THE UNIVERSITY OF BURDWAN

Curriculum and Syllabus For 3-Year B. Sc. (Honours)
in
Botany

Under Choice Based Credit System (CBCS)
(*w.e.f.* Academic Year 2017-2018)

Structure of B.Sc. Honours Botany under CBCS

Core Courses

1. Microbiology and Phycology
2. Archegoniatae
3. Mycology and Phytopathology
4. Morphology & Anatomy of Angiosperms
5. Plant Ecology & Phytogeography
6. Plant Systematics
7. Economic Botany
8. Palaeobotany & Palynology
9. Biomolecules and Cell Biology
10. Molecular Biology
11. Plant Physiology
12. Plant Metabolism
13. Genetics & Plant Breeding
14 Plant Biotechnology

Skill Enhancement Courses: Elective (Two)	
Semester –III SEC-1	**SEC-1 (Any one)** 1. Ethnobotany 2. Intellectual Property Rights 3. Medicinal Botany 4. Mushroom Culture Technology 5. Agricultural Botany
Semester IV SEC- 2	**SEC - 2 (Any One)** 1. Biofertilizers 2. Herbal Technology 3. Nursery & Gardening 4. Floriculture 5. Plant Diversity & Human Welfare

Generic Electives (Four) Offered to the students of other Departments	
Semester –I GE-1	**GE-1** (*Same as core course-1 of B.Sc. Botany general*) Biodiversity (Microbes, Algae, Fungi and Archegoniatae)
Semester –II GE-2	**GE-2**(*Same as core course-1 of B.Sc. Botany general*) Plant Ecology and Taxonomy
Semester –III GE- 3	GE- 3 Plant Anatomy and Embryology (*Same as core course-1 of B.Sc. Botany general*)
Semester –IV GE-4	GE-4 Plant Physiology & Plant Metabolism (*Same as core course-1 of B.Sc. Botany general*)

Discipline Specific Electives (Four)

SEMISTER - V	**DSE-1**. (Any One) 1.Techniques in Plant Sciences 2.Reproductive Biology of Angiosperms (Rep. Biol. of Angio.) 3. Sylviculture & Forest Management (Sylvi. Cult. & Forest Mangt.) **DSE-2**. (Any One) 1.Biostatistics; 2.Bioinformatics; 3. Natural Resource Management **(**Nat. Res. Mgmt)
SEMISTER - VI	**DSE – 3**(Any One) 1.Phytoremediation & Immunology (Phyt. Rem & Immn) 2.Plant Evolution & Biodiversity **(** Plnt. Evl. & BioDv) 3.Marine Biology & Phycotechnology (Mar. Biol. & PyTec) **DSE – 4** (Any One) 1.Horticulture Practices & Post-Harvest Technology (. Hort. Prct. & PHT) 2.Industrial and Environmental Microbiology **(**Ind & Env. Microb.)

Ability Enhancement Compulsory Course

AECC-1. Environmental Studies (ENVS)
AECC-2. English Communication / MIL

OUTLINE OF DISTRIBUTION

Semester	Core Course(14)	Ability Enhancement Compulsory Course (AEC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective: (DSE) (4)	Generic Elective: GE) (4)
I	Microbiology and Phycology Archegoniatae	ENVS			GE-1
II	Mycology and Phytopathology Morphology & Anatomy	Communicative English / MIL			GE-2
III	Plant Ecology & Phytogeography Plant Systematics Economic Botany		**SEC-1 (Any one)** 1. Ethnobotany 2. Intellectual Property Rights 3. Medicinal Botany 4. Mushroom Culture Technology 5. Agricultural Botany		GE- 3
IV	Palaeobotany & Palynology Biomolecules & Cell Biology Molecular Biology		**SEC-2 (Any one)** 1.Biofertilizers 2.Herbal Technology 3.Nursery & Gardening 4.Floriculture 5. Plant Diversity & Human Welfare		GE-4
V	Plant Physiology Plant Metabolism			**DSE-1 (Any One)** 1.Techniques in Plant Sciences 2. Rep. Biol. of Angio. 3. Sylvi. Cult. & Forest Mangt. **DSE-2 (Any One)** 1.Biostatistics 2. Bioinformatics 3. Nat. Res. Mgmt	
VI	Genetics & Plant Breeding Plant Biotechnology			**DSE-3 (Any One)** 1.Phyt. Rem & Immn 2. Plnt. Evl. & BioDv 3. Mar. Biol. & PyTec **DSE-4 (Any One)** 1. Hort. Prct.& PHT 2. Ind & Env. Microb.	

CREDIT DISTRIBUTION

SEMESTER	COURSE OPTED	COURSE: NAME	Credits
	Ability Enhancement Compulsory Course-1	ENVS	4
	Core Course-1	Microbiology and Phycology	4
	Core Course-1 **Practical**	Microbiology and Phycology- Practical	2
	Core Course- 2	Archegoniate	4
	Core Course- 2 **Practical**	Archegoniate - Practical	2
	Generic Elective-1	GE-1	4
	Generic Elective-1 **Practical/Tutorial**	GE-1 Practical	2
SEM - II Total Credit **20**	Ability Enhancement Compulsory Course-2	English Communication/MIL	2
	Core Course- 3	Mycology and Phytopathology	4
	Core Course- 3 **Practical**	Mycology and Phytopathology- Practical	2
	Core Course-IV	Morphology & Anatomy	4
	Core Course-IV **Practical**	Morphology & Anatomy - Practical	2
	Generic Elective-2	GE- 2	4
	Generic Elective-2 **Practical**	GE-2 Practical	2
SEM - III Total Credit **26**	Core Course-5	Plant Ecology & Phytogeography	4
	Core Course-5 **Practical**	Plant Ecology & Phytogeography - Practical	2
	Core Course-6	Plant Systematics	4
	Core Course-6 **Practical**	Plant Systematics –Practical	2
	Core Course-7	Economic Botany	4
	Core Course-7 **Practical**	Economic Botany - Practical	2
	Skill Enhancement Course	SEC-1 (Any one)	2
	Generic Elective- 3	GE- 3 (Any one)	4
	Generic Elective- 3 **Practical**	GE- 3 Practical	2

SEM - IV Total Credit **26**	Core Course- 8	Palaeobotany& Palynology	4
	Core Course- 8 **Practical**	Palaeobotany& Palynology – Practical	2
	Core Course- 9	Biomolecule & Cell Biology	4
	Core Course- 9 **Practical**	Biomolecule & Cell Biology – Practical	2
	Core Course- 10	Molecular Biology	4
	Core Course- 10 **Practical**	Molecular Biology - Practical	2
	SkillEnhancement Course-2	SEC-2 (Any one)	2
	Generic Elective- 4	GE- 4	4
	Generic Elective- 4 **Practical**	GE-4 Practical	2
SEM - V Total Credit **24**	Core Course- 11	Plant Physiology	4
	Core Course- 11 **Practical**	Plant Physiology - Practical	2
	Core Course- 12	Plant Metabolism	4
	Core Course- 12 **Practical**	Plant Metabolism - Practical	2
	Discipline Specific Elective	DSE- 1	4
	Discipline Specific Elective **Practical**	DSE- 1 Practical	2
	Discipline Specific Elective	DSE- 2	4
	Discipline Specific Elective **Practical**	DSE- 2 Practical	2
SEM - VI Total Credit **24**	Core Course- 13	Genetics	4
	Core Course - 13 **Practical**	Genetics - Practical	2
	Core Course- 14	Plant Biotechnology	4
	Core Course- 14 **Practical**	Plant Biotechnology- Practical	2
	Discipline SpecificElective	DSE- 3	4
	Discipline SpecificElective- **Practical**	DSE- 3 Practical	2
	Discipline SpecificElective	DSE – 4	4
	Discipline SpecificElective- **Practical**	DSE – 4 Practical	2
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Semester-I

Core Course I: Microbiology and Phycology
(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

Unit 1: Introduction to microbial world
Microbial nutrition, growth and metabolism. Economic importance of viruses with reference to vaccine production, role in medicine and as causal organisms of plant diseases. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and antibiotics). **(8 lectures)**

Unit 2: Viruses
Discovery, physiochemical and biological characteristics; classification (Baltimore), general structure with special reference to TMV, T_2-Phage, viroids and prions; lytic and lysogenic cycle. **(8 lectures)**

Unit 3: Bacteria
Discovery, general characteristics; Principles in Bacterial Taxonomy, Bergey's Man. of Syst. Bact.; 2nd Ed. – 2001-05; Types-Archaea, Eubacteria, wall-less forms (mycoplasma and spheroplasts); Cell structure; Bacterial Chromosome & extra-chromosomal genetic elements; Nutritional types; Vegetative Reproduction and genetic recombination (conjugation, transformation and transduction), Endospore.
(14 lectures)

Unit 4: Algae
General characteristics; range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; methods of reproduction; Classification; criteria, general concept of endosymbiosis, system of Fritsch' 1935 (only upto class), and evolutionary classification of Lee' 2008 (only upto groups); Significant contributions of important phycologists (F.E. Fritsch & M.O.P. Iyengar); Role of algae in the environment, agriculture, biotechnology and industry.
(**6 lectures)**

Unit 5: Cyanophyta and Xanthophyta
Ecology and occurrence; Cell structure; Reproduction, Genetic recombination (in Cyanophyta); Morphology and life-cycle of *Vaucheria.* (**6 lectures)**

Unit 6: Chlorophyta and Charophyta
General characteristics; Occurrence; Cell structure. Life-cycles of *Volvox, Zygnema, Oedogonium, Coleochaete* and *Chara.* (**10 lectures)**

Unit 7: Phaeophyta and Rhodophyta
Characteristics; Occurrence; Cell structure; Reproduction. life-cycles of *Fucus* and *Polysiphonia.*
(**8 lectures)**

Practical

Microbiology

1. Aseptic method
   a) Sterilization technique by Autoclaving, Hot air oven and surface sterilization.
   b) Preparation of standard bacteriological medium (Nutrient agar, Nutrient broth and glucose – peptone medium).
   c) Preparation of slant and plates.
   d) Subculturing of pure bacteriological culture.
   e) Pure culture technique: dilution streak method.

2. Simple staining; Differential staining: Gram staining.

3. Microscopic examination of bacteria from natural habitats: curd and root nodules of leguminous plants.

Phycology

1. Study and Camera Lucida drawings of vegetative and reproductive structures of *Nostoc, Scytonema, Zygnema, Oedogonium, Chara* and *Vaucheria* temporary preparations and identification from permanent slides.

2. Identification of all the genera included in the theoretical syllabus from Permanent slides (vegetative and reproductive structures).

Suggested Readings

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.

2. Wiley JM, Sherwood LM and Woolverton CJ. (2013). Prescott's Microbiology. 9th Edition. McGraw Hill International.

3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.

4. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.

5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.

6. Pelczar, M.J. (2001). Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.

Core Course II: Archegoniate
(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

Unit 1: Introduction Unifying features of archegoniates; Transition and adaptation to land habit; Alternation of generations. **(4 lectures)**

Unit 2: Bryophytes
General characteristics & Classification [upto order] of Schuster (1968); Adaptations to land habit; Range of thallus organization. **(6 lectures)**

Unit 3: Type Studies- Bryophytes
Morphology, anatomy, reproduction and evolutionary trends in *Riccia, Marchantia, Pellia, Anthoceros, Sphagnum* and *Funaria* (developmental stages not included). Ecological and economic importance of bryophytes (a brief account). **(12 lectures)**

Unit 4: Pteridophytes
General characteristics; Classification (Pichi Sermolli, 1977 upto order); early land plants (*Cooksonia* and *Rhynia*). **(6 lectures)**

Unit 5: Type Studies- Pteridophytes
Morphology, anatomy and reproduction of *Lycopodium*, *Selaginella*, *Equisetum*, *Pteris* and *Marsilea* (Developmental details not to be included). Apogamy, and apospory, heterospory and seed habit, telome theory, stelar evolution; Ecological and economic importance **(14 lectures)**

Unit 6: Gymnosperms
General characteristics, classification (Stewart and Rothwell 1993, up to order), morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Gnetum* (Developmental details not to be included); Ecological and economic importance. **(18 lectures)**

Practical

1. ***Marchantia-*** Morphology of thallus, whole mount of rhizoids & Scales, vertical section of thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (from permanent slides).
2. ***Anthoceros-*** Morphology of thallus, dissection of sporophyte (to show stomata, spores, pseudoelaters, columella) (temporary slide), vertical section of thallus (from permanent slide).
3. ***Pellia -*** Study from Permanent slides.
4. ***Funaria-*** Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule.
5. ***Lycopodium-*** Morphology, whole mount of leaf, transverse section of stem (temporary slide), longitudinal section of strobilus (from permanent slide).
6. ***Selaginella-*** Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (from permanent slide).
7. ***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 (from permanent slide).
8. ***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 (from permanent slide).
9. ***Cycas-*** Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll, transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide).
10. ***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 (Permanent slide), tangential longitudinal section & radial longitudinal sections stem (permanent slide).
11. ***Gnetum-*** Morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide)

Suggested Readings

1. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
2. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi,
India.
3. 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., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.
5. Vanderpoorten, A. & Goffinet, B. (2009) Introduction to Bryophytes. Cambridge University

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Semester-II

Core Course III: Mycology and Phytopathology

(Credits: Theory-4, Practical-2)

THEORY

Lectures: 60

Unit 1: Introduction to true fungi

General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification (Alexopoulos & Mims, 1979). **(6 lectures)**

Unit 2: Chytridiomycota and Zygomycota

Characteristic features; Thallus organisation; Life cycle with reference to *Synchytrium* and *Rhizopus*.

(5 lecture)

Unit 3: Ascomycota

General characteristics, sexual reproduction and development of ascus and ascospores, types of ascocarp; Phenomenon of Heterokaryosis and parasexuality in asexual members; Life cycle of *Saccharomyces, Talaromyces, Neurospora* and *Ascobolus.* **(8 lectures)**

Unit 4: Basidiomycota

General characteristics; Phenomenon of dikaryotization, development of basidia and basidiospores and basidiocarp, Life cycle of *Puccinia* (Physiological Specialization) and *Agaricus*, Bioluminescence, Fairy Rings and Mushroom Cultivation. **(8 lectures)**

Unit 5: Allied Fungi **(3 lectures)**

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

Unit 6: Oomycota

General characteristics; Life cycle of *Phytophthora* and *Albugo.* **(4 lectures)**

Unit 7: Symbiotic associations

Lichen – Occurrence; General characteristics; Range of thallus organization; Nature of associations of algal and fungal partners; Reproduction; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza with special reference to VAM and their significance. **(4 lectures)**

Unit 8: Applied Mycology

Role of fungi in biotechnology; Application of fungi in food industry (Flavour & texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides). **(10 Lectures)**

Unit 9: Phytopathology

Terms and concepts; General symptoms; Geographical distribution of diseases; Symptomology; Koch's Postulate; Host-Pathogen relationships; Disease cycle and environmental relation; types of diseases, host defense mechanism; prevention and control of plant diseases (biological & chemical), and role of quarantine.

Bacterial diseases – Citrus canker and bacterial blight of rice. Viral diseases – Tobacco Mosaic virus.

Fungal diseases & Control – Late blight of potato, Ergot of rye; Black stem rust of wheat, loose and covered smut of wheat, White rust of crucifers. **(12 Lectures)**

Practical

Fungi

1. Study of the following genera and their identification: *Rhizopus, Talaromyces, Alterneria, Ascobolus, Agaricus* and *Polyporus.*

2. Identification of all the macroscopic and microscopic genera included in the theoretical syllabus.

Plant Pathology

1. Identification of diseases prescribed in the theoretical syllabus.

2. Study of the following diseases: White rust, Rust of wheat/*Justicia*, loose smut of wheat.

3. Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early & Late blight of potato, Black stem rust of wheat and White rust of crucifers.

4. Mycorrhizae – Ecto and Endo mycorrhizae (photographs only)

Suggested Readings

1. Agrios, G.N. (1997). Plant Pathology, 4th edition, Academic Press, U.K.

2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.

3. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.

4. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
5. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

Core Course IV:
Morphology & Anatomy of Angiosperms
(Credits: Theory-4, Practical-2)
THEORY
Lectures: 60

Unit 1: Introduction and scope of Plant Anatomy
Applications in systematics, forensics and pharmacognosy**.** **(1 Lectures)**

Unit 2: Structure and Development of Plant Body
Internal organization of plant body: The three tissue systems, types of cells and tissues; Development of plant body: a brief account. **(3 Lectures)**

Unit 3: Tissues
Classification of tissues; Simple and complex tissues (no phylogeny); cyto-differentiation of tracheary elements and sieve elements; Cell wall and it's secondary growth; Pits and plasmodesmata; Ergastic substances. Hydathodes, cavities, lithocysts and laticifers. **(10 Lectures)**

Unit 4: Apical meristems
Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cytohistological zonation); Types of vascular bundles; Structural differences of dicot and monocot stem, root & leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Endodermis, exodermis and origin of lateral root. **(14 Lectures)**

Unit 5: Vascular Cambium and Wood
Structure, function and seasonal activity of cambium; Secondary growth in root and stem with special reference to *Bignonia, Dracaena (Cordyline), Boerhaavia and Strychnos*. Types of rays and axial parenchyma; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. Development and composition of periderm; General account of Rhytidome and lenticels. **(14 Lectures)**

Unit 6: Adaptive and Protective Systems
Epidermal tissue system, cuticle, epicuticular waxes, trichomes(uni-and multicellular, glandular and nonglandular, two examples of each), stomata (classification). **(8 Lectures)**

Unit 7: Leaves and Inflorescence **(4 Lectures)**
Leaves – types, phyllotaxy and modifications; Inflorescence – Types and evolution

Unit 8: Flower, Fruit and Seed
Types of flower; Aestivation, placentation – types and evolution. Floral formula & floral diagram; Adhesion-Cohesion of floral parts, micro and mega gameto- and sporogenesis; embryosac, Fruits – types, dispersal. Seed dispersal. **(6 Lectures)**

Practical

1. Study of anatomical details through permanent slides/temporary stain mounts/ macerations/museum specimens with the help of suitable examples.

2. Study of the secondary structures of stem of the following genera: *Bignonia, Dracaena (Cordyline), Boerhaavia* and *Strychnos.*

3. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates;xylem fibres. (from permanent slides)

4. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres. (from permanent slides)

5. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular, lenticels.

6. Root: monocot, dicot, secondary growth (from permanent slides).

7. Stem: monocot, dicot - primary and secondary growth; periderm (from permanent slides);

8. Leaf: Different variations; C4 leaves (Kranz anatomy).

9. Cystolith, lithocysts and Raphides.

10. Types of inflorescence, placentation and fruits.

Suggested Readings

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.

2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.

3. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.

4. Evert, R.F. (2006). Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.

Semester III

Core Course 5 : Plant Ecology and Phytogeography Credits: 6

(Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Introduction **(6 lectures)**

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

Unit 2: Soil **(6 lectures)**

Importance; Origin; Formation; Composition; Physical; Chemical and Biological components.

Unit 3: Water **(4 lectures)**

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

Unit 4: Light, temperature, wind and fire **(4 lectures)**

Climatic variables; adaptations of plants to their variation.

Unit 5: Ecosystem **(8 lectures)**

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

Unit 6: Population ecology

Characteristics and Dynamics .Ecological Speciation **(4 lectures)**

Unit 7: Plant communities **(8 lectures)**

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

Unit 8: Functional aspects of ecosystem **(8 lectures)**

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

Unit 9: Phytogeography

Principles; Continental drift; Theory of tolerance; Endemism; Characteristicfeatures of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division ofIndia [Phytogeographical classification of India (D. Chatterjee- 1962)]; Vegetation Characteristics of Eastern Himalaya and Sunderbans. **(12 lectures)**

Practical

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.

2. Determination of pH of various soil and water samples (pH meter, universal indicator and pH paper)

3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.

4. Determination of organic matter of different soil samples by Walkley & Black rapid titration method.

5. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.

6. Ecological adaptations of some species: *Ipomoea aquatica* stem, Phyllode of *Acaccia auriculiformis*, *Nerium* leaf and *Vanda* root

7. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).

8. Field visit to familiarize students with ecology of different sites.

Suggested Readings

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

Core Course 6 : Plant Systematics **Credits: 6**

(Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Significance of Plant systematics (12 lectures)

Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences from palynology, cytology, phytochemistry and molecular data. Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Revision, Monographs, Journals; Keys:Single access and Multi-access.

Unit 2: Taxonomic hierarchy (6 lectures)

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

Unit 3: Botanical nomenclature (10 lectures)

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

Unit 4: Systems of classification (12 lectures)

Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker [1862-83 (upto series)] and Takhtajan (1997); Brief idea of APG System.

Unit 5: Biometrics, numerical taxonomy and cladistics (10 lectures)

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

Unit 6: Phylogeny of Angiosperms (12 lectures)

Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

Practical

1. Study of vegetative and floral characters from the locally available plants of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):
   Dicotyledons: Malvaceae, Fabaceae, Euphorbiaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Scrophulariaceae, Lamiaceae, Verbenaceae, Acanthaceae, Rubiaceae, Asteraceae.
   Monocotyledons: Liliaceae, Poaceae.

2. Field visit -

3. Demonstration of mounting of a properly dried and pressed specimens of any wild plant with herbarium label (to be submitted in the record book).

4. Submission will include only herbarium sheets of 15 common angiosperms from local flora (EXCLUDING ENDANGERED AND THREATENED SPECIES). Emphasis should be given in preparation field record book with photographic documentation.

[**N.B**. One field excursion is recommended for familiarization with the flora. In addition, the field visit to AJC Bose Indian Botanic Garden and CNH, Shibpur, Howrah is desirable.]

Suggested Readings

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

Core Course 7 : Economic Botany **Credits: 6**

(Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Origin of Cultivated Plants **(6 lectures)**
Concept of Centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity.

Unit 2: Cereals **(6 lectures)**
Wheat and Rice (origin, morphology, processing & uses); Brief account of millets.

Unit 3: Legumes **(6 lectures)**
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 lectures)**
Morphology and processing of sugarcane, products and by-products of sugarcane industry.
Potato – morphology, propagation & uses.

Unit 5: Spices **(6 lectures)**
Listing of important spices, their family and part used. Economic importance with special reference to fennel, saffron, clove and black pepper

Unit 6: Beverages **(4 lectures)**
Tea, Coffee (morphology, processing & uses)

Unit 7: Sources of oils and fats **(10 lectures)**
General description, classification, extraction, their uses and health implications groundnut, coconut, linseed, soybean, mustard and coconut (Botanical name, family & uses). Essential Oils: General account, extraction methods, comparison with fatty oils & their uses.

Unit 8: Natural Rubber **(3 lectures)**
Para-rubber: tapping, processing and uses.

Unit 9: Drug-yielding plants **(8 lectures)**
Therapeutic and habit-forming drugs with special reference to Cinchona, Digitalis, Papaver and Cannabis; Tobacco (Morphology, processing, uses and health hazards).

Unit 10: Timber plants **(3 lectures)**
General account with special reference to teak and pine.

Unit 11: Fibers **(4 lectures)**
Classification based on the origin of fibers; Cotton, Coir and Jute (morphology, extraction and uses).

Practical

1. **Cereals**: Rice(habit sketch, study of paddy and grain, starch grains, micro-chemical tests).
2. **Legumes**: Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3. **Sources of sugars and starches**: Sugarcane (habit sketch; cane juice- micro-chemical tests),Potato(habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, w.m. starch grains, micro-chemical tests).
4. **Spices:** Black pepper, Fennel and Clove (Macromorphology).
5. **Beverages**: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. **Sources of oils and fats**: Coconut- T.S. nut (photograph), Mustard–plant specimen, seeds; tests for fats incrushed seeds.
7. **Essential oil-yielding plants**: Habit sketch of*Rosa*and*Eucalyptus***-** specimens/photographs.
8. **Rubber**: specimen, photograph/model of tapping, samples of rubber products.
9. **Drug-yielding plants**: Organoleptic study of specimens of*Andrographis*and *Catharanthus.*
10. **Woods:** *Tectona, Pinus*: Specimen, Section of young stem.
11. **Fiber-yielding plants**: Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber)

N.B. **–** Students are required to submit a **PROJECT COPY** containing photographs of all above mentioned "Economically Important" plants with few identifying characters, economic use and local names.

Suggested Readings

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

Skill Enhancement Courses

SEC-1 (any one)

(1) Ethnobotany Credits 2 **Lectures: 30**

Unit 1: Ethnobotany (6 Lectures)

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

Unit 2: Methodology of Ethnobotanical studies (6 lectures)

a) Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) Sacred groves.

Unit 3: Role of ethnobotany in modern Medicine (10 lectures)
Medico-ethnobotanical sources in India;Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) *Azadiractha indica* b) *Ocimum tenuiflorum* c)*Vitex negundo*. d) *Gloriosa superba* e) *Tribulus terrestris* f) *Pongamia pinnata* g) *Cassia auriculata* h) *Indigofera tinctoria*. Role of ethnobotany in modern medicine with specialexample *Rauvolfia sepentina, Trichopus zeylanicus, Artemisia*sp.*,Withania somnifera*.
Role of ethnic groups in conservation of plant genetic resources.Endangered taxa and forest management (participatory forest management).

Unit 4: Ethnobotany and legal aspects (8 lectures)
Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge.

Suggested Readings

1. S.K. Jain, Manual of Ethnobotany, Scientific Publishers, Jodhpur, 1995.

2. S.K. Jain (ed.) Glimpses of Indian. Ethnobotny, Oxford and I B H, New Delhi – 1981

3. Lone et al,. Palaeoethnobotany

4. S.K. Jain (ed.) 1989. Methods and approaches in ethnobotany. Society of ethnobotanists, Lucknow, India.

5. S.K. Jain, 1990. Contributions of Indian ethnobotny.Scientific publishers, Jodhpur.

6. Colton C.M. 1997. Ethnobotany – Principles and applications. John Wiley and sons – Chichester

7. Rama Ro, N and A.N. Henry (1996). The Ethnobotany of Eastern Ghats in Andhra Pradesh, India.Botanical Survey of India. Howrah. 8) Rajiv K. Sinha – Ethnobotany The Renaissance of Traditional Herbal Medicine – INA –SHREE Publishers, Jaipur-1996 9) Faulks, P.J. 1958.An introduction to Ethnobotany, Moredale pub. Ltd.

(2) Intellectual Property Rights Credits 2 **Lectures: 30**

Unit 1: Introduction to intellectual property right (IPR) (2 lectures)
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 Lectures)
Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents. Infringement.

Unit 3: Copyrights (3 Lectures)
Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement.

Unit4: Trademark **(3 Lectures)**

Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defences, Domain name.

Unit 5: Geographical Indications **(3 Lectures)**

Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position.

Unit 6:Protection of Traditional Knowledge **(4 Lectures)**

Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, needfor a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Traditional Knowledge Digital Library.

Unit 7: Industrial Designs **(2 Lectures)**

Objectives, Rights, Assignments, Infringements, Defences of Design Infringement

Unit 8: Protection of Plant Varieties **(2 Lectures)**

Plant Varieties Protection-Objectives, Justification, International Position, Plantvarieties 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 Lectures)**

Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name ProtectionComputer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection

Unit 10: Biotechnology and Intellectual Property Rights **(4 Lectures)**

Patenting Biotech Inventions: Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues in Patenting Biotechnological inventions.

Suggested Readings

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

(3) Medicinal Botany Credits 2 **(Lectures : 30)**

Unit 1: History, Scope and Importance of Medicinal Plants. Indigenous Medicinal Sciences; Definitionand 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. **(10 Lectures)**

Unit 2: 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. **(10 Lectures)**

Unit 3: Ethnobotany and Folk medicines. Definition; Ethnobotany in India: Methods to studyethnobotany; 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. **(10 Lectures)**

Suggested Readings

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

(4) Mushroom Culture Technology Credits 2 **Lectures: 30**

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

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 Lectures)**

Unit 3: Storage and nutrition : Short-term storage (Refrigeration - upto 24 hours) Long termStorage (canning, pickels, papads), drying, storage in saltsolutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins. **(8 Lectures)**

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, ExportValue. **(5 Lectures)**

Suggested Readings

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991) Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.
3. Tewari, Pankaj Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
4. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol. II.

(5) Agricultural Botany Credit 2 **Lectures =30**

Unit: 1 Plant physiology **(Lectures : 11)**

a) Plant water relation, stomatal regulation, mineral nutrition, N_2 cycle.

b) CO_2 fixation mechanism in C2,C3,C4 and CAM plants. Transport of water and photosynthate.

c) Plant development Phytohormones : IAA, GA, Cytokinin, ABA, Ethylene; their role and regulation in plant system

d) Physiology of flowering and seed development

Unit: 2 Organic farming **(Lectures : 6)**

a) Microbes used as bio fertilizer

b) Cyanobacteria isolation and mass multiplication

c) Mycorrhizal association in Agriculture

Unit:3 Plant breeding, Tissue culture and Biotechnology **(Lectures : 13)**

a) Mass selection and pure line selection, heterosis breeding

b) Marker assisted breeding for agronomic crops

c) Micro propagation techniques, different organ culture

d) *Agrobacterium* mediated transformation, vector mediated transformation, Biolistics

e) GMO, transgenic plant, patent.

f) Molecular markers used in Agriculture

Suggested Reading

1. Plant Physiology -Plant Physiology by Taiz and Zeiger
2. Marker-Assisted Plant Breeding: Principles and Practices - A. K. Singh and B. D. Singh

3. Cytogenetics, Evolution, Biostatistics and Plant Breeding by P Chandel and RS Shukla, S Chand Publisher

Semester IV

Core Course 8: Palaeobotany & Palynology

Credits: 6

(Theory-4, Practical-2)

THEORY

Lecture : 60

1. Introduction, importance of Palaeobotany. **(5 lectures)**

2. Definition of fossil, process of fossilization, types of fossils on the basis of their preservation; concept of Form Genus. **(15 lectures)**

3. Introductory idea of correlation and stratigraphy; stratigraphic deductions based on plant fossils. **(15 lectures)**

4. Age of the earth, Geologic Time Scale, major events of plant life through geologic time. **(10 lectures)**

5. Microsporogenesis; Spore/pollen morphology with reference to polarity, size, shape, symmetry, aperture and sculpture. **(15 lectures)**

6. Organization of orthotropous ovule, types of ovules; megasporogenesis. **(10 lectures)**

7. Pollination: Types and contrivances. **(10 lectures)**

Practical

1. Study (including mode of preservation) of the following: *Lepidodendron,* (stem in T. S.), *Calamites* (stem in T. S.), *Bucklandia* (stem, specimen), *Glossopteris* (leaf, specimen), *Lyginopteris* (stem in T. S.), *Vertebraria* (root, specimen).

2. Pollen morphological studies of *Impatiens* and *Hibiscus* pollens form prepared slides.

Suggested Reading

1. Erdtman, G. 1952. Pollen morphology and Plant Taxonomy. Angiosperms (An introduction to Palynology I). Almqvist & Wiksell, Stockholm.
2. Moore, P. D., J. A. Webb and M. E. Collison. 1991. Pollen analysis. Blackwell Sci. Ltd.
3. Shivana, K. R. 2003. Pollen biology and biotechnology. Oxford & IHB Publishing Co.
4. Maheshwari, P. 1960. An Introduction to the Embryology of Angiosperms. McGraw-Hill Publ. Co.

5. Bhojwani, S. S. and S. P. Bhatnagar. 1992. The Embryology of Angiosperms. Vikas Publ. House.

Core Course 9 : Biomolecules and Cell Biology

Credits: 6

(Theory-4, Practical-2)

THEORY **Lectures : 60**

Unit 1: Biomolecules **(20 lectures)**

Types and significance of chemical bonds; Structure and properties of water; pH and buffers. **Carbohydrates:** Nomenclature and classification; Monosaccharides; Disaccharides;Oligosaccharides and polysaccharides.
Lipids: Definition and major classes of storage and structural lipids; Fatty acids structure andfunctions; Essential fatty acids; Triacyl glycerols structure, functions and properties; Phosphoglycerides.
Proteins: Structure of amino acids; Levels of protein structure-primary, secondary, tertiary andquarternary; Biological roles of proteins in plants.
Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types ofnucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.

Unit 2: Bioenergenetics **(4 lectures)**

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

Unit 3: Enzymes **(6 lectures)**

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 theroy), Michaelis – Menten equation, enzyme inhibition and factors affecting enzyme activity.

Unit4: The cell **(4 lectures)**

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

Unit 5: Cell wall and plasma membrane **(4 lectures)**

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 lectures)**

Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecularorganization of chromatin; nucleolus.
Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament.
Chloroplast,mitochondria and peroxisomes: Structural organization, function, Semiautonomous nature of mitochondria and chloroplast.
Endomembrane system: Endoplasmic Reticulum – Structure, targeting and insertion of proteinsin the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins and lipids; Golgi Apparatus – organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes

Unit 7: Cell division **(6 lectures)**

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

Practical

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 Onion/*Rhoeo/Crinum*.
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
4. Measurement of cell size by the technique of micrometry.
5. Cytochemical staining of: DNA- Feulgen and cell wall in the epidermal peel of onion using Periodic Schiff's (PAS) staining technique.
6. Study the phenomenon of plasmolysis and deplasmolysis.
7. Study the effect of organic solvent and temperature on membrane permeability.
8. Study different stages of mitosis and meiosis of *Allium cepa*.

Suggested Readings

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

6. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
7. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
8. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
9. 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

Core Course 10 : Molecular Biology — Credit : 6

(THEORY : 4, PRACTICAL : 2)

THEORY — **Lectures : 60**

Unit 1: Nucleic acids: Carriers of genetic information (4 lectures)

Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey &Chase, Avery, McLeod & McCarty, Fraenkel-Conrat's experiment.

Unit 2. The Structures of DNA and RNA / Genetic Material (10 lectures)

DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; Organization of DNA- Prokaryotes, Viruses, Eukaryotes.RNA Structure Organelle DNA -- mitochondria and chloroplast DNA.The Nucleosome Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit 2:The replication of DNA (10 lectures)

Chemistry of DNA synthesis (Kornberg's discovery); General principles – bidirectional, semi-conservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear ds-DNA, replication of the 5'end of linear chromosome; Enzymes involved in DNA replication.

Unit 3: Central dogma and genetic code (2 lectures)

Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features**)**

Unit 4: Transcription (18 lectures)

Transcription in prokaryotes and eukaryotes. Principles of transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E.coli.* Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing.

Unit 5: Processing and modification of RNA (8 lectures)

Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I and group II intron splicing, alternative splicing eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes; RNA editing and mRNA transport.

Unit 6: Translation **(8 lectures)**

Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

Practical

1. Preparation of LB medium and raising *E. coli.*
2. Study of genomic DNA from *E. coli.* through photographs
3. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
4. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
5. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
6. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing.

Suggested Readings

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

Skill Enhancement Courses

SEC-2 (any one)

(1) Biofertilizers Credits : 2 Lectures: 30

Unit 1: General account about the microbes used as biofertilizer – Rhizobium – isolation,identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.

(4 lectures)

Unit 2: *Azospirillum:*isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms.*Azotobacter*: classification, characteristics – crop response to *Azotobacter* inoculum, maintenance and mass multiplication. **(8 lectures)**

Unit 3: Cyanobacteria (blue green algae),*Azolla*and*Anabaena azollae*association, nitrogenfixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.

(4 lectures)

Unit 4: Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence anddistribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

(8 lectures)

Unit 5: Organic farming – Green manuring and organic fertilizers, Recycling of bio-degradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application. **(6 lectures)**

Suggested Readings

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

(2) Herbal Technology Credits : 2 Lectures: 30

Unit 1: Herbal medicines: history and scope - definition of medical terms - role of medicinalplants in Siddha systems of medicine; cultivation - harvesting - processing - storage -marketing and utilization of medicinal plants.

(6 Lectures)

Unit 2: Pharmacognosy - systematic position m edicinal uses of the following herbs in curingvarious ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka. **(6 Lectures)**

Unit 3: Phytochemistry - active principles and methods of their testing - identification andutilization of the medicinal herbs; *Catharanthus roseus* (cardiotonic), *Withania somnifera* (drugs acting on nervous system), *Clerodendrum phlomides* (anti-rheumatic) and *Centellaasiatica* (memory booster). **(6 Lectures)**

Unit 4: Analytical pharmacognosy: Drug adulteration - types, methods of drug evaluation -Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites(alkaloids, flavonoids,

steroids, triterpenoids, phenolic compounds) **(8 Lectures)**

Unit 5: Medicinal plant banks micro propagation of important species (*Withania somnifera*,neem and tulsi- Herbal foods-future of pharmacognosy) **(4 Lectures)**

Suggested Readings

1.Glossary of Indian medicinal plants, R.N.Chopra, S.L.Nayar and I.C.Chopra, 1956. C.S.I.R, New Delhi.
2.The indigenous drugs of India, Kanny, Lall, Dey and Raj Bahadur, 1984. International Book Distributors.
3.Herbal plants and Drugs Agnes Arber, 1999. Mangal Deep Publications.
4.Ayurvedic drugs and their plant source. V.V. Sivarajan and Balachandran Indra 1994. Oxford IBH publishing Co.
5.Ayurveda and Aromatherapy. Miller, Light and Miller, Bryan, 1998. Banarsidass, Delhi.
6.Principles of Ayurveda, Anne Green, 2000. Thomsons, London.
7.Pharmacognosy, Dr.C.K.Kokate et al. 1999. Nirali Prakashan.

(3) Nursery and Gardening Credits : 2 **Lectures: 30**

Unit 1: Nursery: definition, objectives and scope and building up of infrastructure for nursery,planning and seasonal activities - Planting - direct seeding and transplants. **(4 Lectures)**

Unit 2: Seed: Structure and types - Seed dormancy; causes and methods of breaking dormancy - Seed storage: Seed banks, factors affecting seed viability, genetic erosion – Seedproduction technology - seed testing and certification. **(6 Lectures)**

Unit 3: Vegetative propagation: air-layering, cutting, selection of cutting, collecting season,treatment of cutting, rooting medium and planting of cuttings - Hardening of plants – greenhouse - mist chamber, shed root, shade house and glass house. **(6 Lectures)**

Unit 4: Gardening: definition, objectives and scope - different types of gardening - landscapeand home gardening - parks and its components - plant materials and design - computer applications in landscaping - Gardening operations: soil laying, manuring, watering, management of pests and diseases and harvesting. **(8 Lectures)**

Unit 5: Sowing/raising of seeds and seedlings - Transplanting of seedlings - Study of cultivation of different vegetables: cabbage, brinjal, lady's finger, onion, garlic, tomatoes, and carrots - Storage and marketing procedures. **(6 Lectures)**

Suggested Readings

1. Bose T.K. & Mukherjee, D., 1972, Gardening in India, Oxford & IBH Publishing Co., New Delhi.
2. Sandhu, M.K., 1989, Plant Propagation, Wile Eastern Ltd., Bangalore, Madras.
3. Kumar, N., 1997, Introduction to Horticulture, Rajalakshmi Publications, Nagercoil.Edmond Musser & Andres, Fundamentals of Horticulture, McGraw Hill Book Co., New Delhi.
4. Agrawal, P.K. 1993, Hand Book of Seed Technology, Dept. of Agriculture and Cooperation, National Seed Corporation Ltd., New Delhi.

5. Janick Jules. 1979. Horticultural Science. (3rd Ed.), W.H. Freeman and Co., San Francisco, USA.

(4) Floriculture Credits : 2 Lectures: 30

Unit 1: Introduction: History of gardening; Importance and scope of floriculture and landscape gardening.

(2 Lectures)

Unit 2: Nursery Management and Routine Garden Operations: Sexual and vegetative methodsof propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Shading; Stopping or pinching; Defoliation; Wintering; Mulching; Topiary; Role of plant growth regulators

(8 lectures)

Unit 3: Ornamental Plants: Flowering annuals; Herbaceous perennials; Divine vines; Shadeand ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms and Cycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai. **(4 lectures)**

Unit 4: Principles of Garden Designs: English, Italian, French, Persian, Mughal and Japanesegardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India.

(4 lectures)

Unit 5: Landscaping Places of Public Importance: Landscaping highways and Educational institutions.

(4 lectures)

Unit 6: Commercial Floriculture: Factors affecting flower production; Production andpackaging 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).

(6 lectures)

Unit 7:Diseases and Pests of Ornamental Plants. **(2 lectures)**

Suggested Readings

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

(5) Plant Diversity and Human Welfare Credits 2 Lectures: 30

Unit 1: Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity attheecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity:Ethical and aesthetic values, Precautionary principle, Methodologies forvaluation, Uses of plants, Uses of microbes. **(8 lectures)**

Unit 2:Loss of Biodiversity: Loss of genetic diversity, Loss of species diversity, Loss ofecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss, **Management of Plant Biodiversity:** Organizations associated with biodiversitymanagement-Methodology for execution-IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity information management andcommunication. **(8 lectures)**

Unit 3:Conservation of Biodiversity: Conservation of genetic diversity, speciesdiversity andecosystem diversity, *In situ* and *ex situ* conservation, Socialapproaches to conservation,Biodiversity awareness programmes, Sustainable development. **(8 lectures)**

Unit 4: Role of plants in relation to Human Welfare; a) Importance of forestry theirutilization 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.
(6 lectures)

Suggested Readings

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

Semester V

Core Course 11 : Plant Physiology **Credits: 6**

(Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Plant-water relations **(10 lectures)**

Water Potential and its components, water absorption by roots, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap – cohesion-tension theory.Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement.

Unit 2: Mineral nutrition **(8 lectures)**

Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents.

Unit 3: Nutrient Uptake **(8 lectures)**

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, uniprot, co-transport, symport, antiport.

Unit 4: Translocation in the phloem **(8 lectures)**

Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.

Unit 5: Plant growth regulators **(14 lectures)**

Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids (Outline) and Jasmonic acid (Outline).

Unit 6: Physiology of flowering **(6 lectures)**

Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy.

Unit 7: Phytochrome , crytochromes and phototropins **(6 lectures)**

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

Practical

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of Humidity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To study the phenomenon of seed dormancy (TTZ).
6. Demonstration on the effect of different concentrations of IAA on *Plant* (Locally Available) coleoptile elongation (IAA Bioassay).
7. To study the induction of amylase activity in germinating grains.

Suggested Readings

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

Core Course 12 : Plant Metabolism Credits: 6

(Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Concept of metabolism **(6 lectures)**

Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric,covalent modulation and Isozymes).

Unit 2: Carbon assimilation **(14 lectures)**

Historical background, photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO_2 reduction, photorespiration, C_4pathways; Crassulacean acid metabolism; Factors affecting CO_2 reduction.

Unit 3: Carbohydrate metabolism **(2 lectures)**

Synthesis and catabolism of sucrose and starch.

Unit 4: Carbon Oxidation **(10 lectures)**

Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle,amphibolic role, anaplerotic reactions, regulation of the cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

Unit 5: ATP-Synthesis **(8 lectures)**

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

Unit 6: Lipid metabolism **(8 lectures)**

Synthesis and breakdown of triglycerides, β-oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination, α oxidation.

Unit 7: Nitrogen metabolism **(8 lectures)**

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 lectures)**

Receptor-ligand interactions; Second messenger concept, Calcium calmodulin, MAP kinase cascade.

Practical

1. Chemical separation of photosynthetic pigments.
2. To study the effect of light intensity on the rate of photosynthesis.
3. Effect of carbon dioxide on the rate of photosynthesis.
4. To compare the rate of respiration in different parts of a plant.
5. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.
6. To study the activity of lipases in germinating oil-seeds and demonstrate mobilization of lipids during germination.
7. Demonstration of absorption spectrum of photosynthetic pigments.

Suggested Readings

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

Discipline Specific Elective

DSE 1 (any one):

(1) Techniques in Plant Sciences Credits: 6

(Theory-4, Practical-2)

THEORY Lectures: 60

Unit 1: Imaging and related techniques (15 lectures)

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 (9 lectures)

Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CsCl2gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3: Radioisotopes
Use in biological research, auto-radiography, pulse chase experiment. **(4 lectures)**

Unit 4: Spectrophotometry
Principle and its application in biological research. **(3 lectures)**

Unit 5: Chromatography **(8 lectures)**
Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion-exchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6: Characterization of proteins and nucleic acids **(6 lectures)**
Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAGE

Unit 7: Biostatistics **(15 lectures)**
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.

Practical

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. To separate nitrogenous bases by paper chromatography - Demonstration
3. To separate sugars by thin layer chromatography - Demonstration
4. To separate chloroplast pigments by column chromatography - Protocol
5. To estimate protein concentration through Lowry's method.
6. To separate proteins using PAGE - Demonstration
7. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
8. Preparation of permanent slides (double staining).

Suggested Readings

1. Plummer, D.T. (1996). An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd. New Delhi. 3rd edition.
2. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. U.S.A.
3. 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.
4. Zar, J.H. (2012). Biostatistical Analysis. Pearson Publication. U.S.A. 4th edition.

(2) Reproductive Biology of Angiosperms

Credits: 6 (Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Introduction **(4 lectures)**

History and scope.

Unit 2: Reproductive development **(6 lectures)**

Induction of flowering. Flower development: genetic and molecular aspects.

Unit 3: Anther and pollen biology **(10 lectures)**

Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure, NPC system;Palynology and scope (a brief account); Pollen viability, storage and Germination.

Unit 4: Ovule **(10 lectures)**

Structure; Types; 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 lectures)**

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

Unit 5: Self incompatibility **(10 lectures)**

Basic concepts; Methods to overcome self- incompatibility: mixed pollination, bud pollination, Intra-ovarian and *in vitro* pollination; Modification of stigma surface,Cybrids, *in vitro* fertilization.

Unit 6: Embryo, Endosperm and Seed **(10 lectures)**

Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Seed structure and importance.

Units 7: Polyembryony and apomixis **(6 lectures)**

Causes and applications.

Practical

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), Pollen viability: Tetrazolium test.germination: Calculation of percentage germination in different media using hanging drop method.

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

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

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

Suggested Readings

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.

2. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.

3. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.

4. Johri, B.M. l (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.

(3) Silviculture & Forest Management

Credits: 6

(Theory-4, Practical-2)

THEORY **Lectures 60**

1. *Silviculture*:Concepts; role of silviculture; concept of sustainability; social forestry; agroforestry; biofertilizer; green manuring, vermicomposting, phytoremediation. **(Lectures = 10)**
2. *Forest Types and Management*: Forest types and classification (dry deciduous forest, thorn forest, intertidal forest, tropical and subtropical savannah, tropical desert, evergreen coniferous forest, alpine vegetation). Concept and management of forests in India. Changing perspectives of forest management. National forest policies. **(Lectures = 14)**
3. *Autecology of forest*: Forest site considerations in autecology; tree classifications; wood properties; phenology;anomalous secondary growth. **(Lectures = 6)**
4. *Synecology of forest*: Effects of climate, landform and soil on site suitability; site quality; site classification; site vulnerability; stand development and production ecology; vegetative description of stands; transfer and storage of energy; tree Improvement Programmes. **(Lectures = 9)**
5. *Plant animal interaction*: Evolution of plant and animal defenses against each other; herbivores and their feeding. Pollination and seed dispersal by animals; plant chemicalsmetabolism in defense; biological control and plant derived insecticides;man forest interaction and man-wildlife conflict– case studies. **(Lectures = 11)**

6. *Forest products*: major and minor forest products. **(Lectures = 3)**
7. *Forest wealth*: Vegetation mapping; comparison of litter-fall; identification of silviculturally important tree species;identification of important medicinal and weed species. **(Lectures = 7)**

Practical

1. Determination of wood volume
2. Work out and identification of plants use in silviculture practice.
3. Measurement of biodiversity of a forest area using different diversity indices.
4. Demonstration of equipment and use of tags, camera and radio tracking.
5. Vegetation mapping using digital aerial forest images of a forest and software.
6. Comparison of litter-fall.
7. Documentation of medicinally important forest plants by consulting with local people.
8. Application of quadrat methods to determine relative frequency (R.F.), relative density (R.D.) and relative dominance (R.Dm.) of a forest area.
9. Determination of Species importance value index (IVI).
10. Field visit and report preparation.

Suggested Books

1. An Introduction to Forestryby Luther R. Hilterbrand Balt, 1967
2. The Practice of Silviculture: Applied Forest Ecology ***by***David M. Smith, Bruce C. Larson, P. Mark S. Ashton, Matthew J. Kelty Wiley, 1996
3. The Biological Basis of Silviculture***by*** Harold John Lutz, University of British Columbia, 1959,
4. Plant Communities: A Textbook of Plant Synecology Rexford F. Daubenmire Harper and Row, 1968.
5. An Introduction to Agroforestry ***by*** P.K. Ramachandran Nair. Kluwer Academic Publishers. 1993.

DSE- 2 (any one)

(1) Biostatistics

Credits: 6

(Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Biostatistics **(12 lectures)**

Definition - statistical methods - basic principles. Variables - measurements, functions, limitations and uses of statistics.

Unit 2: Collection of data primary and secondary **(12 lectures)**

Types and methods of data collection procedures - merits and demerits. Classification tabulation and presentation of data - sampling methods.

Unit 3: Measures of central tendency **(14 lectures)**

Mean, median, mode, geometric mean - merits & demerits. Measures of dispersion - range, standard deviation, mean deviation, quartile deviation - merits and demerits; Co- efficient of variations.

Unit 4: Correlation **(12 lectures)**
Types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression

Unit 5: Statistical inference **(10 lectures)**
Hypothesis - simple hypothesis - student 't' test - chi square test.

Practical

1. Calculation of mean, standard deviation and standard error - Protocol
2. Calculation of correlation coefficient values and finding out the probability
3. Calculation of 'F' value and finding out the probability value for the F value.

Suggested Readings

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

(2) Bioinformatics **Credits: 6**

(Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1. Introduction to Bioinformatics **(5 Lectures)**
Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.

Unit 2. Databases in Bioinformatics **(5 Lectures)**
Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.

Unit 3. Biological Sequence Databases **(25 Lectures)**
National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database.
EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools.

DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ.
Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.

Unit 4. Sequence Alignments **(10 Lectures)**
Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

Unit 5. Molecular Phylogeny **(8 Lectures)**
Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.
Unit 6. Applications of Bioinformatics **(7 Lectures)**
Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement

Practical

1. Nucleic acid and protein databases – Technique study
2. Sequence retrieval from databases - Demonstration
3. Sequence alignment - Protocol
4. Sequence homology and Gene annotation – Technique study
5. Construction of phylogenetic tree - Protocol

Suggested Readings

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

(3) Natural Resource Management **Credits: 6**

(Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Natural resources: Definition and types. **(2 lectures)**
Unit 2: Sustainable utilization
Concept, approaches (economic, ecological and socio-cultural). **(8 lectures)**
Unit 3: Land **(8 lectures)**
Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management.
Unit 4: Water **(8 lectures)**
Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies.
Unit 5: Biological Resources **(12 lectures)**
Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan).
Unit 6: Forests **(6 lectures)**
Definition, Cover and its significance (with special reference to India); Major and minor forestproducts; Depletion; Management.
Unit 7: Energy Renewable and non-renewable sources of energy **(6 lectures)**
Unit 8: Contemporary practices in resource management EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management. **(8 lectures)**
Unit 9: National and international efforts in resource management and conservation **(4 lectures)**

Practical

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

Suggested Readings

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

Semester VI

Core Course 13 : Genetics & Plant Breeding

Credits: 6

(Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Mendelian genetics and its extension **(10 lectures)**

Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Numericals; Polygenic inheritance.

Unit 2: Extrachromosomal Inheritance **(2 lectures)**

Chloroplast mutation: Variegation in Four o'clock plant

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

Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping; Sex Linkage.

Unit 4: Variation in chromosome number and structure **(5 lectures)**

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

Unit 5: Gene mutations **(5 lectures)**

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 6: Fine structure of gene **(2 lectures)**

Classical vs molecular concepts of gene;

Unit 7. Population and Evolutionary Genetics **(4 lectures)**

Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

Unit 8: Plant Breeding **(4 lectures)**

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

Unit 9: Methods of crop improvement **(4 lectures)**

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 10: Inbreeding depression and heterosis **(5 lectures)**

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

Unit 11: Crop improvement and breeding **(2 lectures)**

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

Practical

1. Meiosis through temporary squash preparation*Allium cepa*.
2. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
3. Chromosome mapping using point test cross data.
4. Pedigree analysis for dominant and recessive autosomal and sex linked traits.
5. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
6. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
7. Testing of goodness of fit with Mendelian mono and dihybrid ratios

Suggested Readings

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.

4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.
5. Singh, B. D. – Plant Breeding, Kalyani Publishers.
6. Vijendradas L. D.; Plant Breeding. New Age International (p).
7. Pohelman and Borthakur – Plant Breeding.
8. R. C. Choudhury – An Introduction to Plant Breeding. Oxford I. B. H. Publication.
9. Crop Breeding and Genetics – H. H. Ram & H. G. Singh. New Age International.

Core Course 14: Plant Biotechnology **Credits: 6**

(Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Plant Tissue Culture **(16 lectures)**

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 lectures)**

Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).

Unit 3:Gene Cloning **(10 lectures)**

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 lectures)**

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

Unit 5: Applications of Biotechnology **(14 lectures)**

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

enzymes (Aspergillase, Protease, Lipase); Gentically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns.

Practical

1. (a) Preparation of MS medium.

   (b) Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.

2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.

3. Isolation of protoplasts-Protocol

4. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.

5. Study of steps of genetic engineering for production of Bt cotton, Golden rice, through photographs.

6. Isolation of plasmid DNA - Protocol

Suggested Readings

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

Discipline Specific Elective

DSE - 3 (any one)

(1) Phytoremediation & Immunology **Credits: 6**

(Theory-4, Practical-2)

THEORY **Lectures: 60**

Group-A
Phytoremediation

Unit:1 Phytoremediation: Definition, concept and objectives. **(2 lectures)**
Unit:2 Brief idea about phytoremediation and its types: Phytoextraction, Phytoevaporation, Phytostabilization, Phytodegradation, Phytovolatilization, Phytostimulation, Phytoassimilation, Phytotransformation. **(12 lectures)**
Unit:3 Metallophytes: Role in Phytoremediation and types (Metal excluders, Metal indicators, Metal hyperaccumulators). **(5 lectures)**
Unit:4 Role of phytochelatins and metallothioneins in phytoextraction.The fate of plants used for Phytoextraction: Phytomining and Bio-ore production. **(9 lectures)**
Unit:5 Advantages and Disadvantages of phytoremediation. **(2 lectures)**

Group B
Immunology

Unit 1: Overview of ImmuneSystem: Historical perspective of Immunology, Early theories of Immunology, Cells and organs of the Immune system **(3 lectures)**

Unit 2: Innate and Adaptive Immunity Anatomical barriers, Inflammation, Cell and molecules involved in innate immunity, Adaptive immunity (Cell mediated and humoral), Passive: Artificial and natural Immunity, Active: Artificial and natural Immunity **(4 lectures**

Unit 3: Antigens Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes (**2 lectures)**

Unit 4: Immunoglobulins Structure and functions of different classes of immunoglobulins, Antigen-antibody reactions, Immunoassays (ELISA and RIA) **(8 lectures)**

Unit 5: Major Histocompatibility Complex Structure and functions of MHC molecules. Endogenous and exogenous pathways of antigen processing and presentation **(6 lectures)**

Unit 6: Cytokines Properties and functions of cytokines, Therapeutics Cytokines **(2 lectures)**

Unit 7: Complement System Components and pathways of complement activation **(2 lectures)**

Unit 8. Vaccines: Various types of vaccines. **(3 lectures)**

PRACTICAL **(Credits 2)**

1. Analysis of soil - pH, moisture content, water holding capacity, percolation, capillary action.
2. Isolation of microbes (bacteria & fungi) from soil (28ºC & 45ºC).
3. Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
4. Isolation of *Rhizobium* from root nodules.
6. Demonstration of lymphoid organs by photograph.
7. Histological study of spleen, thymus and lymph nodes through slides/photographs
8. Preparation of stained blood film to study various types of blood cells.
9. ABO blood group determination.

SUGGESTED READINGS

1. Environmental Biotechnology: Concepts and Applications Hans-Joachim Jördening, Josef Winter John Wiley & Sons,
2. Advanced Environmental Biotechnology By S.K.Agarwal APH Publishing,
3. Environmental Biotechnology By S.N Jogdand Himalaya Publishing
4. Textbook of Environmental Biotechnology By Mohapatra I. K. International Pvt Ltd
5. Environmental Biotechnology: Basic Concepts and Applications By Indu Shekhar Thakur
6. Environmental Biotechnology: Theory and Application By Gareth G. Evans , Judy Furlong
7. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). *Immunology*, VI Edition. W.H. Freeman and Company.
8. David, M., Jonathan, B., David, R. B. and Ivan R. (2006). *Immunology,* VII Edition, Mosby, Elsevier Publication.
9. Abbas, K. Abul and Lechtman H. Andrew (2003.) *Cellular and Molecular Immunology.* V Edition. Saunders Publication.
10. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, AcademicPress
11. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer,New York
12. Singh A, Kuhad, RC & Ward OP (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg

(2) Plant Evolution and Biodiversity Credits: 6

(Theory-4, Practical-2)

Theory Lectures 60

Unit 1: Earliest forms of plant life: the earliest environment; formation of first cell; first prokaryotes; evolution of eukaryotes. **(12 lectures)**

Unit 2: Evolutionary trends: green algae to land plants; non-vascular to vascular plants; gymnosperm to angiosperms; evolution of plants using C_4 and CAM photosynthetic pathway. **(12 lectures)**

Unit 3: Phylogeny of plants: the archetypes of plants; evolution in major groups of plants. Phylogeny of flowering plants: Basal flowering plants and Eumagnoliids; Monocots; Eudicots; Core eudicots. **(12 lectures)**

Unit 4: Evolutionary theories: Natural Selection, Group Selection, Neutral theory of molecular evolution. **(12 lectures)**

Unit 5: Plant diversity around the world: aquatic and wetland plants; halophytes; plant of low-nutrient conditions; plants of moist shady habitats (Sciophytes); epiphytes; climbers; plants of cold or hot arid habitats; island floras. **(12 lectures)**

Practical (Credit 2)

1. Study of vegetative and reproductive structure of aquatic plants (*Nostoc*, *Chlamydomonas*, *Oedogonium*, *Vaucheria*, *Polysiphonia*).
2. Study of vegetative and reproductive structure of plants of moist shady habitats (*Marchantia*, *Funaria*, *Pteris*).
3. Leaf anatomy of *Suaeda*, *Avicennia* and *Hertiera* (Halophytes)- Photographs
4. Morphological and anatomical study of *Hydrilla*, *Vallisnaria* and arum.
5. Morphological and anatomical study of plants of arid habitat (*Nerium* and*Pinus*).
6. Field visit and report preparation.

Suggested reading

1. Plant Diversity and Evolution: Genotypic and Phenotypic Variation in Higher Plants– edited ***by*** Robert J. Henry, CABI Publishing.
2. Plants: Evolution and Diversity ***by*** Martin Ingrouille and Bill Eddie, Cambridge University Press.
3. The Evolution of Plants ***by*** K.J. Willis & J.C. McElwain, Oxford University Press.

(3) Marine Biology & Phycotechnology Credits: 6

(Theory-4, Practical-2)

THEORY Lecture 60

Unit 1: Marine algae and its uses; phycocolloids:Algaenates,Carrageenan,Agar-agar source and uses; Important seaweeds of India and its cultivation practices with special references to *Gracillaria,Gelidium* and*Eucheuma*(Kappaphycus) **(10 lectures)**

Unit 2: Medicinal uses of marine algae: traditional and modern;biology and classification of sea weeds **(10 lectures)**

Unit 3: Distribution and ecology of seaweeds according to depth of water and continental shelf. **(10 lectures)**

Unit 4: Planktonic marine algae,its ecology and importance;cocco -lithophorides,dinoflagellates and diatoms.Coralline algae and its importance **(10 lectures)**

Unit 5: Microalgae and its uses;SCP ,Bioethanol,Biodiesel and H_2 production; Its status in India. **(10 lectures)**

Unit 6: Race way ponds and Photobioreactors;Types and uses **(10 lectures)**

PRACTICAL

1.Culture of algae;different types ;Isolation and purification of algae from nature using differentmedia(CHU-10,BBM modified;BG-11);Culture techniques and media preparation;Demonstration of photobioreactor(Lab scale) and Race way ponds.

2.Economically important algae and its identification (through photograph): *Ulva,Padina,Corallina,Sargassum,Dictyota, Spirulina, Chlorella, Dunalielta, Botryococcus, Chlorcoccum* and *Lemanea*

3.One field visit to algae cultivation and production industry in India.

Suggested Reading

1. Bux, F. &Chisti, Y. (2016) Algal Biotechnology: Products and Processes. Springer
2. Kaushik, B. D. &Sahoo, D. (2012) Algal Biotechnology & Environment. IK International, New Delhi
3. Khattar, J. S., Singh, D. P. &Kaur, G. (2009) Algal Biology & Biotechnology IK International, New Delhi
4. Tripathy, B. N. & Kumar, D. (2017) Prospects & Challenges in Algal Biotechnology Springer
5. Das, M. K. (2010) Algal Biotechnology. Daya Publishing House
6. Moheimani, N. R., McHenry, M. P., Boer, Karne de, & Bahri, Parisa A. (2015). Biomass & Biofuels from microalgae. Springer
7. Richmond, A. & Hu, Q. (2013) Handbook of Microalgal Culture: Biotechnology and Applied Phycology

Discipline Specific Elective

DSE 4 (any one)

(1) Horticultural Practices and Post-Harvest Technology **Credits: 6**
(Theory-4, Practical-2)

THEORY **Lectures: 60**

Unit 1: Introduction **(4 lectures)**

Scope and importance, Branches of horticulture; Role in rural economy and employment generation; Importance in food and nutritional security; Urban horticulture and ecotourism.

Unit 2: Ornamental plants **(4 lectures)**

Types, classification (annuals, perennials, climbers and trees); Identification and salient features of some ornamental plants [rose, marigold, gladiolus, carnations, orchids, poppies, gerberas, tuberose, sages, cacti and succulents (opuntia, agave and spurges)] Ornamental flowering trees (Indian laburnum, gulmohar, Jacaranda, Lagerstroemia, fishtail and areca palms, semul, coraltree).

Unit 3: Fruit and vegetable crops **(4 lectures)**

Production, origin and distribution; Description of plants and their economic products; Management and marketing of vegetable and fruit crops; Identification of some fruits and vegetable varieties (citrus, banana, mango, chillies and cucurbits).

Unit 4: Horticultural techniques **(8 lectures)**

Application of manure, fertilizers, nutrients and PGRs; Weed control; Biofertilizers, biopesticides; Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics; Propagation Methods: asexual (grafting, cutting, layering, budding), sexual (seed propagation), Scope and limitations.

Unit 5: Landscaping and garden design **(6 lectures)**

Planning and layout (parks and avenues); gardening traditions - Ancient Indian, European, Mughal and Japanese Gardens; Urban forestry; policies and practices.

Unit 6: Floriculture **(6 lectures)**

Cut flowers, bonsai, commerce (market demand and supply); Importance of flower shows and exhibitions.

Unit 7: Post-harvest technology **(10 lectures)**

Importance of post-harvest technology in horticultural crops; Evaluation of quality traits; Harvesting and handling of fruits, vegetables and cut flowers; Principles, methods of preservation and processing; Methods of minimizing loses during storage and transportation; Food irradiation - advantages and disadvantages; food safety.

Unit 8: Disease control and management **(8 lectures)**

Field and post-harvest diseases; Identification of deficiency symptoms; remedial measures and nutritional management practices; Crop sanitation; IPM strategies (genetic, biological andchemical methods for pest control); Quarantine practices; Identification of common diseases andpests of ornamentals, fruits and vegetable crops.

Unit 9: Horticultural crops - conservation and management **(10 lectures)**

Documentation and conservation of germplasm; Role of micropropagation and tissue culture techniques; Varieties and cultivars of various horticultural crops; IPR issues; National, international and professional societies and sources of information on horticulture.

Field trip and Practical

Field visits to gardens, standing crop sites, nurseries, vegetable gardens and horticultural fields at IARI or other suitable locations (like Horticulture Society of India, Alipore Kolkata) and preparation of Detailed report with suitable photographs.

Suggested Readings

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

(2) Industrial and Environmental Microbiology

Credits: 6

(Theory-4, Practical-2)

THEORY **Lectures: 60**

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

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

Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilotscale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

Unit 3: Microbial production of industrial products (12 lectures)

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 Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin)

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

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 lectures)

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

Unit 6: Microbial flora of water. (8 lectures)

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

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

Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots.

Practical

1.Principles and functioning of instruments in microbiology laboratory
2. Study different parts of fermenter as demonstration by photograph
3.Hands on sterilization techniques and preparation of culture media.
4. Assessment of microbiological quality of water-protocol
5. A visit to any educational institute/industry to see an industrial fermenter, and other downstream processing operations.

Suggested Readings

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition.
3. Sullia S. B& Shantharam S: (1998) General Microbiology, Oxford & IBH Publishing Co. Pvt.Ltd.
4. Glaser A.N & Nilaido.H (1995) Microbial Biotechnology,W.H Freeman & Co.
5. Prescott & Dunn (1987) Industrial Microbiology 4th Edition, CBS Publishers & Distributors.
6. Prescott & Dunn (2002) Industrial Microbiology, Agrobios (India) Publishers.
7. Crueger W. & Crueger A. (2000) A text of Industrial Microbiology, 2nd Edition, PanimaPublishingCorp.
8. Stanbury P.F, Ehitaker H, Hall S.J (1997) Priciples of Fermentation Technology., Aditya Books (P) Ltd.
9. S.N.Jogdan (2006) Industrial Biotechnology, Himalaya Publishing House
10. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press.
11. .Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer, New York

GENERIC ELECTIVES

[For other Disciplines]

GE- 1 : Biodiversity (Microbes, Algae, Fungi and Archegoniate)

Credits: 6 (Theory-4, Practicals-2)

THEORY **Lectures: 60**

Unit 1: Microbes **(10 Lectures)**

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 Lectures)**

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life-cycles of the following: *Chlamydomonas, Oedogonium*, *Chara*, *Fucus, Polysiphonia*. Economic importance of algae

Unit 3: Fungi **(12 Lectures)**

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

Unit 4: Introduction to Archegoniate **(2 Lectures)**

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

Unit 5: Bryophytes **(10 Lectures)**

General characteristics, adaptations to land habit, Classification, Range of thallus organization.
Classification (up to family), 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 Lectures)**

General characteristics, classification, Early land plants (*Rhynia*). Classification (upto family), morphology, anatomy and reproduction of *Lycopodium*, *Selaginella*, *Equisetum* and *Pteris*. (Developmental details not to be included). Heterospory, stelar evolution. economic importance of Pteridophytes.

Unit 7: Gymnosperms **(6 Lectures)**

General characteristics, classification. Classification (up to family), morphology, anatomy and reproduction of *Cycas* and *Pinus*. (Developmental details not to be included). Economic importance.

Practical

1. Dissection (where necessary), mounting, description, drawing and identification of the following genera:
a. Algae: *Nostoc, Oedogonium, Chara.*
b. Fungi: *Ascobolus, Puccinia* (Uredosorus and teleutosorus).
c. Bryophytes: *Riccia, Marchantia and Funaria.*
2. Dissection, mounting, description, drawing, labeling and identification of the following genera:
a. Pteridophytes: *Lycopodium* (stem), *Selaginella* (stem) and *Pteris (*leaflet).
b. Gymnosperms: *Cycas* leaflet*, Pinus* needle.
3. Identification of all above mentioned genera in theoretical syllabus from permanent slides

4. Microbiology: Sterilization techniques.; Simple staining of Bacteria with methylene blue/Carbol Fuchsin – Curd

Suggested Readings

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

GE – 2 : Plant Ecology and Taxonomy **Credits: 6**

(Theory-4, Practicals-2)

THEORY **Lectures: 60**

Unit 1: Introduction **(2 Lectures)**
Plant Ecology and Taxonomy

Unit 2: Ecological factors **(10 Lectures)**
Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors. Adaptation of hydrophytes, halophytes and xerophytes.

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

Unit 4: Ecosystem **(8 Lectures)**
Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous

Unit 5: Phytogeography **(4 Lectures)**
Principle biogeographical zones; Endemism

Unit 6 Plant taxonomy **(2 Lectures)**
Identification, Classification, Nomenclature.

Unit 7 Identification **(4 Lectures)**
Functions of Herbarium, important herbaria and botanical gardens of the world and India;
Documentation: Flora, Keys: single access and multi-access

Unit 8 Taxonomic evidences **(6 Lectures)**
Taxonomic evidences from palynology, cytology, phytochemistry and molecular data.

Unit 9 Taxonomic hierarchy **(2 Lectures)**
Ranks, categories and taxonomic groups

Unit 10 Botanical nomenclature **(6 Lectures)**
Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Unit 11 Classification **(6 Lectures)**
Types of classification-artificial, natural and phylogenetic. Classification Bentham and Hooker (upto series), Takhtajan.

Unit 12 Biometrics, numerical taxonomy and cladistics **(4 Lectures)**
Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

Practical

1. Study of vegetative and reproductive organs, description, drawing and labeling, floral diagram, floral formula and identification of the following families: Malvaceae, Rubiaceae, Papilionaceae, Caesalpiniaceae, Apocynaceae, Labiatae (Lamiaceae), Solanaceae.
2. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

3. Ecological adaptations of some species: *Ipomoea aquatica* stem, Phyllode of *Acaccia auriculiformis*, *Nerium* leaf and *Vanda* root

Suggested Readings

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

GE – 3 : Plant Anatomy and Embryology **Credits: 6**

(Theory-4, Practicals-2)

THEORY **Lectures: 60**

Unit 1: Meristematic and permanent tissues **(8 Lectures)**
Root and shoot apical meristems; Simple and complex tissues.

Unit 2: Organs **(4 Lectures)**
Structure of dicot and monocot root stem and leaf.

Unit 3: Secondary Growth **(8 Lectures)**
Vascular cambium – structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood).

Unit 4: Adaptive and protective systems **(8 Lectures)**
Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.

Unit 5: Structural organization of flower **(8 Lectures)**
Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac.

Unit 6: Pollination and fertilization **(8 Lectures)**
Pollination mechanisms and adaptations; Double fertilization; Seed-structure appendages and dispersal mechanisms.

Unit 7: Embryo and endosperm **(8 Lectures)**
Endosperm types, structure and functions; Dicot and monocot embryo; Embryo-endosperm relationship.

Unit 8: Apomixis and polyembryony **(8 Lectures)**
Definition, types and practical applications.

Practical

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Stem: Monocot: *Zea mays;* Dicot: *Helianthus*; Secondary: *Helianthus* (only Permanent slides).
4. Root: Monocot: *Zea mays*; Dicot: *Helianthus*; Secondary: *Helianthus* (only Permanent slides).

5. Leaf: Dicot and Monocot leaf (only Permanent slides).
6. Adaptive anatomy: Xerophyte (*Nerium* leaf); Hydrophyte (*Hydrilla* stem).
7. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous – Through Permanent Slides/Photographs
8. Female gametophyte: *Polygonum* (monosporic) type of Embryo sac Development (Permanent slides/photographs).
9. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) (Photographs and specimens).

Suggested Readings

1. Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.
2. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.

GE – 4 : Plant Physiology and Metabolism Credits: 6

(Theory-4, Practicals-2)

THEORY **Lectures: 60**

Unit 1: Plant-water relations **(8 Lectures)**

Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.

Unit 2: Mineral nutrition **(8 Lectures)**

Essential elements, macro and micronutrients; Criteria of essentiality of elements; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps.

Unit 3: Translocation in phloem **(6 Lectures)**

Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading.

Unit 4: Photosynthesis **(12 Lectures)**

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 Lectures)**

Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate pathway

Unit 6: Enzymes **(4 Lectures)**

Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition.

Unit 7: Nitrogen metabolism **(4 Lectures)**

Biological nitrogen fixation; Nitrate and ammonia assimilation.

Unit 8: Plant growth regulators **(6 Lectures)**

Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.

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

Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red light responses on photomorphogenesis; Vernalization.

Practical

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of two environmental factors (light and wind) on transpiration by excised twig.
3. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. Demonstration of Hill reaction.
5. To study the effect of light intensity and bicarbonate concentration on O_2 evolution in photosynthesis.
6. Comparison of the rate of respiration in any two parts of a plant.

Suggested Readings

1. Taiz, L., Zeiger, E., (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.

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