3	3	2	2	14	84
DSE (6)	--	--	--	--	2	2	04	24
GE (6)	1	1	1	1	--	--	04	24
AECC (2)	1	1	--	--	--	--	02	04
SEC (2)	--	--	1	1	--	--	02	04
Total No. of Course/ Sem.	4	4	5	5	4	4	26	--
Total Credit/ Semester	**20**	**20**	**26**	**26**	**24**	**24**	--	**140**

University of Kalyani

Course Structure: UG (Botany Honours) CBCS Curriculum

SEMESTER-I			
COURSE CODE	**COURSE TITLE**	**COURSE WISE CLASS**	**CREDIT**
UG-H-BOT-CC-T-01	Biomolecules and Cell Biology	Core (60L)	4
UG-H-BOT-CC-P-01		Core (60P)	2
UG-H-BOT-CC-T-02	Plant Morphology and Anatomy	Core (60L)	4
UG-H-BOT-CC-P-02		Core (60P)	2
UG-H-BOT-GE-T-01	Biodiversity of Microbes, Algae, Fungi and Archegoniate	Generic Elective (60L)	4
UG-H-BOT-GE-P-01		Generic Elective (60P)	2
UG-H-AECC-01	English Communication/ Environmental Science	Ability Enhancement Compulsory (30L)	2
TOTAL FOUR (4) COURSES			**20**
SEMESTER-II			
COURSE CODE	**COURSE TITLE**	**COURSE WISE CLASS**	**CREDIT**
UG-H-BOT-CC-T-03	Diversity of Microbes and Algae	Core (60L)	4
UG-H-BOT-CC-P-03		Core (60P)	2
UG-H-BOT-CC-T-04	Diversity of Fungi and Plant Pathology	Core (60L)	4
UG-H-BOT-CC-P-04		Core (60P)	2
UG-H-BOT-GE-T-02	Plant Ecology, Morphology and Taxonomy	Generic Elective (60L)	4
UG-H-BOT-GE-P-02		Generic Elective (60P)	2
UG-H-AECC-02	Environmental Science/ English Communication	Ability Enhancement Compulsory (30L)	2
TOTAL FOUR (4) COURSES			**20**
SEMESTER-III			
COURSE CODE	**COURSE TITLE**	**COURSE WISE CLASS**	**CREDIT**
UG-H-BOT-CC-T-05	Diversity of Bryophytes and Pteridophytes	Core (60L)	4
UG-H-BOT-CC-P-05		Core (60P)	2
UG-H-BOT-CC-T-06	Diversity of Gymnosperms and Palaeobotany	Core (60L)	4
UG-H-BOT-CC-P-06		Core (60P)	2
UG-H-BOT-CC-T-07	Reproductive Biology of Plants	Core (60L)	4
UG-H-BOT-CC-P-07		Core (60P)	2
UG-H-BOT-GE-T-03	Plant Cell, Anatomy and Embryology	Generic Elective (60L)	4
UG-H-BOT-GE-P-03		Generic Elective (60P)	2
UG-H-BOT-SEC-T-01 (ANY ONE)	A. Biofertilizers	Skill Enhancement (30L)	2
	B. Plant Diversity and Human Welfare		
	C. Floriculture		
TOTAL FIVE (5) COURSES			**26**
SEMESTER-IV			
COURSE CODE	**COURSE TITLE**	**COURSE WISE CLASS**	**CREDIT**
UG-H -BOT-CC-T-08	Taxonomy of Angiosperms and Plant Systematics	Core (60L)	4
UG-H -BOT-CC-P-08		Core (60P)	2
UG-H -BOT-CC-T-09	Plant Ecology and Phytogeography	Core (60L)	4
UG-H -BOT-CC-P-09		Core (60P)	2
UG-H -BOT-CC-T-10	Economic Botany and Pharmacognosy	Core (60L)	4
UG-H -BOT-CC-P-10		Core (60P)	2
UG-H -BOT-GE-T-04	Plant Physiology and Metabolism	Generic Elective (60L)	4
UG-H -BOT-GE-P-04		Generic Elective (60P)	2
UG-H-BOT-SEC-T-02 (ANY ONE)	A. Medicinal Botany	Skill Enhancement (30L)	2
	B. Mushroom Culture		
	C. Intellectual Property Rights		
TOTAL FIVE (5) COURSES			**26**

SEMESTER-V			
COURSE CODE	**COURSE TITLE**	**COURSE WISE CLASS**	**CREDIT**
UG-H-BOT-CC-T-11	Plant Physiology	Core (60L)	4
UG-H-BOT-CC-P-11		Core (60P)	2
UG-H-BOT-CC-T-12	Plant Metabolism	Core (60L)	4
UG-H-BOT-CC-P-12		Core (60P)	2
UG-H-BOT-DSE-T-01 UG-H-BOT-DSE-P-01	A. Analytical Techniques in Plant Science **OR** B. Industrial and Environmental Microbiology	Discipline Specific Elective (60L+60P)	6 (4T+2P)
UG-H-BOT-DSE-T-02 UG-H-BOT-DSE-P-02	A. Stress Biology **OR** B. Plant Breeding and Biometry	Discipline Specific Elective (60L+60P)	6 (4T+2P)
TOTAL FOUR (4) COURSES			**24**
SEMESTER-VI			
COURSE CODE	**COURSE TITLE**	**COURSE WISE CLASS**	**CREDIT**
UG-H -BOT-CC-T-13	Genetics	Core (60L)	4
UG-H -BOT-CC-P-13		Core (60P)	2
UG-H -BOT-CC-T-14	Plant Molecular Biology and Biotechnology	Core (60L)	4
UG-H -BOT-CC-P-14		Core (60P)	2
UG-H -BOT-DSE-T-03 UG-H -BOT-DSE-P-03	A. Biodiversity and Conservation **OR** B. Coastal Biology	Discipline Specific Elective (60L+60P)	6 (4T+2P)
UG-H -BOT-DSE-T-04 UG-H -BOT-DSE-P-04	A. Research Methodology **OR**	Discipline Specific Elective (60L+60P)	6 A:4T+2P
UG-H -BOT-DSE-P-04	B. Dissertation/ Project	Discipline Specific Elective (180P)	B:6P
TOTAL FOUR (4) Courses			**24**
GRAND TOTAL (ALL SEMESTERS): TWENTY SIX (26) COURSES			**140**

SEMESTER-I

Course: UG-H-BOT-CC-T-01 & UG-H-BOT-CC-P-01

Course title: Biomolecules and Cell Biology

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- describe the types, nomenclature and structures of biomolecules;
- explain the function and structure of cells including the metabolic reactions that occur in cells;
- elucidate the laws of thermodynamics and translate reaction mechanisms within cells into their final expressions;
- discuss the origin of eukaryotic cell;
- explain the processes of cell division and inheritance.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-01:

Unit 1: Biomolecules (20)

A. Types and significance of chemical bonds; Structure and properties of water; pH and buffers.

B. Carbohydrates: Nomenclature and classification; Monosaccharides; Disaccharides; Oligosaccharides and Polysaccharides.

C. Lipids: Definition and major classes of storage and structural lipids; Fatty acids structure and functions; Essential fatty acids; Triacyl glycerol structure, functions and properties; Phosphoglycerides.

D. Proteins: Structure of amino acids; Levels of protein structure-primary, secondary, tertiary and quaternary; Protein denaturation and biological roles of proteins.

E. 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.

Unit 2: Bioenergetics (4)

Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as an energy currency molecule.

Unit 3: Enzymes (6)

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.

Unit 4: The cell (4)

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory).

Unit 5: Cell wall and plasma membrane (4)

Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.

Unit 6: Cell organelles (16)

A. Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus.
B. Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament.
C. Chloroplast, Mitochondrion, and Peroxisome: Structural organization; Function; Semiautonomous nature of mitochondrion and chloroplast.
D. Endomembrane system: Endoplasmic Reticulum (ER) – 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; Lysosome
E. Organelle without membranes: Ribosomes – structure and function

Unit 7: Cell division (6)

Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle- checkpoints, role of protein kinases.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-01:

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
2. Study of plant cell structure with the help of epidermal peel mount of *Allium cepa*/ *Rhoeo*/ *Crinum*.
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
4. Measurement of cell size by the technique of micrometry.
5. Counting the cells per unit volume using haemocytometer (Yeast/pollen grains).
6. Study of cell and its organelles with the help of electron micrographs.
7. Cytochemical staining of: DNA- Feulgen and cell wall in the epidermal peel of onion using Periodic Schiff's (PAS) staining technique (demonstration only).
8. Study the phenomenon of plasmolysis and deplasmolysis.
9. Study different stages of mitosis and meiosis.

SUGGESTED READINGS/ REFERENCES:

1. 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.
2. Berg J.M., Tymoczko J.L. and Stryer L. (2011) Biochemistry, W.H.Freeman and Company.
3. Campbell, M.K. (2012) Biochemistry, 7th ed., Published by Cengage Learning.
4. Campbell, P.N. and Smith A.D. (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone.
5. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
6. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
7. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
8. Nelson D.L. and Cox M.M. (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company.
9. Tymoczko J.L., Berg J.M. and Stryer L. (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman

Course: UG-H-BOT-CC-T-02 & UG-H-BOT-CC-P-02

Course title: Plant Morphology and Anatomy

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- describe plants by morphological and anatomical features for correct identification;
- explain developmental patterns of both vegetative and reproductive organs of plants;
- apply the knowledge gained in taxonomical studies, and evolutionary biology and ontogeny studies;
- analyse and comprehend wood structure.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-02:

Unit 1: Morphology of leaves (3)

Types, phyllotaxy, modification of leaves; stipules.

Unit 2: Morphology of inflorescence (6)

Types, examples and evolution.

Unit 3: Morphology of flower (6)

Calyx and its modification, types of flower, aestivation, floral formula and floral diagram, adhesion and cohesion of floral parts, placentation types.

Unit 4: Morphology of fruits and seeds (4)

Definition and types of fruits and seeds, dispersal of fruits and seeds.

Unit 5: Cell wall (4)

Ultrastructure and Chemical constituents; Plasmodesmata – ultrastructure; Concept of Apoplast and Symplast; Growth and Thickening of cell wall.

Unit 6: Tissue (9)

Classification of tissues; Simple and complex tissues; Cytodifferentiation of tracheary elements and sieve elements; Pits and plasmodesmata; ergastic substances, hydathodes, cavities, lithocytes and laticifers; Stomatal Types

Unit 7: Apical Meristem (9)

Organization of shoot apex (Apical cell theory, Histogen theory, Tunica corpus theory, Continuing meristematic residue, Cytohistological zonations); Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiscent centre; Root cap.

Unit 8: Primary plant body (4)

Primary structure of plant body; Leaf-trace and leaf-gap; Stelar types and evolution; Kranz anatomy.

Unit 9: Secondary plant body (10)

Structure, function and seasonal activity of cambium; Secondary growth in root and stem; Anomalous secondary growth (*Bignonia*, *Dracaena*, *Boerhaavia, Strychnos* and *Tinospora*), sapwood and heartwood; ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology, development and compositions of periderm, rhytidome and lenticels.

Unit 10: Adaptive and Protective systems (3)

Epidermal system, cuticle, epicuticular waxes, trichomes (uni-and multicellular, glandular and nonglandular with examples); adcrustation and incrustation.

Unit 11: Scope of plant anatomy (2)

Application in systematics, forensics and pharmacognosy.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-02:

Morphology

1. Identification with reasons: different types of stipules, inflorescence, flowers and fruits.

Anatomy

2. Identification of apical meristem of root, shoot and vascular cambium (from permanent slides).
3. Study of distribution and types of parenchyma, collenchyma and sclerenchyma.
4. Study of the secondary growth in stems and root (both normal and anomalous) in *Dracaena, Boerhaavia, Bignonia, Strychnos* and *Tinospora.*
5. Study of leaf anatomy: isobilateral, dorsiventral, C_4 leaves (Kranz anatomy).
6. Microscopic identification: xylem (tracheary elements: tracheids, vessel elements, xylem fibres); wood (heart – and sap wood). Phloem (sieve tubes, sieve plates, companion cells, phloem fibres); epidermal system (stomatal types, non- glandular and glandular trichomes); secretory tissues (cavities, lithocytes, laticifers); ergastic substances (cystolith, raphides).

SUGGESTED READINGS/ REFERENCES:

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. 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.
3. Fahn, A. (1974). Plant Anatomy. Pergamon Press, USA.
4. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/ Cummings Publisher, USA.
5. Sachdeva, S.K. (1990). Angiosperms, Morphology, Anatomy, Taxonomy, Evolution. Kalyani Publishers, New Delhi.

Course: UG-H-BOT-GE-T-01 & UG-H-BOT-GE-P-01

Course title: Biodiversity of Microbes, Algae, Fungi and Archegoniate

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- describe general characteristics of viruses, bacteria, algae, fungi and archegoniate with special reference to their classification, morphology, reproduction and ecology;
- explain their role in environment, human welfare and in industrial applications;
- apply this knowledge in understanding the evolutionary significance of these organisms.

COURSE CONTENT (THEORY) - UG-H-BOT-GE-T-01:

Unit 1: Microbes **(10)**

Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance; Bacteria – Discovery,

General characteristics and cell structure; Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.

Unit 2: Algae (12)

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae by Fritsch (1935); Morphology and life-cycles of the following: *Nostoc*, *Chlamydomonas, Oedogonium*, *Vaucheria, Fucus, Polysiphonia*. Economic importance of algae.

Unit 3: Fungi (12)

Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition, nutrition, reproduction and classification (Alexopoulos, Mims, and Blackwell, 1996); True Fungi- General characteristics, ecology and significance, life cycle of *Rhizopus* (Zygomycota) *Talaromyces* (*Penicillium;* Ascomycota), *Puccinia, Agaricus* (Basidiomycota); Symbiotic Associations-Lichens: Genera account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance.

Unit 4: Introduction to Archegoniate (2)

Unifying features of archegoniates; Transition to land habit; Alternation of generations.

Unit 5: Bryophytes (10)

General characteristics, adaptations to land habit, Classification, Range of thallus organization. Classification following GM Smith (1955), morphology, anatomy and reproduction of *Marchantia* and *Funaria* (Developmental details not to be included). Ecology and economic importance of bryophytes with special mention of *Sphagnum*.

Unit 6: Pteridophytes (8)

General characteristics; Classification of vascular plants by Gifford and Foster (1989) with diagnostic features and examples (from division Rhyniophyta to Filicophyta); Early land plants (*Cooksonia* and *Rhynia*); Systematic position, morphology, anatomy and reproduction of *Lycopodium*, *Selaginella*, *Equisetum* and *Pteris* (Developmental details not to be included); Heterospory and seed habit, Stelar evolution; Ecological and economical importance.

Unit 7: Gymnosperms (6)

General characteristics; Classification of vascular plants by Gifford and Foster (1989) with diagnostic features and examples (from division Pteridospermophyta to Gnetophyta); Systematic position, morphology, anatomy and reproduction of *Cycas* and *Pinus* (Developmental details not to be included); Ecological and economical importance.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-GE-P-01:

1. EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
2. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary Fission; Conjugation; Structure of root nodule.
3. Gram staining.
4. Study of vegetative and reproductive structures of *Nostoc, Oedogonium, Vaucheria*, and *Polysiphonia* through temporary preparations; *Chlamydomonas* and *Fucus* through permanent slides and preserved specimens.
5. *Rhizopus and Penicillium*: Asexual stage from temporary mounts and sexual structures through permanent slides.
6. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; section/tease mounts of spores on Wheat and permanent slides of both hosts.

7. *Agaricus*: Specimens of button stage and full grown mushroom; Sectioning of gills of *Agaricus*.
8. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose).
9. Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs).
10. *Marchantia*- morphology of thallus, whole mount (WM) rhizoids and scales, vertical section (VS) thallus through gemma cup, WM gemmae (all temporary slides), VS antheridiophore, archegoniophore, longitudinal section (LS) sporophyte (all permanent slides).
11. *Funaria*- morphology, WM leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, LS capsule and protonema.
12. *Lycopodium*- morphology, transverse section (TS) stem, w.m. strobilus, w.m. sporophyll, and LS strobilus (permanent slide).
13. *Selaginella*- morphology, WM leaf with ligule, TS stem, WM strobilus, microsporophyll and megasporophyll (temporary slides), LS strobilus (permanent slide).
14. *Equisetum*- morphology, TS internode, LS strobilus, TS strobilus, WM sporangiophore, and spores (temporary slides); TS rhizome (permanent slide).
15. *Pteris*- morphology, TS rachis, VS sporophyll, WM sporangium, WM spores (temporary slides), TS rhizome, WM prothallus with sex organs and young sporophyte (permanent slides)

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1. Alexopoulos, C.J., Mims, C.W., and Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
2. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press Pvt. Ltd. Delhi. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.
4. Raven, P.H., Johnson, G.B., Losos, J.B., and Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi, India.
5. Ray, S. and Bhattacharya, S. (2016). Manual for Bryophytes: Morphotaxonomy, diversity, spore germination, conservation. Levants Books, Sarat Book Distributors, Kolkata, pp. 123
6. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
7. Tortora, G.J., Funke, B.R., and Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
8. Vashishta, P.C., Sinha, A.K., and Kumar, A. (2010). Pteridophyta, S. Chand. Delhi, India.

Course: UG-H-AECC-01; Course title: English Communication/ Environmental Science

Core Course; Credit – 02; Full Points – 50

COURSE CONTENT (THEORY) - AECC-1:

SEMESTER-II

Course: UG-H-BOT-CC-T-03 & UG-H-BOT-CC-P-03

Course title: Diversity of Microbes and Algae

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- describe general characteristics of viruses, bacteria and algae with special to their classification, morphology, reproduction, distribution and ecology;
- explain their role in environment, human welfare and in industrial applications;
- apply this knowledge in understanding the evolutionary significance of these organisms.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-03:

Unit 1: Introduction to microbial world, microbial nutrition, growth and metabolism. (3)

Unit 2: Viruses (9)

Discovery, physiochemical and biological characteristics; classification (Baltimore, 1971), general structure with special reference to viroids and prions; replication (general accounts). DNA Virus (T_4 phage), lytic and lysogenic cycle; RNA virus (TMV); Economic importance of viruses with special reference to vaccine production, role in research, medicines and diagnostics, as causal organism of plant diseases.

Unit 3: Bacteria (9)

Discovery, general characteristics; types – archaebacteria, eubacteria, wall – less forms (mycoplasma and spheroplasts); cell structure, nutritional types; bacterial growth; reproduction - vegetative, asexual and recombination (conjugation, transformation and transduction); endospore; economic importance with reference to their role in agriculture and industry (fermentation and medicine).

Unit 4: Introduction to Algae (10)

General characteristics; Ecology and distribution; range of thallus organization; Cell structure and components; cell wall, pigments and reserve food of groups represented in the syllabus; flagella; methods of reproduction; Classification: different criteria, classification system of Fritsch (1935, 1948), and evolutionary classification of Lee (2008) only up to groups; Significant contributions of important phycologists (F.E. Fritsch, G.M. Smith, R.N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P. Iyengar). Role of algae in the environment, agriculture, biotechnology and industry.

Unit 5: Cyanophyta and Prochlorophyta (9)

Ecology and occurrence; Range of thallus organization; Cell structure; Pigments; Nitrogen fixation; Reproduction; Morphology and life-cycle of *Nostoc*. Evolutionary significance of *Prochloron.*

Unit 6: Rhodophyta, Chlorophyta and Charophyta (12)

General characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Chlamydomonas, Oedogonium, Coleochaete, Chara* and *Polysiphonia.*

Unit 7: Xanthophyta and Phaeophyta (8)

Characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Vaucheria, Ectocarpus* and *Fucus.*

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-03:

Microbiology

1. Models of viruses – T-phage and TMV, Line drawings/photographs of Lytic and Lysogenic Cycles.
2. Types of bacteria to be observed from temporary/permanent slide. Electron micrographs of bacteria, binary fission, conjugation, root nodule.
3. Sterilization technique by Autoclaving, Hot air oven and surface sterilization.
4. Preparation of standard bacteriological medium (nutrient agar, nutrient broth), slant and stabs, streak, pouring of Petriplates.
5. Sub culturing of bacterial culture.
6. Microscopic examination of bacteria from natural habitats: curd and root nodules of leguminous plants.

Phycology

1. Study of vegetative and reproductive structures of *Nostoc, Oedogonium, Chara, Vaucheria, Ectocarpus* and *Polysiphonia* through temporary preparations, *Fucus, Chlamydomonas*, *Coleochaete* through preserved specimens and permanent slides and *Procholoron* through electron microphotographs.

SUGGESTED READINGS/ REFERENCES:

1. Dubey, R. C., and Maheshwari, D. K. (2006). Practical Microbiology, 2nd edition, S. Chand and Company Ltd., New Delhi.
2. Fritsch, F. E. (1935). The Structure and Reproduction of the Algae. Volume 1. Cambridge University Press, London.
3. Kumar, H.D. (1999). Introductory Phycology. 2nd Edition. Affiliated East-West Press, Delhi.
4. Lee, R. E. (2008). Phycology. 4th Edition. Cambridge University Press. Cambridge.
5. Pelczar, M. J., Chan, E.C.S. and Kreig, N.R. (2001). Microbiology, 5th edition, Tata McGraw Hill Co., New Delhi.
6. Ray, S. (2008). Cyanobacteria. New Age International Publishers, New Delhi.
7. Tortora, G. J., Funke, B. P., and Case, C. L. (2016). Microbiology, 11th edition, Pearson Education, India.
8. Van Den Hoek, C., D. G. Mann and H. M. Jahns. (2009). Algae – An introduction to phycology. Cambridge University Press.
9. Willey, J.M. (2017). Prescott's Microbiology, 10th edition, McGraw Hill.

Course: UG-H-BOT-CC-T-04 & UG-H-BOT-CC-P-04

Course title: Diversity of Fungi and Plant Pathology

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- describe general characteristics of fungi with special reference to their classification, somatic diversity, reproduction, symbiosis and applied aspects;
- explain plant pathogen interactions, control spread of plant pathogens and plant diseases.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-04:

Unit 1: Introduction to true fungi (6)

General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification (Alexopoulos, Mims and Blackwell, 1996).

Unit 2: Chytridiomycota and Zygomycota (5)

Characteristic features; Thallus organisation; Reproduction; Life cycle of *Synchytrium,* and *Rhizopus*.

Unit 3: Ascomycota (10)

General characteristics, Sexual reproduction, development of ascus and ascospores, types of ascocarps; Heterokaryosis and parasexuality in asexual members; Life cycle of *Saccharomyces, Talaromyces (Penicillium), Neurospora* and *Ascobolus.*

Unit 4: Basidiomycota (8)

General characteristics; development of basidia and basidiospores and basidiocarp, Life cycle of *Puccinia* emphasizing physiological specialization and *Agaricus*; Bioluminescence, Fairy Rings and Mushroom Cultivation.

Unit 5: Allied Fungi (3)

General characteristics; Status of Slime molds, Occurrence; Types of plasmodia.

Unit 6: Oomycota (4)

General characteristics; Life cycle of *Phytophthora* and *Albugo.*

Unit 7: Symbiotic associations (4)

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.

Unit 8: Applied Mycology (10)

Role of fungi in biotechnology; Application of fungi in food industry (Flavour and texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides).

Unit 9: Plant Pathology (10)

A. Terms and concepts; General symptoms; Geographical distribution of diseases; Etiology; Symptomology; Koch's postulates; Host-Pathogen relationships; Disease cycle and environmental relation; types of diseases; Host defense mechanisms; prevention and control of plant diseases, and role of quarantine.
B. Bacterial diseases: Citrus canker and bacterial blight of rice.
C. Viral diseases: Tobacco Mosaic virus.
D. Fungal diseases – Late blight of potato, White rust of crucifers, Black stem rust of wheat, Loose smut of wheat, Brown spot of rice.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-04:

Fungi

1. Study of the following genera from temporary mounts and permanent slides (when necessary): *Rhizopus*, *Talaromyces (Penicillium), Ascobolus,* and *Agaricus.*
2. Identification of all the macroscopic and microscopic genera included in the theoretical syllabus through permanent slides, museum/ herbarium specimens.
3. Demonstration of different growth forms of lichens from preserved specimens. Mycorrhiza – Ectomycorrhiza, Endomycorrhiza (photographs).

Plant Pathology

1. Identification of following diseases through herbarium specimens:
   a) Viral diseases: TMV, Vein clearing.
   b) Bacterial diseases; Citrus Canker; bacterial blight of rice.
   c) Fungal diseases: Early and Late blight of potato, White rust of crucifers, Loose and covered smut of wheat, Black stem rust of wheat and Brown spot of rice.
2. Study of the following diseases: White rust of crucifer/Amaranths, Rust of wheat/ *Justicia*, loose smut of wheat, brown spot of rice.

SUGGESTED READINGS/ REFERENCES:

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. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
4. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.
5. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.

Course: UG-H-BOT-GE-T-02 & UG-H-BOT-GE-P-02

Course title: Plant Ecology, Morphology and Taxonomy

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- explain the concept of ecology and the influence of different environmental, climatic and physiographic and edaphic factors on plant life;
- comprehend the concept of phytogeography, describe botanical zones in India and explain endemism;
- describe the importance of biodiversity and relevance of conservation;
- apply morphological features in describing plants;
- discuss the essentials of plant taxonomy, explain taxonomic hierarchy and explain the classification system of Bentham and Hooker;
- explain the concepts of numerical taxonomy and cladistics.

COURSE CONTENT (THEORY) - UG-H-BOT-GE-T-02:

Unit 1: Introduction (2)
Concept of ecology.

Unit 2: Ecological factors (5)
Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature. Adaptation of hydrophytes, halophytes and xerophytes.

Unit 3: Plant communities (6)
Characters; Ecotone and edge effect; Succession; Processes and types.

Unit 4: Ecosystem (6)
Structure; energy flow, trophic organisation; Food chains and food webs, Ecological pyramids, production and productivity; Tritrophic interactions (plant defense against herbivore) with reference to Volatile Organic Compounds (VOC) and other secondary compounds, Biogeochemical cycling; Cycling of carbon, nitrogen and phosphorous.

Unit 5: Phytogeography (4)
Botanical zones in India (D. Chatterjee, 1962), Present status; Endemism.

Unit 6: Conservation of Biodiversity (3)
Level of Biodiversity: genetic, species and ecosystem diversity, Biodiversity hot spots-criteria, Indian hotspots, *In- situ and ex-situ* conservation, Ecological restoration, Geographic Information System and Remote Sensing (brief idea).

Unit 7: Plant Morphology (10)
Variations in leaf morphology; phyllotaxy; types of inflorescence; morphology of flowers – types of flowers; modification of calyx; aestivation; floral formula and floral diagram; adhesion and cohesion of floral parts; placentation types; types of fruits and seeds.

Unit 8: Introduction to plant taxonomy (2)
Identification, Classification, Nomenclature.

Unit 9: Identification (4)
Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access.

Unit 10: Taxonomic hierarchy (2)
Ranks, categories and taxonomic groups.

Unit 11: Botanical nomenclature (4)
Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations (with examples).

Unit 12: Classification (2)
Types of classification - artificial, natural and phylogenetic. Outline of Bentham and Hooker (up to series) classification with merits and demerits.

Unit 13: Numerical taxonomy and cladistics (brief idea) (2)

Unit 14: Salient features, Systematic position (Bentham and Hooker), economically important plants of the following families (8)
Monocotyledons: Liliaceae; Arecaceae; Poaceae; Orchidaceae
Dicotyledons: Brassicaceae; Leguminosae (*s.l.*); Malvaceae; Solanaceae; Lamiaceae; Cucurbitaceae; Euphorbiaceae; Asteraceae

COURSE CONTENT (PRACTICAL) - UG-H-BOT-GE-P-02:

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Comparison of bulk density, porosity and rate of infiltration of water in soil of two habitats.
3. Study of morphological adaptations of hydrophytes, halophytes and xerophytes (four each).
4. Study of biotic interactions of the following: Stem parasite (*Cuscuta)*, Root parasite (*Orobanche*)- illustration only, Epiphytes, Predation (Insectivorous plants)- illustration only.
5. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method (species to be listed).
6. Quantitative analysis of herbaceous vegetation in any suitable habitat for frequency distribution and comparison with Raunkiaer's frequency distribution law.
7. Study of vegetative and floral characters of following families of the available genera distributed locally according to Bentham & Hooker's system of classification:
   Dicotyledons: Brassicaceae; Leguminosae (Papilionoidae and Caesalpinioidae); Euphorbiaceae, Malvaceae; Lamiaceae; Solanaceae; Asteraceae
   Monocotyledons: Poaceae
8. Spot identification (Binomial, Family) of common wild plants from families included in Theoretical syllabus.
9. Submission of properly preserved herbarium specimens of at least 15 common wild plants with herbarium label, proper field record and notes. The herbarium specimens should be submitted during End Term Examination and to be arranged following Bentham and Hooker's system of classification.

SUGGESTED READINGS/ REFERENCES:

1. Gurevitch, J. et al. (2006). The Ecology of Plants. Sinauer Associates, USA.
2. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
3. Prain, D. (1905) Bengal Plants I & II. Bishen Singh Mahendra Pal Singh, Dehradun, India.
4. Rao, R.R. (1994). Biodiversity in India Floristic Aspects. Bishen Singh Mahendra Pal Singh, Dehradun, India.
5. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
6. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A
7. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.

Course: UG-H-AECC-02; Course title: English Communication/ Environmental Science

Core Course; Credit – 2; Full Points – 50

COURSE CONTENT (THEORY) – UG-H-AECC-02:

SEMESTER-III

Course: UG-H-BOT-CC-T-05 & UG-H-BOT-CC-P-05

Course title: Diversity of Bryophytes and Pteridophytes

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- describe general characteristics of bryophytes and pteridophytes with special to their classification, morphology, reproduction, distribution and ecology;
- explain their role in environment, human welfare and in industrial applications;
- apply this knowledge in understanding the evolutionary significance of these organisms.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-05:

Unit 1: General account of Bryophytes (5)

General characteristics; Adaptations to land habit; Habitats; Range of thallus organization.

Unit 2: Classification of Bryophytes (4)

Classification following Smith, G.M. (1955) and modern concepts in bryophyte classification with special reference to Shaw and Goffinet (2000).

Unit 3: Type Studies of Bryophyte (12)

Systematic position, morphology, anatomy and reproduction of *Riccia*, *Marchantia*, *Pellia*, *Anthoceros*, *Sphagnum* and *Funaria*; Evolutionary trends in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria.*

Unit 4: Origin and Evolution of Bryophytes (7)

Origin of bryophytes; Origin of alternation of generation (Homologous and Antithetic theories); Evolution of sporophyte (Progressive and Regressive concepts).

Unit 5: Importance of Bryophytes (2)

Ecological and economic importance of bryophytes with special reference to *Sphagnum.*

Unit 6: General Account of Pteridophytes (5)

General characteristics; Basic concepts of life cycle patterns of homosporous and heterosporous pteridophytes; Apospory and Apogamy; Habitat diversity.

Unit 7: Classification of Pteridophytes (4)

Classification of vascular plants by Gifford and Foster (1989) with diagnostic features and examples [from division Rhyniophyta to Filicophyta].

Unit 8: Type Studies of Pteridophytes (12)

Systematic position, morphology, anatomy and reproduction of *Psilotum*, *Lycopodium*, *Selaginella*, *Equisetum*, *Ophioglossum*, *Pteris* and *Marsilea.*

Unit 9: Origin and Evolution (7)

Origin of pteridophytes; Telome concept in land plant evolution; Structural features, geological and geographical distributions and evolutionary trends in early land plants *Cooksonia*, *Rhynia*, *Lepidodendron* and *Calamites.*

Unit 10: Importance of Pteridophytes (2)

Ecological and economic importance of pteridophytes.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-05:

1. ***Riccia* –** Morphology of thallus.
2. ***Marchantia*-** Morphology of thallus, whole mount of rhizoids and 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. ***Pellia* -** Permanent slides.
5. ***Sphagnum*-** Morphology of plant, whole mount of leaf (permanent slide only).
6. ***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
7. ***Psilotum*-** Study of specimen, transverse section of synangium (permanent slide)
8. ***Lycopodium*-** Morphology, transverse section of stem, whole mount of sporophyll (temporary slides), whole mount of strobilus, longitudinal section of strobilus.
9. ***Selaginella*-** Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of microsporophyll and megasporophyll (temporary slides), whole mount of strobilus, longitudinal section of strobilus.
10. ***Equisetum*-** Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (temporary slide), transverse section of rhizome (permanent slide).
11. ***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).
12. **Early land plants-** Transverse section of stem of *Cooksonia*, *Rhynia*, *Lepidodendron*, *Calamites* (permanent fossil slides if available or photographs).

SUGGESTED READINGS/ REFERENCES:

Bryophytes

1. Chopra, R.N. and Kumar, P.K. (1988). Biology of Bryophyta, Wiley Eastern.
2. Parihar, N.S. (1959). Introduction to Embryophyta (Vol. 1 Bryophyta), Central Book Distributors
3. Puri, P. (1980). Bryophyte. Atmaram & Sons.
4. Rashid, A. (1998). An Introduction to Bryophyta, Vikas Publishing House.
5. Ray, S. & Bhattacharya, S. (2016). Manual for Bryophytes: Morphotaxonomy, diversity, spore germination, conservation. Levants Books, Sarat Book Distributors, Kolkata.
6. Schofield, W.B. (2001). Introduction to Bryology, Blackburn Press.
7. Shaw, A. Jonathan and Goffinet Bernard (2009). Bryophyte Biology, Cambridge University Press.
8. Smith, A.J.E. (ed.) (1982). Bryophyte Ecology, Chapman and Hall.
9. Vanderpoorten, A. and Goffinet, B. (2009). Introduction to Bryophytes, Cambridge University Press.
10. Vashista, B.R. (2001). Bryophyta, S. Chand & Company.

Pteridophytes

1. Gifford, E. M. and Foster, A. S. (1998). Morphology & Evolution of Vascular Plants (3rd ed.), Freeman and Co.
2. Mukherjee, R.N. and Chakraborty, K.A. (1995). Introduction to Vascular Cryptogams (Pteridophyta) Kalyani Publications.
3. Parihar, N.S. (1989). The Biology & Morphology of Pteridophytes (2nd ed.), Central Book Distributors.
4. Rashid, A. (1998). An Introduction to Pteridophyta, Latest Ed., Vani Educational Books.
5. Sporne, K.R. (1962). The Morphology of Pteridophyte, Latest Ed., Hutchinson & Co. Ltd.
6. Vashista, P.C. (2006). Pteridophyta. S. Chand & Company Pvt. Ltd.

Course: UG-H-BOT-CC-T-06 & UG-H-BOT-CC-P-06

Course title: Diversity of Gymnosperms and Palaeobotany

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- determine the concept of progymnosperms and its significance in plant evolutionary history
- describe general characteristics of gymnospermous plant group with special reference to their classification, morphology, reproduction, distribution, and ecology;
- explain their role in environment, and their economic importance;
- apply this knowledge in understanding their evolutionary significance;
- describe primordial life forms and their evolution through geological ages;
- explain the rate of diversification and extinction of plant species;
- determine the age of sediments and fossils;
- translate plant fossil evidences to continental drift and plate tectonic theory.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-06:

Unit 1: Progymnosperms and General account of Gymnosperms (4)

Development of Progymnosperm concept; Diagnostic features of Progymnospermophyta; General characteristics of Gymnosperms.

Unit 2: Classification of Gymnosperms (4)

Classification of vascular plants by Gifford and Foster (1989) with diagnostic features and examples (from division Pteridospermophyta to Gnetophyta)**.**

Unit 3: Type Studies of Gymnosperms (12)

Systematic position, vegetative and reproductive morphology of sporophyte, wood anatomy, development of gametophyte, and embryogeny of *Cycas, Pinus, Ginkgo, Ephedra, Gnetum*; Indian distribution of each taxa.

Unit 4: Origin and Evolution of Gymnosperms (8)

Origin and evolution of seed habit; Structural features, geological and geographical distribution, evolutionary trends in reconstructed genera *Lyginopteris*, *Williamsonia*, *Cordaites.*

Unit 5: Importance of Gymnosperms (2)
Ecological and economic importance of gymnosperms.
Unit 6: Introduction to Palaeobotany (4)
Definition of Palaeobotany and Fossil; Uses of fossils.
Unit 7: Plant fossil & their age determination (12)
Rocks containing plant fossils; Environments for fossilization; Modes of preservation (after James M. Schopf, 1975); Perfection of preservation; Geological ages in time scale; Radiometric dating method for age determination of fossil with special reference to radiocarbon dating.
Unit 8: Study of plant fossil records (4)
Common form of evidences used in reconstruction of plant fossils with examples; Nomenclature of plant fossils and their problems; Appearance of major plant groups through geological ages as evidenced from plant fossil records.
Unit 9: Evolutionary theories, mass extinction and the plant fossil record (5)
Evolutionary theories- Phyletic gradualism and Punctuated equilibrium; Patterns of evolutionary change in the plant fossil records; Definition of mass extinction and five big mass extinction events in Earth's history; Causes of no mass extinction in the plant fossil records.
Unit 10: Gondwana land and plant fossil (*Glossopteris*) (5)
Concept of Gondwana land and their geological and geographical distributions; Brief idea of *Glossopteris* plant and its importance in establishing existence of Gondwana land; A brief account of three-fold classification of Indian Gondwana system and major megafossil assemblages.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-06:

Gymnosperms
Cycas- Morphology (coralloid root, 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).
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 and radial longitudinal sections stem (permanent slide).
Gnetum- Morphology (stem, male and female cones), transverse section of stem, vertical section of ovule (permanent slide).
Ephedra- Morphology (stem, male and female cones), transverse section of stem, vertical section of ovule (permanent slide).

Palaeobotany
Study of external and internal morphology of fossils as representative of major plant groups through geological ages (*Rhynia*- t.s. of stem, *Lepidodendron*- t.s. of stem, *Calamites*- t.s. of stem, *Glossopteris*-leaf, *Ptilophyllum*- leaf, *Cordaites*- leaf, *Lyginopteris*- t.s. of stem, *Williamsonia*- fructification, any angiosperm leaf (from available specimens or photographs)

SUGGESTED READINGS/ REFERENCES:

Gymnosperms

1. Bhatnagar, S.P. and Moitra, A. (1997). Gymnosperm, New Age International.
2. Biswas, C. and Johri, P.M. (1997). The Gymnosperm, Narosa Publishing House.
3. Dutta, S.C. (1984). An Introduction to Gymnosperms (3rd ed.), Kalyani Publishers.
4. Friedman, W.E. (1996). Biology and Evolution of the Gnetales, University of Chicago Press.
5. Gifford, E.M. and Foster, A.S. (1989). Morphology and Evolution of Vascular Plants (3rd ed.), Freeman and Co.
6. Norstag, J. and Nicholls. T.J. (1997). The Biology of the Cycads, Cornell University Press.
7. Sporne, K.R. (1965). The Morphology of Gymnosperms, Hutchinson and Co. Ltd.
8. Vashishta, P.C. (2006). Gymnosperm, S. Chand and Company Pvt.

Palaeobotany

1. Agashe S.N. (1997). Paleobotany: Plants of the Past, Their Evolution, Paleoenvironment and Application in Exploration of Fossil Fuels. Science Publishers, U.S.
2. Andrews, H.N. (1961). Studies in Palaeobotany, John Wiley and Sons.
3. Gifford Ernest M. & Foster Adriance S. (1989). Morphology and Evolution of vascular plants. 3rd edn. New York: Freeman Publ.
4. Meyen, S.V. (1987). Fundamentals of Palaeobotany, Chapman and Hill.
5. Stewart W. N. & Rothwell G. W. (1993). Palaeobotany and the evolution of plants. 2nd edn. Cambridge: Cambridge University Press.
6. Taylor Thomas N., Taylor Edith L. & Krings Michael. (2009). Palaeobotany: The biology and Evolution of fossil plants. 2nd edn. Elsevier Publication.
7. Thomas, B.A. and Spicer, R.A. (1987). The Evolution and Palaeobotany of Land Plants, Croomhelm.
8. Willis K. J. and McElwain J. C. (2002). The evolution of plants. 1st edn. New York: Oxford University Press.

Course: UG-H-BOT-CC-T-07 & UG-H-BOT-CC-P-07

Course title: Reproductive Biology of Plants

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- explain the process of pollination and fertilization in flowering plants;
- apply the knowledge gained to comprehend self-incompatibility in plants and apply methods to overcome it;
- describe embryo development and seed formation.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-07:

Unit 1: Introduction **(4)**

History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and scope.

Unit 2: Reproductive development (6)

Induction of flowering; flower as a modified determinate shoot. Flower development: genetic and molecular aspects.

Unit 3: Anther and pollen biology (10)

Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; male germ unit (MGU) structure; Characteristics of pollen grains - polarity, symmetry, shape, size; Abnormal features: Pseudomonads, polyads, massulae, pollinia; NPC system; Pollen wall structure (sporoderm stratification), Pollen wall proteins; Pollen viability, storage and germination; Definition of Palynology and its scope with special reference to Aeropalynology, Forensic Palynology, and Melissopalynology

Unit 4: Ovule (10)

Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte – megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac.

Unit 4: Pollination and fertilization (6)

Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization.

Unit 5: Self incompatibility (10)

Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intra-ovarian and *in vitro* pollination; Modification of stigma surface, parasexual hybridization; Cybrids, *in vitro* fertilization.

Unit 6: Embryo, Endosperm and Seed (10)

Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in *Paeonia*. Seed structure, importance and dispersal mechanisms

Units 7: Polyembryony and Apomixis (4)

Introduction; Classification; Causes and applications.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-07:

1. **Anther:** Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
2. **Pollen grains:** Fresh and acetolyzed showing ornamentation and aperture, psuedomonads, polyads, pollinia (slides/photographs, fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test; Calculation of percentage germination in different media using hanging drop method.
3. **Ovule:** Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).
4. **Female gametophyte through permanent slides/ photographs:** Types, ultrastructure of mature egg apparatus.
5. **Pollination:** Intra-ovarian pollination; Test tube pollination through photographs.

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

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

SUGGESTED READINGS/ REFERENCES:

1. Bhattacharya, K., Majumdar, M.R. & Gupta Bhattacharya, S. (2006). A Text Book of Palynology, New Central Book Agency.
2. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition. Vikas Publishing House
3. Erdtman, G. (1986). Pollen Morphology and Plant Taxonomy, Latest Ed., Lelden, E.G. Brill
4. Faegri, K. and Iversen, J. (1964). Text Book of Pollen Analysis, Munksgor, Copenhagen
5. Heslop- Harisson (1971). Pollen: Development and Physiology, Butterworth
6. Johri, B.M. (ed.). (1982). Experimental Embryology of Vascular Plants, Springer, Heidelberg.
7. Johri, B.M. (Ed.) (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.
8. Maheswari, P. (2012). An Introduction to Embryology of Angiosperm, Tata McGraw Hill.
9. Nair, P.K. K. (1970). Pollen Morphology of Angiosperms, Latest Ed., Scholar Publications
10. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
11. Raghavan, V. (1986). Embryogenesis in Angiosperms: A Development & Experimental Study, 1986, Cambridge University Press.
12. Raghavan, V. (1997). Molecular Embryology of Flowering Plants, Camb. University Press.
13. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
14. Westhaff, P. et al. (1998). Molecular Plant Development; From Gene to plant, Oxford University Press.

Course: UG-H-BOT-GE-T-03 & UG-H-BOT-GE-P-03

Course title: Plant Cell, Anatomy and Embryology

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- identify, describe and differentiate plant cells and cell organelles and their functions;
- apply plant anatomical features for correct identification;
- explain the developmental patterns of both vegetative and reproductive organs of plants;
- apply the knowledge gained in taxonomical studies and evolutionary biology and ontogeny studies;
- analyse and comprehend wood structure.
- apply knowledge about embryological characters in explaining plant reproductive biology.

COURSE CONTENT (THEORY) - UG-H-BOT-GE-T-03:

Plant Cell

Unit 1: Cell as a unit of life (2)

The cell theory, Prokaryotic and Eukaryotic cells.

Unit 2: Cell organelles (8)

Membrane bound: Mitochondrion: Structure, semiautonomous nature, mitochondrial DNA; Chloroplast: Structure, semiautonomous nature, chloroplast DNA; Endoplasmic Reticulum (ER), Golgi body, Lysosome (structure and role); Peroxisome and Glyoxisome (structure, composition and function), Nucleus; Non-membrane bound: Ribosome (brief structure and function).

Unit 3: Cell membrane and Cell wall (4)

Structure and function of membranes, fluidity of membrane; Cell wall, structure and function (in brief).

Unit 4: Cell cycle (2)

Overview of cell cycle, Mitosis and Meiosis.

Unit 5: Genetic material and protein synthesis (4)

DNA : structure, types, replication: protein synthesis (brief idea).

Anatomy

Unit 6: Meristematic tissues, permanent tissues and organs (8)

Root and shoot apical meristems; simple and complex tissues; structure of dicot and monocot root, stem and leaf.

Unit 7: Secondary growth, adaptive and protective systems (8)

Vascular cambium – structure and functions, seasonal activities, secondary growth in root and stem; wood (heartwood and sapwood).

Embryology

Unit 8: Structural organization of flower (8)

Structure of anther and pollen grains; structure and type of ovules; type of embryo sacs, organization and ultrastructure of mature embryo sac.

Unit 9: Pollination and fertilization (6)

Pollination: types, mechanisms and adaptations; Double fertilization; Structure of typical monocotyledonous and dicotyledonous seeds.

Unit 10: Embryo and endosperm (6)

Endosperm types, structure and functions; Dicot and monocot embryo; Embryo- endosperm relationship.

Unit 11: Apomixis and polyembryony (4)

Definition, types and practical applications.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-GE-P-03:

Plant Cell

1. To study prokaryotic cells (bacterial), viruses, eukaryotic cells with the help of light and electron micrographs.
2. Study of the photomicrographs of cell organelles.
3. Study the structure of plant cells through temporary mounts.
4. Study of mitosis and meiosis (temporary mounts and permanent slides).
5. Study of plasmolysis and deplasmolysis on *Rhoeo* leaf.
6. Measurement of cell size by micrometry (either length or breadth/diameter).

Anatomy

7. Study of meristems through permanent slides and photographs.
8. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (permanent slides, photographs).
9. Stem: Monocot (*Zea mays*); Dicot (*Helianthus*) Secondary: *Helianthus* (only permanent slides).
10. Root: Monocot (*Zea mays*); Dicot (*Helianthus*); Secondary: *Helianthus* (only permanent slides).
11. Leaf: Dicot and Monocot leaf (only permanent slides)

Embryology

12. Structure of young and mature anther (permanent slides).
13. Types of ovules: anatropous, orthotropous, circinotropous/ amphitropous/ campylotropous (from permanent slides).
14. Female gametophyte: *Polygonum* (monosporic), type of embryo sac development (permanent slides/photographs).
15. Dissection of embryo/endosperm from developing seeds.
16. Determination of germination percentage of pollen grains.

SUGGESTED READINGS/ REFERENCES:

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi, 5th edition.
2. Karp, G. (2010). Cell and Molecular Biology. Concepts and Experiments, 6th Edition. John Wiley and Sons, Inc.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/ Cummings Publisher, USA.
4. Pandey, B.P. (2001). Plant Anatomy. S. Chand and Company Ltd., New Delhi.

Course: UG-H-BOT-SEC-T-01

Course title: A. Biofertilizers

Core Course; Credit – 2; Full Points – 50

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- elucidate different types of fertilizers using biological organisms;
- apply the knowledge gained in utilization of biofertilizers in organic farming.

COURSE CONTENT (THEORY) - UG-BOT-SEC-T-01:

Unit 1: (4)

General account about the microbes used as biofertilizer – *Rhizobium* – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.

Unit 2: (8)

Azospirillum: isolation and mass multiplication – carrier based inoculants, associative effect

of different microorganisms. *Azotobacter*: classification, characteristics – crop response to *Azotobacter* inoculum, maintenance and mass multiplication.

Unit 3: (4)

Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.

Unit 4: (8)

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of AM – isolation and inoculum production of AM, and its influence on growth and yield of crop plants.

Unit 5: (6)

Organic farming – Green manuring and organic fertilizers, recycling of biodegradable municipal, agricultural and industrial wastes – biocompost making methods, types and method of vermicomposting – field application.

SUGGESTED READINGS/ REFERENCES:

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

Course: UG-H-BOT-SEC-T-01

Course title: B. Plant Diversity and Human Welfare

Core Course; Credit – 2; Full Points – 50

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- explain the concept and value of biodiversity, threats to biodiversity, need for conservation and environmental stewardship;
- apply and implement conservation strategies for biodiversity management.

COURSE CONTENT (THEORY) - UG-H-BOT-SEC-T-01:

Unit 1: Plant diversity and its scope (8)

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.

Unit 2: Loss and Management of Biodiversity (8)

Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss, Management of Plant Biodiversity:

Organizations associated with biodiversity management- Methodology for execution- IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management and communication.

Unit 3: Conservation of Biodiversity: (8)

Conservation of genetic diversity, species diversity and ecosystem diversity, *In situ* and *ex situ* conservation, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development.

Unit 4: Role of plants in relation to Human Welfare (6)

a) Importance of forestry their utilization and commercial aspects, b) Avenue trees, c) Ornamental plants of India, d) Alcoholic beverages through ages. Fruits and nuts: Important fruit crops their commercial importance. Wood and its uses.

SUGGESTED READINGS/ REFERENCES:

1. Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.

Course: UG-H-BOT-SEC-T-01

Course title: C. Floriculture

Core Course; Credit – 2; Full Points – 50

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- apply the assimilated knowledge and skills in production, processing, and distribution of flowers, cut flowers, foliage, and related plant materials;
- prescribe best management practices in field and greenhouse production of flowers and related plant materials and the arrangement of plant materials for ornamental purposes.

COURSE CONTENT (THEORY) - UG-H-BOT-SEC-T-01:

Unit 1: (2)

Introduction: History of gardening; Importance and scope of floriculture and landscape gardening.

Unit 2: (8)

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.

Unit 3: (4)

Ornamental Plants: 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.

Unit 4: (4)

Principles of Garden Designs: 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.

Unit 5: **(4)**

Landscaping Places of Public Importance: Landscaping highways and Educational institutions.

Unit 6: **(6)**

Commercial Floriculture: 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, Lilium, Orchids).

Unit 7: **(2)**

Diseases and Pests of Ornamental Plants.

SUGGESTED READINGS/ REFERENCES:

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

SEMESTER-IV

Course: UG-H-BOT-CC-T-08 & UG-BOT-CC-P-08

Course title: Taxonomy of Angiosperms and Plant Systematics

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- classify the plant Kingdom;
- identify and name a plant and fix its rank under any system of classification;
- apply taxonomic treatment using gross morphology ('alpha' taxonomy), cytology, breeding behavior and barriers ('omega' taxonomy);
- apply mathematical techniques to assess similarities and disparities by means of diagrams and mathematical coefficients (numerical taxonomy);
- postulate evolutionary pathways, links and trace phyletic lines;
- find different germplasms, new distributional records and new taxa through taxonomic practice;
- contribute to plant resource documentation (herbarium technique) for identification and description of changing patterns of floristic components of an area.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-08:

Unit 1: Significance of plant systematics (10)

Introduction to systematics; Plant identification, Classification (Artificial, Natural, Phylogenetic and Modern systems), Nomenclature. Taxonomy and its phases (Pioneer, Consolidation, Biosystematic and Encylopaedic; alpha- and omega-taxonomy. Evidences from palynology, cytology, phytochemistry and molecular data. Field inventory (Data sources in Taxonomy); 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. Application of plant taxonomy in ecological and natural hybridization studies.

Unit 2: Taxonomic hierarchy (4)

Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary).

Unit 3: Botanical nomenclature (8)

Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Unit 4: Systems of classification (10)

Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Outline of classification systems of Bentham and Hooker (1862-1883) (up to series) and Cronquist (1988); Brief reference of Angiosperm Phylogeny Group (APG III) classification.

Unit 5: Biometrics, numerical taxonomy and cladistics (4)

Characters; Variations; OTUs; Cluster analysis; Phenograms, cladograms (definitions and differences).

Unit 6: Phylogeny of Angiosperms (6)

Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, paraphyly, polyphyly and clades). Origin and evolution of angiosperms.

Unit 7: Diagnostic features, Systematic position (Bentham and Hooker, and Cronquist), Economically important plants (parts used and uses) of the following families (18)

Monocotyledons: Alismataceae, Poaceae, Arecaceae, Zingiberaceae, Orchidaceae.

Dicotyledons: Nymphaeceae, Ranunculaceae, Magnoliaceae, Leguminosae (subfamilies), Euphorbiaceae, Malvaceae, Lamiaceae, Solanaceae, Acanthaceae, Rubiaceae, Cucurbitaceae, Asteraceae.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-08:

1. Study of vegetative and floral characters of the following families according to Bentham & Hooker's system of classification:
   Dicotyledons: Leguminosae (subfamilies- Papilionoidae and Caesalpinioidae), Euphorbiaceae, Malvaceae, Solanaceae, Lamiaceae, Acanthaceae, Rubiaceae, Asteraceae
   Monocotyledons: Poaceae
   Construction of dichotomous keys (indented/bracketed) for the genera.
2. Spot identification (Binomial, Family) of common wild plants from families included in Theoretical syllabus.
3. Field visit (2 local and 1 to different phytogeographic zone). Among the two local field visits one should be at Acharya Jagadish Chandra Bose Indian Botanic Garden, Shibpur, Howrah and Central National Herbarium (CNH).
4. Submission of properly preserved herbarium specimens of at least 25 common wild plants with herbarium label, proper field record and notes. The herbarium specimens should be submitted during End Term Examination and to be arranged following Bentham & Hooker's system of classification.

SUGGESTED READINGS/ REFERENCES:

1. Heywood, V.H. (1993) Flowering Plants of the World. Oxford University Press.
2. Hutchinson, J. (1959) Key to the families of flowering plants of the world. Oxford.
3. Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press.
4. 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
5. Lawrence, G.H.M. (1952) Taxonomy of Vascular Plants. The Macmillan Company, New York, USA.
6. Mabberley, D.J. (2017). Mabberley's Plant Book: A Portable Dictionary of Plants, their Classification and Uses. Cambridge University Press, UK. 4th Edition.
7. Prain, D. (1905) Bengal Plants I & II. Bishen Singh Mahendra Pal Singh, Dehradun, India
8. Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York
9. Simpson, M.G. (2010) Plant Systematics. Academic Press, USA.
10. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition

Course: UG-H-BOT-CC-T-09 & UG-BOT-CC-P-09

Course title: Plant Ecology and Phytogeography

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- elucidate the interactions between biotic and abiotic constituents of the ecosystems;
- explain interactions at inter and intra-specific levels and at different trophic levels;
- analyse and describe on community structures of different biomes;
- describe the dynamics of ecosystems.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-09:

Unit 1: Introduction (4)

Basic concepts; Levels of organization. Inter-relationships between the living world and the environment, the components and dynamism, homeostasis.

Unit 2: Soil (8)

Importance; Origin; Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development.

Unit 3: Water (4)

Importance: States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water in soil; Water table.

Unit 4: Light, temperature, wind and fire (6)

Variations; adaptations of plants to their variation.

Unit 5: Biotic interactions (2)

Trophic organization, basic source of energy, autotrophy, heterotrophy; symbiosis, commensalism, parasitism; food chains and webs; ecological pyramids; biomass, standing crop.

Unit 6: Population ecology (4)

Characteristics and Dynamics; Ecological Speciation.

Unit 7: Plant communities (8)

Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.

Unit 8: Ecosystems (4)

Structure; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids.

Unit 9: Functional aspects of ecosystem (8)

Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.

Unit 10: Phytogeography (12)

Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division of India; Local vegetation.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-09:

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 (using pH meter and pH paper).
3. Comparison of physical characteristics (temperature, colour and texture) and water holding capacity of two soil samples.
4. Comparison of chemical characteristics of two soil samples (carbonate content, nitrate content and base deficiency) by rapid field tests.
5. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
6. Study of morphological adaptations of hydrophytes and xerophytes (two each).
7. Determination of minimum quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
8. Determination of minimum quadrat number for the study of herbaceous vegetation in the college campus.
9. Field visit to familiarise students with ecology of different sites.

SUGGESTED READINGS/ REFERENCES:

1. Chapman, J.L. and M. J. Reiss (2005). Ecology: Principles and Applications. Second Edition. Cambridge University Press.
2. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.
3. Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5th edition.
4. Schulze, E.D., Beck, E. and Muller-Hohenstein, K. (2005). Plant Ecology. Springer Publication.
5. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
6. Stiling, P. (2002). Ecology: Theories and Applications. Fourth Edition. Prentice-Hall, Inc.
7. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.

Course: UG-H-BOT-CC-T-10 & UG-H-BOT-CC-P-10

Course title: Economic Botany and Pharmacognosy

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- identify the plant parts of economic importance and their uses;
- identify the medicinal plants from the pharmacognostic preparations;
- distinguish between the adulterants and authentic pharmacognostic preparations;
- elucidate the chemical constituents of medicinal plants.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-10:

Unit 1: Origin of Cultivated Plants (4)

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.

Unit 2: Cereals (4)

Rice and Wheat (origin, morphology, processing and uses); Brief account of millets.

Unit 3: Legumes (4)

Origin, morphology and uses of Chick pea, Pigeon pea and fodder legumes. Importance to man and ecosystem.

Unit 4: Sources of sugars and starches (4)

Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation and uses.

Unit 5: Spices and Condiments (6)

General description of important spices, their families, part used and economic importance with special reference to coriander, cumin, fennel, saffron, cardamom, clove and black pepper.

Unit 6: Beverages (2)

Tea, Coffee and Cacao (morphology, processing & uses)

Unit 7: Sources of oils and fats (8)

General description, classification, extraction, their uses and health implications safflower, linseed, soybean, mustard and coconut (botanical name, family and uses). Essential Oils: General account, extraction methods, comparison with fatty oils and their uses.

Unit 8: Natural Rubber (2)

Para-rubber: tapping, processing and uses.

Unit 10: Timber plants (2)

General account with special reference to teak/ sissoo and pine.

Unit 11: Fibers (3)

Classification based on the origin of fibers; Cotton, Coir and Jute (morphology, extraction and uses).

Unit 12: Pharmacognosy (6)

Introduction (Definition; Drug – Crude and commercial); Preparation of drugs; Organoleptic study of drugs; Physical and chemical evaluation of drugs; Classification of drug plants; Individual drugs; drug adulteration; constituents.

Unit 13: Study of following drug plants (Botanical name with family, source, short description, histology, constituents, uses, adulterants) (15)

Swertia chirata, *Andrographis paniculata*, *Justicia adhatoda*, *Aloe barbedensis, Centella asiatica, Ephedra gerardiana, Zingiber officinale, Rauvolfia serpentina, Alstonia scholaris, Mentha piperita, Dioscorea alata, Aconitum heterophyllum, Atropa belladonna, Hemidesmus indicus, Withania somnifera.*

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-10:

1. **Cereals**: Rice/Wheat (habit sketch, L.S./T.S. grain, starch grains, micro-chemical tests).
2. **Legumes**: Soybean, Gram (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, whole mount of starch grains, micro-chemical tests).

4. **Spices:** Black pepper, Fennel and Clove (habit and sections).
5. **Beverages**: Tea (plant specimen/tea leaves), Coffee (plant specimen/beans).
6. **Sources of oils and fats**: Coconut- T.S. nut, Mustard–plant specimen, seeds; tests for fats in crushed seeds.
7. **Essential oil-yielding plants**: Habit sketch of *Rosa*, *Vetiveria/ Cymbopogon* and *Eucalyptus* (specimens/ photographs).
8. **Rubber**: specimen, photograph/model of tapping, samples of rubber products.
11. **Woods:** *Tectona/ Dalbergia, Pinus*: Herbarium and wood 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).

Pharmacognosy:

Specimens of *Rauvolfia, Zingiber, Alstonia* for following examinations-

1. Study of drug plants - Microscopical preparation, Stomatal Index, Vein-islet number, Palisade ratio, Fibres, Vessels.
2. Study of powdered drugs – Morphological observations and identification of tissue elements.

SUGGESTED READINGS/ REFERENCES:

1. Chrispeels, M.J. and Sadava, D.E. (1994). Plants, Genes and Agriculture. Jones & Bartlett.
2. Gangulee, H.C., Kar, A.K. (2011). College Botany, Vol. II. New Central Book Agency (P) Ltd., Kolkata, India.
3. Kochhar, S.L. (2017). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
4. Mitra, D, Guha, J. Chowdhuri, S.K. (2009). Studies in Botany, Vol. II. Moulik Library, Kolkata, India.
5. Ramstad, E. (1959). Modern Pharmacognosy. The Blakiston Division. McGraw-Hill Book Co. New York, USA.
6. Trease, G.E. and Evans, W.C. (1983). Pharmacognosy. Bailliere, Tindall, London, UK.
7. Wickens, G.E. (2001). Economic Botany: Principles and Practices. Kluwer Academic Publishers, The Netherlands.

Course: UG-H-BOT-GE-T-04 & UG-H-BOT-GE-P-04

Course title: Plant Physiology and Metabolism

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- explain plant water relations and elucidate mineral nutrients that plants require, how they are obtained, metabolized and transported;
- describe physiological details of photosynthesis and respiration in plants;
- describe enzymes, hormones, environmental responses and nitrogen metabolism required for plant growth and development.

COURSE CONTENT (THEORY) - UG-H-BOT-GE-T-04:

Unit 1: Plant-water relations (8)

Properties of water and its role in cells, osmosis, absorption of water by roots, Transpiration (mechanisms) and its significance.

Unit 2: Mineral nutrition (8)

Concept of Essential elements, macro and micronutrients; Physiological Role of essential elements; Movement of solutes through conducting tissues active and passive transport, carriers, channels and pumps.

Unit 3: Translocation in phloem. (6)

Concept of phloem, composition; Pressure flow model; Phloem loading and unloading, source – sink concept.

Unit 4: Photosynthesis (12)

Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C_3, C_4 and CAM pathways of carbon fixation; Photorespiration.

Unit 5: Respiration (6)

Aerobic and anaerobic respiration, Glycolysis, and TCA cycle; Oxidative phosphorylation, ATP synthesis and its balance sheet. Oxidative Pentose Phosphate Pathway, significance.

Unit 6: Enzymes (4)

Structure and properties; Mechanism of enzyme catalysis, coenzymes, co-factors, effects of temperature and pH.

Unit 7: Nitrogen metabolism (4)

Biological nitrogen fixation; nitrate and ammonia assimilation.

Unit 8: Plant growth regulators (6)

Properties of plant growth regulators and function: auxins, gibberellins, cytokinins, ABA, ethylene.

Unit 9: Plant response to light and temperature (6)

Definition of Photoperiodism, types, (SDP, LDP, Day neutral plants); Phytochrome: structure and function red and far red light responses on photomorphogenesis; Vernalization.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-GE-P-04:

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Effect of two environmental factors (light and humidity) on transpiration by excised twig.
3. Determination of stomatal index and stomatal frequency.
4. Effect of bicarbonate concentration on O_2 evolution in photosynthesis.
7. Comparison of the rate of respiration in different plant parts.
8. Separation of amino acids by paper chromatography.

Demonstration experiments

1. Effect of IAA on rooting.
2. Demonstration of suction due to transpiration.
3. Demonstration of R.Q. in germinating seeds.

SUGGESTED READINGS/ REFERENCES:

1. Gangulee, H.C., Das, K. S., Datta, C. (2011). College Botany, Vol. I. New Central Book Agency (P) Ltd, Kolkata, India

2. Mitra, D, Guha, J. Chowdhuri, S.K. (2009). Studies in Botany, Vol. II. Moulik Library, Kolkata, India.
3. Mukherjee, S. and A.K. Ghosh (2009). Plant Physiology (2nd Edition), New Central Book Agency.
4. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.

Course: UG-H-BOT-SEC-T-02

Course title: A. Medicinal Botany

Core Course; Credit – 2; Full Points – 50

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- discuss the history, scope and importance of plants as sources of medicines;
- describe methods for sustainable utilization of plant herbal resources;
- apply the knowledge gained in utilising plants used as traditional/ folk medicines and strategise their conservation.

COURSE CONTENT (THEORY) - UG-H-BOT-SEC-T-02:

Unit 1: (10)

History, Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences; Definition and Scope - Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridosha concepts, Rasayana, plants used in ayurvedic treatments, Siddha: Origin of Siddha medicinal systems, Basis of Siddha system, plants used in Siddha medicine. Unani: History, concept: Umoor-e- tabiya, tumors treatments/ therapy, polyherbal formulations.

Unit 2: (10)

Conservation of endangered and endemic medicinal plants. Definition: endemic and endangered medicinal plants, Red list criteria; *In situ* conservation: Biosphere reserves, sacred groves, National Parks; *Ex situ* conservation: Botanic Gardens, Ethnomedicinal plant Gardens. Propagation of Medicinal Plants: Objectives of the nursery, its classification, important components of a nursery, sowing, pricking, use of green house for nursery production, propagation through cuttings, layering, grafting and budding.

Unit 3: (10)

Ethnobotany and Folk medicines. Definition; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany. Folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases.

SUGGESTED READINGS/ REFERENCES:

1. Purohit, S.S. and Vyas, S.P. (2008). Medicinal Plant Cultivation: A Scientific Approach, 2nd edn. Agrobios, India.
2. Trivedi P.C. (2006). Medicinal Plants: Ethnobotanical Approach, Agrobios, India.

Course: UG-H-BOT-SEC-T-02

Course title: B. Mushroom Culture

Core Course; Credit – 2; Full Points – 50

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- describe nutritional and medicinal values of edible mushrooms and their cultivation strategies;
- apply the knowledge gained in storage and food preparation.

COURSE CONTENT (THEORY) - UG-H-BOT-SEC-T-02:

Unit 1: Introduction, history. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India - *Volvariella volvacea, Pleurotus citrinopileatus, Agaricus bisporus*. **(5)**

Unit 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, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation - Low cost technology, Composting technology in mushroom production. **(12)**

Unit 3: Storage and nutrition: Short-term storage (Refrigeration – up to 24 hours) Long term Storage (canning, pickles, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins. **(8)**

Unit 4: 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. **(5)**

SUGGESTED READINGS/ REFERENCES:

1. Bahl, N. (1984-1988). Hand book of Mushrooms, II Edition, Vol. I & Vol. II.
2. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991). 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, P. and Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.

Course: UG-H-BOT-SEC-T-02

Course title: C. Intellectual Property Rights

Core Course; Credit – 2; Full Points – 50

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- identify different types of Intellectual Properties (IPs), right of ownership, scope of protection of IP and ways to create and extract value from IP;
- recognize the role of IP in different sectors for promoting product and technology development;
- identify activities that constitute IP infringements and the remedies available to the IP owner and describe the steps to be taken to prevent infringement of such rights in products and technology development;
- discuss the processes and various approaches of Intellectual Property Management (IPM).

COURSE CONTENT (THEORY) - UG-H-BOT-SEC-T-02:

Unit 1: Introduction to intellectual property rights (IPR) (2)
Concept and kinds. Economic importance. IPR in India and World. Genesis and scope, some important examples. IPR and WTO (TRIPS, WIPO).

Unit 2: Patents (3)
Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents. Infringement.

Unit 3: Copyrights (3)
Introduction, works protected under copyright law, rights, transfer of copyright, infringement.

Unit 4: Trademarks (3)
Objectives, types, rights, protection of goodwill, infringement, passing off, defences, domain name.

Unit 5: Geographical Indications (3)
Objectives, justification, international position, multilateral treaties, national level, Indian position.

Unit 6: Protection of Traditional Knowledge (4)
Objective, concept of traditional knowledge, holders, issues concerning, bio-prospecting and bio-piracy, alternative ways, protectability, need for a *Sui-Generis* regime, traditional knowledge on the International arena, at WTO, at national level, Traditional Knowledge Digital Library.

Unit 7: Industrial Designs (2)
Objectives, rights, assignments, infringements, defences of design Infringement.

Unit 8: Protection of Plant Varieties (2)
Plant Varieties Protection- objectives, justification, International position, Plant varieties protection in India. Rights of farmers, breeders and researchers. National gene bank, benefit sharing. Protection of Plant Varieties and Farmers' Rights Act, 2001.

Unit 9: Information Technology related Intellectual Property Rights (4)
Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection.

Unit 10: Biotechnology and Intellectual Property Rights (4)
Patenting Biotech Inventions: objective, applications, concept of novelty, concept of inventive step, microorganisms, moral issues in patenting biotechnological inventions.

SUGGESTED READINGS/ REFERENCES:

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

SEMESTER-V

Course: UG-H-BOT-CC-T-11 & UG-H-BOT-CC-P-11

Course title: Plant Physiology

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- discuss plant water relations, i.e. how plants acquire, utilize, and regulate the flow of water between plant and environment;
- outline the mineral nutrients plants require, and how they are obtained, metabolized, transported and their role in plants;
- explain how plant growth regulators regulate the growth and development in plants;
- describe physiology of flowering, light responses and seed dormancy in plants.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-11:

Unit 1: Plant-water relations (10)

Water in plant life, diffusion, osmosis, imbibitions, water potential and its components; Water absorption by roots, aquaporins, pathways of water movement, symplast, apoplast, transmembrane pathways, root pressure; Ascent of sap-cohesion-tension theory; Transpiration, factors affecting transpiration, antitranspirants, mechanism of stomatal movement, Guttation.

Unit 2: Mineral nutrition (6)

Essential and beneficial elements, macro and micronutrients; Techniques used in nutritional studies and use of nutrient solutions; Criteria of essentiality, Roles of essential elements; Mineral deficiency symptoms.

Unit 3: Nutrient Uptake (8)

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.

Unit 4: Translocation in the phloem (8)

Pathways of translocation, experimental evidence, Phloem sap, P-protein; Mass flow and Pressure-Flow Model; Phloem loading and unloading; Source-sink relationship.

Unit 5: Plant growth regulators (12)

Auxins - Discovery, chemical nature (natural and synthetic), biosynthesis of IAA, bioassay and physiological roles of auxins; Gibberellin, Cytokinin, Abscisic acid and Ethylene - Discovery, chemical nature (natural and synthetic), bioassay and physiological roles; Brassinosteroids and Jasmonic acid-Discovery, chemical nature (natural and synthetic) and physiological roles.

Unit 6: Physiology of flowering (6)

Classification of plants based on photoperiod responses, critical day length, concept of night length monitoring; Perception of flowering stimulus; Florigen concept; role of Flowering Locus T; Vernalization- Role of cold temperature in flowering.

Unit 7: Phytochrome, crytochromes and phototropins (6)

Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.

Unit 8: Seed dormancy **(4)**

Types, factors causing dormancy, breaking down and significance of seed dormancy.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-11:

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weighing method.
3. Determination of stomatal frequency and loss of water per stoma per hour.
4. Effect of humidity and light on the rate of transpiration in excised twig/ leaf.
5. Comparison of imbibitions of water by starchy, proteinaceous and fatty seeds.
6. Comparison of germination frequency of two crop seeds and effect of light and dark thereon.

Demonstration experiments

1. Effect of different concentration of IAA on coleoptile elongation.
2. Induction of amylase activity in germinating wheat grains.
3. Demonstration of rooting from cutting.
4. Demonstration of bolting on plants.
5. Determination of viability of seeds by TTC (TZ) test.

SUGGESTED READINGS/ REFERENCES:

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Jones, R., Ougham, H., Thomas, H., and Waaland, S. (2013). The Molecular Life of Plants. John Wiley and Sons. U.K. 1st edition.
3. Salisbury, F. B. and Ross, C. W. (1992). Plant Physiology. Wordsworth Publishing Company.
4. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A. (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.

Course: UG-H-BOT-CC-T-12 & UG-H-BOT-CC-P-12

Course title: Plant Metabolism

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- describe the concepts of different types of metabolisms and their regulation in plants;
- apply the knowledge gained regarding physiological and biochemical details of photosynthesis and respiration, in how they are organized and regulated in plants.
- discuss bioenergetics in regulation of physico-chemical metabolisms in plants explain the process of signal transduction in plants.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-12:

Unit 1: Concept of metabolism (6)

Introduction, anabolic and catabolic pathways; Regulation of metabolism; Role of regulatory enzymes (allosteric, covalent modulation and Isozymes).

Unit 2: Carbon assimilation (14)

Historical background; Photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres; Photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle; CO_2 reduction: Calvin cycle, photorespiration, C_4 pathways; Crassulacean acid metabolism; Factors affecting CO_2 reduction.

Unit 3: Carbohydrate metabolism (2)

Synthesis and catabolism of sucrose and starch.

Unit 4: Carbon Oxidation (10)

Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate; TCA cycle, amphibolic role, anaplerotic reactions, regulation of the cycle; Mitochondrial electron transport, oxidative phosphorylation; Cyanide-resistant respiration; Factors affecting respiration.

Unit 5: ATP-Synthesis (8)

Mechanism of ATP synthesis; Substrate level phosphorylation: chemiosmotic mechanism (oxidative and photophosphorylation); ATP synthase, Boyers conformational model, Racker's experiment; Role of uncouplers.

Unit 6: Lipid metabolism (8)

Synthesis and breakdown of triglycerides; β-oxidation of fatty acids; Glyoxylate cycle; Gluconeogenesis.

Unit 7: Nitrogen metabolism (8)

Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.

Unit 8: Mechanisms of signal transduction (4)

Receptor-ligand interactions; Second messenger concept, Role of Calcium calmodulin.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-12:

Detection:

1. Determination of rate of photosynthesis under varying HCO_3 concentration in an aquatic plant and to find out the optimum and toxic condition.
2. Determination of effect of promoter and inhibitor on the rate of aerobic respiration using Ganong's Respiroscope.
3. Determination of the rate of respiration of different plant parts using Ganong's Respiroscope.
4. Determination of RQ of germinating seeds.
5. Estimation of nitrogen/ amino acid by formal titration method (for any amino acid).
6. Estimation of glucose by Benedict's quantitative reagent.
7. Estimation of catalase activity in plant samples.
8. Estimation of urease activity in plant samples.
9. Colorimetric estimation of protein by Folin phenol reagent.

Demonstration Experiment

1. Chemical separation of photosynthetic pigments.

SUGGESTED READINGS/ REFERENCES:

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

Course: UG-H-BOT-DSE-T-01 & UG-H-BOT-DSE-P-01

Course title: A. Analytical Techniques in Plant Science

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- describe various imaging related techniques;
- give an overview of the principle of Spectrophotometry and its application in biological research;
- characterize proteins and nucleic acids;
- analyze statistical data and perform chi-square test for goodness of fit.

COURSE CONTENT (THEORY) - UG-H-BOT-DSE-T-01:

Unit 1: Imaging and related techniques (15)

Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 2: Cell fractionation (8)

Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, $CsCl_2$ gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3: Radioisotopes (4)

Use in biological research, auto-radiography, pulse chase experiment.

Unit 4: Spectrophotometry (4)

Principle and its application in biological research.

Unit 5: Chromatography (8)

Principle; Paper chromatography; Column chromatography, Thin Layer Chromatography (TLC), Gas Liquid Chromatography (GLC), High Performance Liquid Chromatography (HPLC), Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6: Characterization of proteins and nucleic acids (6)

Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: Agarose Gel Electrophoresis, Polyacrylamide Gel Electrophoresis (PAGE), Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis (SDS-PAGE)

Unit 7: Biostatistics (15)

Statistics, data, population, samples, parameters; Representation of Data: Tabular, Graphical; Measures of central tendency: Arithmetic mean, mode, median; Measures of dispersion: Range, mean deviation, variation, standard deviation; Chi-square test for goodness of fit.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-DSE-P-01:

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. Separation of amino acids by paper chromatography.
3. Demonstration of pigment separation by column chromatography.
4. Estimation of protein concentration through Lowry's methods.
5. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
6. Preparation of permanent slides by double staining method (*Helianthus* stem, *Nerium* leaf, Maize root).

SUGGESTED READINGS/ REFERENCES:

1. Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. John Wiley & Sons. 3rd edition.
2. Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd. New Delhi. 3rd edition.
3. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. U.S.A.
4. Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition.

Course: UG-H-BOT-DSE-T-01 & UG-H-BOT-DSE-P-01

Course title: B. Industrial and Environmental Microbiology

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- apply the basics of microbiology to build a foundation for studies in microbiology and use of microbes in industry to manufactures food or products in large quantities;
- introduce microbial processes of environmental and geochemical significance;
- utilise microorganisms as tools in environmental remediation.

COURSE CONTENT (THEORY) - UG-H-BOT-DSE-T-01:

Unit 1: Scope of microbes in industry and environment. (6)

General concepts of industrial and environmental microbiology, principles of exploration of microorganisms of their products; Microbes in different habitats with special reference to extremophiles.

Unit 2: Bioreactors/ Fermenters and fermentation processes. (12)

Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Unit3: Microbial production of industrial products. (12)

Microorganisms involved, Media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of enzymes: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (ethanol) and antibiotic (penicillin).

Unit 4: Microbial enzymes of industrial interest and enzyme immobilization. (8)

Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; Cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase).

Unit 5: Microbes and quality of environment. (6)

Distribution of microbes in air: Isolation of microorganisms from soil, air and water.

Unit 6: Microbial flora of water. (8)

Water pollution, role of microbes in sewage and domestic waste water treatment systems. Determination of BOD, COD, TDS and TOC of water samples; Microorganisms as indicators of water quality, coliform and fecal coliform in water sample.

Unit 7: Microbes in agriculture and remediation of contaminated soils. (8)

Biological fixation: Bioremediation of contaminated soils. Isolation of root nodulating bacteria; Mycorrhizae with special reference to arbuscular mycorrhyzal colonization in plant roots.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-DSE-P-01:

1. Principles and functioning of instruments in microbiological laboratory
2. Hands on sterilization techniques and preparation of culture media (Nutrient broth and Nutrient agar).
3. Preparation of slant, stab and pouring Petriplates.
4. Isolation of lactic acid bacteria from curd.
5. Isolation of *Rhizobium* from root nodules.
6. Isolation of microbes from soil.
7. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

SUGGESTED READINGS/ REFERENCES:

1. Casida, L.E. Jr. (2016). Industrial Microbiology. New Age International, New Delhi.
2. Maier, R.M., Pepper, I.L. and Gerba, C.P. (2009). Environmental Microbiology, 2nd Edition, Academic Press.
3. Patel, A.H. (2016). Industrial Microbiology. 2nd Edition. Laxmi Publications.
4. Pelczar, M.J. Jr., Chan, E.C.S, Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., New Delhi.

5. Tortora, G.J., Funke, B.R., Case, C.L. (2007). Microbiology. 9th edition, Pearson Benjamin Cummings, San Francisco, USA.

Course: UG-H-BOT-DSE-T-02 & UG-H-BOT-DSE-P-02

Course title: B. Stress Biology

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- describe stress sensing and signaling pathways in plants;
- give an overview of reactive oxygen species (ROS) production and plant's antioxidant defense mechanism;
- comprehend developmental and physiological mechanisms of environmental stress adaptation;
- Understand the underlying mechanisms of phytoremediation.

COURSE CONTENT (THEORY) - UG-H-BOT-DSE-T-02:

Unit 1: Defining plant stress (5)

Plant stress, Plant responses to abiotic and biotic stresses- acclimatization and adaptation, Secondary metabolites and plant defense.

Unit 2: Stress factors (15)

Drought; Flooding, Salinity, Temperature, Heavy metals stress and potential biotic stress; Hypersensitive reaction; Pathogenesis– related (PR) proteins; Systemic acquired resistance.

Unit 3: Stress sensing and signaling pathways in plants (10)

Role of Ca^{2+} and mitogen-activated protein kinase (MAPK) in stress sensing and signaling; heat shock proteins (HSPs).

Unit 4: Reactive oxygen species–Production and scavenging mechanisms. (10)

Free radicals chemistry, Oxidative stress, Mitochondria as a source for reactive oxygen species, Enzymatic and non-enzymatic antioxidant defense system (Ascorbate-glutathione cycle or Asada-Halliwell pathway), Oxidative damages to lipids, proteins and DNA.

Unit 5: Developmental & physiological mechanisms to confer environmental stresses (10)

Adaptation in plants; Changes in root: shoot ratio; Flooding stress and aerenchyma development; Osmotic adjustment; Compatible solute production.

Unit 6: Phytoremediation (10)

Bioavailability and accumulation of heavy metals, Naturally occurring plants for Phytoremediation, Brief idea about different mechanisms of Phytoremediation, Transgenic approach of Phytoremediation.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-DSE-P-02:

1. Estimation of tissue proline level.
2. Estimation of peroxidase activity in the seedlings grown in the absence and presence of salt stress.

3. Estimation of superoxide dismutase activity in the seedlings grown in the absence and presence of salt stress.
4. Estimation of catalase activity in the seedlings grown in the absence and presence of salt stress.
5. Acquaintance with important phytoremediating plants.

SUGGESTED READINGS/ REFERENCES:

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A. (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Buchanan, B.B., W. Gruissem, and R.L. Jones (2000). Biochemistry and Molecular Biology of Plants. Wiley-Blackwell-ASPB, Rockville, MD. Sons. U.S.A. 4th edition.

Course: UG-H-BOT-DSE-T-02 & UG-H-BOT-DSE-P-02

Course title: B. Plant Breeding and Biometry

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- get an overview of the hybridization technique;
- explain inbreeding depression and heterosis;
- understand the role of biotechnology in crop improvement;
- analyse statistical data and understand the nature of inheritance.

COURSE CONTENT (THEORY) - UG-H-BOT-DSE-T-02:

Unit 1: Plant breeding (10)

Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.

Unit 2: Methods of crop improvement (10)

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.

Unit 3: Quantitative inheritance (10)

Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings. Monogenic *vs* polygenic inheritance.

Unit 4: Inbreeding depression and heterosis (10)

History, genetic basis of inbreeding depression and heterosis; Applications.

Unit 5: Crop improvement and breeding (10)

Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.

Unit 6: Biometry (10)

Terms and Definition– sample and population, quantitative and qualitative variables, random sampling, frequency distribution, arithmetic mean, mode and median; Measurement of dispersion –standard deviation, coefficient of variation and standard error; Test of significance – Null Hypothesis, X^2-test of goodness of fit, probability; Measurement of gene frequency (Hardy Weinberg hypothesis).

COURSE CONTENT (PRACTICAL) - UG-H-BOT-DSE-P-02:

1. Hybridization technique (anthesis, emasculation, pollination) (Demonstration).
2. Differential pollen stainability following aceto-carmine technique.
3. Analysis of statistical data: Calculation of mean, mode, median, standard deviation and standard error.
4. Determination of goodness of fit in normal and modified mono -and dihybrid ratios by Chi-square analysis and comment on the nature of inheritance.
5. Calculation of correlation coefficient values and finding out the probability

SUGGESTED READINGS/ REFERENCES

1. Acquaah, G. (2007). Principles of Plant Genetics & Breeding. Blackwell Publishing.
2. Bishop, O.N. (1980). Statistics for Biology, Boston, Houghton, Mifflin.
3. Campbell, R.C. (1998). Statistics for Biologists, Cambridge University Press.
4. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding. Oxford – IBH. 2nd edition.
5. Danniel, W.W. (1987). Biostatistic. New York, John Wiley Sons.
6. Freedman, P. (1950). The Principles of scientific research, New York, Pergamon Press.
7. Selvin, S. (1991). Statistical Analysis of epidemiological data, New York University Press.
8. Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7th edition.
9. Sundar Rao, P.S.S. and Richards, J. (1991). An Introduction to Biostatistics, 3rd edition, Christian Medical College, Vellore.

SEMESTER-VI

Course: UG-H-BOT-CC-T-13 & UG-H-BOT-CC-P-13

Course title: Genetics

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- explain Mendel's theory of inheritance;
- understand the *extranuclear* inheritance;
- construct chromosome map;
- comprehend the underlying mechanisms of gene mutation;
- describe DNA replication and protein synthesis.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-13:

Unit 1: Mendelian genetics and its extension (10)

Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and dominant traits; Polygenic inheritance.

Unit 2: Extrachromosomal inheritance (5)

Chloroplast mutation: Variegation in Four o'clock plant (*Mirabilis jalapa*); Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in *Paramecium.*

Unit 3: Linkage, crossing over and chromosome mapping (5)

Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Three-point mapping; Interference and coincidence.

Unit 4: Chromosome and nucleic acids (6)

Physical and Chemical structure of chromosome; DNA packaging (Kornberg's Nucleosome Model); Structure of Nucleic acids - DNA, RNA; Types of DNA (A, B and Z); DNA replication: Evidence for semi-conservative replication (Messelson and Stahl); Mechanism of bi-directional replication in bacteria.

Unit 5: Variation in chromosome number and structure (6)

Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy

Unit 6: Fine structure of gene (4)

Classical *vs* molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus.

Unit 7: Gene mutations (6)

Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: ClB method. Role of Transposons in mutation. DNA repair mechanisms.

Unit 8: Central dogma and genetic code (2)

Central Dogma, Genetic code (deciphering and salient features).

Unit 9: Transcription (9)

Transcription in prokaryotes; Principles of transcriptional regulation: Concept of operon; Structure and mode of control of inducible (lactose operon of *E. coli*) and repressible (tryptophan operon of *E. coli*) operons. Brief idea about eukaryotic transcription.

Unit 10: Translation (4)

Various steps of protein synthesis in prokaryotes.

Unit 11. Population genetics (3)

Allele frequencies, Genotype frequencies; Hardy-Weinberg Law.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-13:

1. Meiosis through temporary smear preparation.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
3. Chromosome mapping using three-point test cross data.
4. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
5. Blood Typing: ABO groups and Rh factor.
6. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.
7. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.

SUGGESTED READINGS/ REFERENCES

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

Course: UG-H-BOT-CC-T-14 & UG-H-BOT-CC-P-14

Course title: Plant Molecular Biology and Biotechnology

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- Explain the principles, technical requirement, scientific and commercial applications of plant tissue and cell culture.
- Understand different gene transfer techniques.
- Exploit the recombinant DNA technology for development of transgenic plants.

COURSE CONTENT (THEORY) - UG-H-BOT-CC-T-14:

Unit 1: Plant tissue culture (**16)**

Historical perspective; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).

Unit 2: Recombinant DNA technology **(12)**

Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).

Unit 3: Gene cloning **(10)**

Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; PCR.

Unit 4: Methods of gene transfer **(8)**

Agrobacterium-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes (Luciferase, GFP).

Unit 5: Applications of biotechnology **(14)**

Pest resistant (Bt-cotton); herbicide resistant plants (Roundup Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-CC-P-14:

1. Demonstration of preparation of MS medium; *in vitro* sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.
2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis and artificial seeds through photographs.
3. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
4. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.
5. Visit to a tissue culture laboratory/ biotechnological park.

SUGGESTED READINGS/ REFERENCES

1. Bhojwani, S. S. and P. K. Danta (2013). Plant tissue Culture: An Introductory Text, Springer.
2. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
3. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier, Science Amsterdam. The Netherlands.

4. Chawla, H.S. (2012). Plant Biotechnology, Oxford IBH.
5. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
6. Ramawat, K.G. (2012). Plant Biotechnology, S. Chand Publication.
7. Singh, B.D. (2012). Plant Biotechnology. Kalyani publisher.
8. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.
9. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.

Course: UG-H-BOT-DSE-T-03 & UG-H-BOT-DSE-P-03

Course title: A. Biodiversity and Conservation

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- demonstrate an advanced understanding of the application of fundamental principles of ecological studies to the conservation of biodiversity;
- discuss and cite theories and case studies as prerequisites for success in sustainable utilization and effective species conservation;
- translate theoretical aspects of contemporary practices to recommendations for environmental management;
- communicate effectively in the form of written reports and spoken presentations.

COURSE CONTENT (THEORY) - UG-H-BOT-DSE-T-03:

Unit 1: Natural resources (2)
Definition, types and distribution.

Unit 2: Sustainable utilization (8)
Concept, approaches (economic, ecological and socio-cultural).

Unit 3: Land (8)
Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation, restoration, conservation and management.

Unit 4: Water (8)
Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies.

Unit 5: Biological Resources (10)
Biodiversity- definition and types; Significance; Threats; Management strategies; Bioprospecting; Intellectual Property Regime (IPR); Convention on Biological Diversity (CBD); National Biodiversity Action Plan.

Unit 6: Forests (6)
Definition, Cover and its significance (with special reference to India); Major and minor forest products; Depletion; Management.

Unit 7: Energy (6)
Renewable and non-renewable sources of energy

Unit 8: Contemporary practices in resource management (8)
Environmental Impact Assessment (EIA), Geographical Information System (GIS), Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint; Resource Accounting; Waste management.

Unit 9: National and international efforts in resource management and conservation (4)
National legislations: The Biological Diversity Act, 2002; Forest Conservation Act, 1980; Case studies relevant to resource management and conservation (eg. World Heritage Sites (Natural)/ Sacred Groves/ Biodiversity Heritage Sites/ Protection of Plant Varieties .

COURSE CONTENT (PRACTICAL) - UG-H-BOT-DSE-P-03:

1. Collection of data (qualitative and quantitative) on a local forest/ sacred grove cover (field visit).
2. Collection of data (qualitative and quantitative) on a designated area under Protected Area Network (field visit).
3. Collection of data (qualitative and quantitative) on a specific area exhibiting urban diversity (field visit).
4. Measurement of dominance of woody species by DBH (diameter at breast height) method.
5. Calculation and analysis of ecological footprint.

SUGGESTED READINGS/ REFERENCES

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

Course: UG-H-BOT-DSE-T-03 & UG-H-BOT-DSE-P-03

Course title: B. Coastal Biology

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- explain basic concepts of estuary, biodiversity, ecology and evolution as they pertain to marine, coastal and estuarine environment.
- disseminate basic idea about saline agriculture and forestry;
- apply theoretical and practical knowledge in how environmental and biological factors interact to sustain near-shore ecosystems;
- To acquire knowledge and awareness about the threats and management of biological diversity of near-shore ecosystems.

COURSE CONTENT (THEORY) - UG-H-BOT-DSE-T-03:

Unit 1: Introduction **(4)**
Definition and identification, Types and characteristics, Importance – economic, edaphic, social and environmental.

Unit 2: Coastal Zone Formation and Bio-geochemical Environment. **(8)**
Marine and estuarine land formation / sedimentation, Coastal zone biogeochemical cycles, Tides and soil- water relations, Coastal zone hazards.

Unit 3: Floral and faunal diversity, microbial ecology of coastal zone soil. **(10)**
Diversity of coastal flora (bacteria, fungi, actinomycetes, microalgae, flowering plants with special reference to mangroves) and fauna (protozoans, crustaceans, reptiles, avians, mammals with special reference to tiger).

Unit 4: Biology of Mangroves. **(7)**
Definition, Mangroves and mangrove associates, Diversity and distribution, Formation and development and succession of mangroves, Ecological and economic importance, Sources of damage, Need and approaches for conservation.

Unit 5: Coastal Biology: Processes and impact, Food web development. **(7)**
Biological phenomenon and processes related to productivity and food webs, Community structure and ecology, adaptation, physiology, role of microbes in food chain development, impact of human activities.

Unit 6: Coastal zone Agriculture and Forestry. **(7)**
Soils of coastal zones in relation to crop agriculture and forestry, Salinity and other problems in relation to crop growth, Crops and crop varieties in relation to salinity and salinity tolerance, Management of salinity for productivity and production improvement, Future prospects, Trees and tree farming, Forest management, Wood and other forestry products, Mangrove rejuvenation.

Unit 7: Threats to Coastal zone: Its Physical and Biological Components. **(7)**
Types of threats, Pollutions with special reference to eutrophication, Habitat degradation, Climate change, Ecosystem alteration, Land use and human population, Coastal industries and constructions, Dredging and dumping, Anthropogenic alteration of river run off and load.

Unit 8: Conservation and Management Strategies of Coastal zone. **(10)**
Coastal resources, Value of biodiversity, Hot spots of coastal biodiversity, Conservation priorities, Ecological restoration, Endangered endemic species conservations, ICZM, Sustainable use of biological resources, Importance and urgency of RS (Remote Sensing) and GIS (Geographic Information Systems) in coastal zone monitoring and management, Coastal risk reduction.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-DSE-P-03:

1. Instrumentation: Microscope, Turbidometer, pH meter, Colorimeter and other coastal zone monitoring instruments.
2. Identification of major flora and fauna (herbarium and museum specimens/ photographs).
3. Identification of mangroves, their life cycles and few biological characteristics.
4. Water and /or sediment quality analysis (pH, DO, alkalinity, turbidity, hardness, CO_2).
5. Collection and study of halophytic plants (with field report and preparation of at least 15 herbarium sheets).

SUGGESTED READINGS/ REFERENCES

1. Boaden, P.J.S. and Seed, R. (1988). An introduction to Coastal Ecology. Blackie Academic and Professional.
2. Lobbam, C.S. Harrison, P.J. and Duncan, M.J. (1985). The Physiological Ecology of Seaweeds. Cambridge University Press, New York.
3. Naskar, K.R. (2008). Manual of Mangroves. Daya Publishing House.
4. Sharma, P. (2008). Coastal Zone Management. Global India Publications Pvt. Ltd., New Delhi.
5. Waisel, Y. (2012). Biology of Halophytes. Academic Press.
6. Websites of NIO and Mangrove Society of India.

Course: UG-H-BOT-DSE-T-04 & UG-H-BOT-DSE-P-04

Course title: A. Research Methodology

Core Course; Credit – 6 [4 (Theory) + 2 (Practical)]; Full Points – 75 (50 + 25)

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- define the meaning of research, explain the concept, nature and scope of research in plant science.
- differentiate, apply and practice different laboratory practices in plant science research.
- observe, document and interpret data.
- write research related documents, *viz*., proposal, report, dissertation, etc.

COURSE CONTENT (THEORY) - UG-BOT-DSE-T-04:

Unit 1: Basic concepts of research (10)

Research-definition and types of research. Literature-review and its consolidation; Library research; field research; laboratory research.

Unit 2: General laboratory practices (12)

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 common toxic chemicals and safety measures in their handling.

Unit 3: Data collection and documentation of observations (6)

Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of Tissue specimens and application of scale bars. The art of field photography.

Unit 4: Overview of Biological Problems (6)

History; Key biology research areas, Model organisms in biology (A Brief overview).

Unit 5: **Methods to study plant cell/ tissue structure (6)**

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; Paraffin and plastic infiltration; Preparation of thin and ultrathin sections.

Unit 6: Plant microtechniques (12)

Staining procedures, classification and chemistry of stains. Staining equipment.

Unit 7: The art of scientific writing and its presentation (8)

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.

COURSE CONTENT (PRACTICAL) - UG-H-BOT-DSE-P-04:

1. Experiments based on chemical calculations.
2. Imaging exercise of samples through photomicrography and field photography.
3. Poster presentation on defined topics.
4. Technical writing on topics assigned.

SUGGESTED READINGS/ REFERENCES

Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.

Ruzin, S.E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.

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.

Course: UG-H-BOT-DSE-P-04

Course title: B. Dissertation/ Project

Core Course; Credit – 6 (Practical); Full Points – 75

COURSE OBJECTIVES:

After completion of the course the learners will be able to:

- apply the knowledge gained through different courses in practical field.
- solve problems related to his course of study.
- document, calculate, analyse and interpret data.
- deduce findings from different studies
- write and report in standard academic formats.

COURSE GUIDELINE- UG-BOT-DSE-P-04:

- The students undertaking this course shall be allotted a supervisor/ mentor at the beginning of the semester.
- The student shall select a topic for dissertation from any field of plant science with help from the supervisor/ mentor.
- The work completed within the stipulated time and written in standard academic format shall be submitted at the end of the semester.
- The work shall be evaluated on the basis of the written document submitted by the student and a *viva-voce* conducted on the same.