

DR SHYAMA PRASAD MUKHERJEE UNIVERSITY

Ranchi

Jharkhand



NEP- 2020

Syllabus for B.Sc - Botany

COURSE STRUCTURE FOR B.Sc (Botany)

S. No.	Name of Paper	Semester	Course	Code of Paper	Marks
1	Fundamentals of Botany	I	Major Course	MJ 101T	75
2	Practical	I	Major Course	MJ 101P	25
3	Basics of Angiosperm	II	Major Course	MJ 201T	75
4	Practical	II	Major Course	MJ 201P	25
5	Cell Biology	II	Major Course	MJ 202T	75
6	Practical	II	Major Course	MJ 202P	25
7	Microbiology and Phycology	III	Major Course	MJ 301T	75
8	Practical	III	Major Course	MJ 301P	25
9	Mycology and Phytopathology	III	Major Course	MJ 302T	75
10	Practical	III	Major Course	MJ 302P	25
11	Archigoniata	IV	Major Course	MJ 401T	75
12	Practical	IV	Major Course	MJ 401P	25
13	Genetics	IV	Major Course	MJ 402T	75
14	Practical	IV	Major Course	MJ 402P	25
15	Biomolecules and Biochemistry	IV	Major Course	MJ 403T	75
16	Practical	IV	Major Course	MJ 403P	25
17	Plant Metabolism	V	Major Course	MJ 501T	75
18	Practical	V	Major Course	MJ 501P	25
19	Plant Anatomy	V	Major Course	MJ 502T	75

20	Practical	V	Major Course	MJ 502P	25
21	Plant Systematics	V	Major Course	MJ 503T	75
22	Practical	V	Major Course	MJ 503P	25
23	Economic Botany	VI	Major Course	MJ 601T	75
24	Practical	VI	Major Course	MJ 601P	25
25	Molecular Biology	VI	Major Course	MJ 602T	75
26	Practical	VI	Major Course	MJ 602P	25
27	Plant Physiology	VI	Major Course	MJ 603T	75
28	Practical	VI	Major Course	MJ 603P	25
29	Embryology	VI	Major Course	MJ 604T	75
30	Practical	VI	Major Course	MJ 604P	25
31	Plant Ecology and Environmental Biology	VII	Major Course	MJ 701T	75
32	Practical	VII	Major Course	MJ 701P	25
33	Plant Biotechnology	VII	Major Course	MJ 702T	75
34	Practical	VII	Major Course	MJ 702P	25
35	Analytical Techniques in Plant Sciences	VII	Major Course	MJ 703T	75
36	Practical	VII	Major Course	MJ 703P	25
37	Bio-Informatics	VII	Major Course	MJ 704T	75
38	Practical	VII	Major Course	MJ 704P	25
39	Biostatistics	VIII	Research Course	RC 801	100
40	Research Proposal	VIII	Research Course	RC 802	100
41	Research Project	VIII	Research Course	RC 803	100

42	Plant Breeding	VIII	Advance Major Course	AMJ 801T	100
43	Stress Physiology	VIII	Advance Major Course	AMJ 802T	100
44	Ethnobotany	VIII	Advance Major Course	AMJ 803T	100
45	Algal Biotechnology	VIII	Advance Major Course	AMJ 804T	100
46	Biofertilizers and organic farming	II	Minor Course	MVC 201T	100
47	Multidisciplinary course	I,II,III	MDC	MDC	75
48	Mushroom cultivation	IV	Minor Course	MVC 401T	100
49	Medicinal plants	VI	Minor Course	MVC 601T	100
50	Herbal technology	VIII	Minor Course	MVC 801T	100
51	Biofertilizer	I	Skill Enhancement Course	SEC 101T	75
52	Mushroom Culture Technology	II	Skill Enhancement Course	SEC 201T	75
53	Pharmacognosy and Herbal preparations	III	Skill Enhancement Course	SEC 301T	75
54	Biodiversity	I	Minor Course	MN 101T	75
55	Practical	I	Minor Course	MN 101P	25
56	Plant Ecology and Taxonomy	III	Minor Course	MN 301T	75
57	Practical	III	Minor Course	MN 301P	25
58	Plant Anatomy and Embryology	V	Minor Course	MN 501T	75
59	Practical	V	Minor Course	MN 501P	25
60	Plant Physiology and Metabolism	VII	Minor Course	MN 701T	75

61	Practical	VII	Minor Course	MN 701P	25
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Distribution of Marks

PAPERS	CREDITS	MID SEMESTER EXAMINATION		END SEMESTER EXAMINATION		TOTAL MARKS
				FULL MARKS	PASS MARKS	
Major Courses (MJ)	4	15	Theory	60	30	100
			Practical	25	10	
Minor Courses (MN)	4	15	Theory	60	30	100
			Practical	25	10	
Skill Enhancement Courses (SEC)	3	-	-	75	30	75
Multidisciplinary Courses	3	-	-	75	30	75
Advance Major Courses (AMJ)	4	25	-	75	30	100
Vocational Courses (MVC)	4	25	-	75	30	100
Research Courses (RC1+RC2+RC3)	12	25+ --	-	75+ 100 + 100	30+ --	100+ 200

Syllabus for Graduation (Botany) under NEP- 2020

SEMESTER	CODE	PAPERS	CREDITS
SEM I	MJ 101	Fundamentals of Botany	3+1
	SEC 101	Biofertilizers	3
SEM II	MJ 201	1. Basics of Angiosperm	3+1
	MJ 202	2. Cell Biology	3+1

	SEC 201	Mushroom Cultivation	3
SEM III	MJ 301	1. Microbiology and Phycology	3+1
	MJ 302	2. Mycology and Phytopathology	3+1
	SEC 301	Pharmacognosy and Herbal preparations	3
SEM IV	MJ 401	1. Archigoniata	3+1
	MJ 402	2. Genetics	3+1
	MJ 403	3. Biomolecules and Biochemistry	3+1
SEM V	MJ 501	1. Plant Metabolism	3+1
	MJ 502	2. Plant Anatomy	3+1
	MJ 503	3. Plant Systematics	3+1
SEM VI	MJ 601	1. Economic Botany	3+1
	MJ 602	2. Molecular Biology	3+1
	MJ 603	3. Plant Physiology	3+1
	MJ 604	4. Embryology	3+1
SEM VII	MJ 701	1. Plant Ecology and Environmental Biology	3+1
	MJ 702	2. Plant Biotechnology	3+1
	MJ 703	3. Analytical Techniques in Plant Sciences	3+1
	MJ 704	4. Bio-Informatics	3+1
SEM VIII	RC 801	Biostatistics	4
	RC 802	Research Proposal	4
	RC 803	Research Report	4
	AMJ 801	Plant Breeding	3+1
	AMJ 802	Stress Physiology	3+1
	AMJ 803	Ethnobotany	3+1
	AMJ 804	Algal Biotechnology	3+1

Semester-I

MJ 101: Fundamentals of Botany

Unit 1: Origin and evolution of life

Evolutionary history of biological diversity, Early earth and the origin of life, spontaneous, biogenesis, Pasteur's experiment, germ theory of disease; Major events in the history of life, Classifying the diversity of life, Kingdoms of Life –Prokaryotes, Eukaryotes, Archaea, Darwinian view of life and origin of species, Darwin's theory of evolution.

Unit 2: Microbial diversity

Classification of microorganisms- R. H. Whittaker's five kingdom concept, Carl Woese's-Domain system. Brief account of special groups of bacteria- Archeobacteria, Mycoplasma, Chlamydia, Actinomycetes, Rickettsias and Cyanobacteria.

Unit 3: Biomolecules

Carbohydrates: Nomenclature and classification.

Lipids: Definition and major classes of storage and structural lipids.

Proteins: Structure of amino acids; Levels of protein structure.

Nucleic acids: Structure and function of nucleotides; Types of nucleic acids.

Unit 4: Genetic approach to Biology

Patterns of inheritance and question of biology; Variation on Mendel's Law; The molecular basis of genetic information; The flow of genetic information from DNA to RNA to protein.

PRACTICALS

1. To learn a) use of microscope b) principles of fixation and staining.
2. Preparation of Normal, molar and standard solutions, phosphate buffers, serial dilutions
3. Use of micropipettes
4. Separation of A) amino acids B) chloroplast pigments by paper chromatography.
5. To perform gram staining of bacteria.
6. To study the cytochemical distribution of nucleic acids and mucopolysaccharides with in cells/tissues from permanent slides.
7. To perform quantitative estimation of protein using the Lowry's method. Determine the concentration of the unknown sample using the standard curve plotted.
8. To separate and quantify sugars by thin layer chromatography.
9. To raise the culture of *E. coli* and estimate the culture density by turbidity method. Draw a growth curve from the available data.
10. Isolation of genomic DNA from *E.coli*.

SUGGESTED READINGS

1. Campbell, N.A. and Reece, J. B. (2008) Biology 8th edition, Pearson Benjamin Cummings, San Francisco.
2. Raven, P.H et al (2006) Biology 7th edition Tata McGrawHill Publications, New Delhi
3. Griffiths, A.J.F et al (2008) Introduction to Genetic Analysis, 9th edition, W.H. Freeman & Co. NY

SEC 101: Biofertilizers

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

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.

Unit 3: Cyanobacteria (blue green algae), Azolla & Anabaena azollae association, nitrogen fixation. Factory affecting growth, blue green algae and Azolla in rice cultivation

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

Unit 5: Organic farming--Green manuring and organic fertilisers. Recycling of biodegradable municipal, agricultural & Industrial wastes—biocompost making methods, types and method of vermicomposting—field application.

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 Venniculture 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

Semester-II

MJ 201: Basics of Angiosperms

Unit 1: Root

Modifications of tap roots, modifications of adventitious roots, modifications for storage of food, modifications for mechanical support, modifications for reproductive and physiological functions.

Unit 2: Stem

Types of stems, modifications of stem – underground, sub-aerial, aerial.

Unit 3: Leaf

Phyllotaxy; stipules and their types; petiole modifications; leaflets modifications; types of leaf – simple, compound; leaf modifications.

Unit 4: Inflorescence

Types of inflorescences - racemose, cymose and special types.

Unit 5: Flower

Parts of a flower, terminology pertaining to flowers, insertion of floral leaves; calyx - cohesion, aestivation, duration of calyx; corolla – cohesion, aestivation, shape, appendages of corolla, Perianth; androecium – insertion, cohesion, adhesion, sequence of staminal whorls, length of filaments, position of stamens, number of locules, attachment of the filament to the anther, types of connectives, dehiscence of anther; gynoecium – cohesion of carpels, position of ovary, number of locules, placentation, style, stigma; floral formula, floral diagram.

Unit 6: Fruits

Types – simple, aggregate, composite or multiple fruits

Unit 7: Tissues

Classification of tissues; Simple and complex tissues; Types of vascular bundles; Structure of dicot and monocot stem and root.

Practical

1. Study of types of roots and its modifications.
2. Study of types of stems and its modifications.
3. Study of types of leaf, leaf shapes, leaf margins and leaf apices.
4. Study of different types of inflorescences.
5. Study of different shapes of corolla.
6. Draw floral diagram and floral formula.

Suggested Readings

1. Datta S.C. 1988 Systematic botany, Wailey Eastern, New Delhi.

2. Pandey, B. P. Textbook of Botany- Angiosperms.
2. Bendre & Kumar Text book of Practical botany II, Rastogi Publication, Meerut.

MJ 202: Cell Biology

Unit1: The cell

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

Unit 2: Cell wall and plasma membrane

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 3: Cell organelles

Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus.

Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament.

Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.

Endomembrane system: Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins and lipids; Golgi Apparatus – organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes.

Unit 4: Cell division

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

Practical

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

Suggested Readings

1. 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. 17
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

SEC 201: Mushroom Culture Technology

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

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.

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

Unit 4: Food Preparation: Types of foods prepared from mushroom. Research Centres—National level and Regional level. Cost benefit ratio -Marketing in India and abroad, Export Value.

Suggested Readings

1. Marimuthu T Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991). Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural Univ. Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing & 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.

Semester-III

MJ 301: Microbiology and Phycology

Unit 1: Introduction to microbial world

Microbial nutrition, growth and metabolism. Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of plant

diseases. Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine).

Unit 2: Viruses

Discovery, physiochemical and biological characteristics; classification (Baltimore), general structure with special reference to viroids and prions; replication (general account), DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV).

Unit 3: Bacteria

Discovery, general characteristics; Types-archaebacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts); Cell structure; Nutritional types; Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction).

Unit 4: Algae

General characteristics; Ecology and distribution; 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, system of Fritsch, and evolutionary classification of Lee (only upto groups); Significant contributions of important phycologists (F.E. Fritsch, G.M. Smith, R.N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P. Iyengar). Role of algae in the environment, agriculture, biotechnology and industry.

Unit 5: Cyanophyta and Xanthophyta

Ecology and occurrence; Range of thallus organization; Cell structure; Reproduction, Morphology and life-cycle of *Nostoc* and *Vaucheria*.

Unit 6: Chlorophyta and Charophyta

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

Unit 7: Phaeophyta and Rhodophyta

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

Practical

Microbiology

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

Phycology

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

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.

MJ 302: Mycology and Phytopathology

Unit 1: Introduction to true fungi

General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification.

Unit 2: Chytridiomycota and Zygomycota

Characteristic features; Ecology and significance; Thallus organisation; Reproduction; Life cycle with reference to *Synchytrium*, *Rhizopus*.

Unit 3: Ascomycota

General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; Life cycle and classification with reference to *Saccharomyces*, *Aspergillus*, *Penicillium*, *Alternaria*, *Neurospora* and *Peziza*.

Unit 4: Basidiomycota

General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), loose and covered smut (symptoms only), *Agaricus*; Bioluminescence, Fairy Rings and Mushroom Cultivation.

Unit 5: Allied Fungi

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

Unit 6: Oomycota

General characteristics; Ecology; Life cycle and classification with reference to *Phytophthora*, *Albugo*.

Unit 7: Symbiotic associations

Lichen – Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

Unit 8: Applied Mycology

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); Medical mycology.

Unit 9: Phytopathology

Terms and concepts; General symptoms; Geographical distribution of diseases; Etiology; Symptomology; Host-Pathogen relationships; Disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine.

Bacterial diseases – Citrus canker and angular leaf spot of cotton. Viral diseases – Tobacco Mosaic viruses, vein clearing. Fungal diseases – Early blight of potato, Black stem rust of wheat, White rust of crucifers.

Practical

1. Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, ascocarps & basidiocarps).
2. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. *Aspergillus* and *Penicillium*: study of asexual stage from temporary mounts. Study of Sexualstage from permanent slides/photographs.
4. *Peziza*: sectioning through ascocarp.
5. *Alternaria*: Specimens/photographs and temporary mounts.
6. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
7. *Agaricus*: Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*, fairy rings and bioluminescent mushrooms to be shown.
8. Study of phaneroplasmodium from actual specimens and /or photograph. Study of *Stemonitis* sporangia.
9. *Albugo*: Study of symptoms of plants infected with *Albugo*; asexual phase study through section/temporary mounts and sexual structures through permanent slides.
10. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs)
11. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early blight of potato, Black stem rust of wheat and White rust of crucifers.

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.

SEC 301: Pharmacognosy and herbal preparation

Unit 1: Herbs as raw materials. Definition of herb, herbal medicine, herbal medicinal product, herbal drug preparation. Source of Herbs Selection, identification and authentication of herbal materials Processing of herbal raw material. Biodynamic Agriculture: Good agricultural practices in cultivation of medicinal plants including Organic farming. Pest and Pest management in medicinal plants: Biopesticides/Bioinsecticides.

Unit 2: Study of following herbs as health food: Ginger, Fenugreek, Garlic, Amla, Neem, Ashwagandha, Giloy, Harjod, Munga. Herbal-Drug and Herb-Food Interactions: General introduction to interaction and classification.

Unit 3: Herbal Cosmetics

Sources and description of raw materials of herbal origin used via, fixed oils, waxes, gums colours, perfumes, protective agents, bleaching agents, antioxidants in products such as skin care, hair care and oral hygiene products.

Unit 4: Evaluation of Drugs WHO & ICH guidelines for the assessment of herbal drugs Stability testing of herbal drugs. Patenting and Regulatory requirements of natural products: Definition of the terms: Patent, IPR, Farmers right, Breeder's right, Bioprospecting and Biopiracy, Patenting aspects of Traditional Knowledge and Natural Products. Case study of Curcuma & Neem.

Suggested Readings:

1. Agarwal, S.S. and Paridhavi, M., "Herbal Drug Technology" Universities Press (India) Private Limited, 2007.
2. Wallis, T.E., "Textbook of Pharmacognosy" 5th Edition, CBS Publishers and Distributors, 1985.
3. Evans, W.C., "Trease and Evans Pharmacognosy" 15th Edition, Elsevier Health Sciences, 2001.
4. Lanza, R.P. and Atala, A., "Methods of Tissue Engineering" Elsevier Publications, 2006.
5. Daniel, M., "Herbal Technology: Concepts and Advances" Satish Serial Publishing House, 2008.

Semester-IV

MJ 401: Archigoniate

Unit 1: Introduction

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

Unit 2: Bryophytes

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

Unit 3: Type Studies- Bryophytes

Classification (up to family), morphology, anatomy and reproduction of *Riccia*, *Marchantia*, *Pellia*, *Porella*, *Anthoceros*, *Sphagnum* and *Funaria*; Reproduction and evolutionary trends in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria* (developmental stages not included). Ecological and economic importance of bryophytes with special reference to *Sphagnum*.

Unit 4: Pteridophytes

General characteristics; Classification; Early land plants (*Cooksonia* and *Rhynia*).

Unit 5: Type Studies- Pteridophytes

Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum* and *Pteris* (Developmental details not to be included). Apogamy and apospory, heterospory and seed habit, telome theory, stelar evolution; Ecological and economic importance.

Unit 6: Gymnosperms

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

Practical

1. ***Riccia*** – Morphology of thallus.
2. ***Marchantia***- Morphology of thallus, whole mount of rhizoids & Scales, vertical section of thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).
3. ***Anthoceros***- Morphology of thallus, dissection of sporophyte (to show stomata, spores, pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).
4. ***Pellia*, *Porella***- Permanent slides.
5. ***Sphagnum***- Morphology of plant, whole mount of leaf (permanent slide only).
6. ***Funaria***- Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule and protonema.
7. ***Psilotum***- Study of specimen, transverse section of synangium (permanent slide).
8. ***Selaginella***- Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide).
9. ***Equisetum***- Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
10. ***Pteris***- Morphology, transverse section of rachis, vertical section of sporophyll, whole mount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).
11. ***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).

12. ***Pinus***- Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), transverse section of Needle, transverse section of stem, longitudinal section of / transverse section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), longitudinal section of female cone, tangential longitudinal section & radial longitudinal sections stem (permanent slide).

13. ***Gnetum***- Morphology (stem, male & female cones), transverse section of stem, vertical section of ovule (permanent slide)

14. **Botanical excursion.**

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 Press.

MJ 402: Genetics

Unit 1: Mendelian genetics and its extension

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

Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in *Paramecium*.

Unit 3: Linkage, crossing over and chromosome mapping

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

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

Unit 5: Gene mutations

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

Unit 6: Fine structure of gene

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

Unit 7: Population and Evolutionary Genetics

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

Practical

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

Suggested Readings

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

MJ 403: Biomolecules and Biochemistry

Unit 1: Biomolecules

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 and functions; Essential fatty acids; Triacyl glycerols structure, functions and properties; Phosphoglycerides.

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

Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.

Unit 2: Bioenergetics

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

Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced - fit theory), Michaelis – Menten equation, enzyme inhibition and factors affecting enzyme activity.

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. Counting the cells per unit volume with the help of haemocytometer. (Yeast/pollen grains).
6. Study of cell and its organelles with the help of electron micrographs.
7. Cytochemical staining of: DNA- Feulgen and cell wall in the epidermal peel of onion using Periodic Schiff's (PAS) staining technique.
8. Study the phenomenon of plasmolysis and deplasmolysis.
9. Study the effect of organic solvent and temperature on membrane permeability.

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.17
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

Semester-V

MJ 501: Plant Metabolism

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, CO₂ reduction, photorespiration, C₄ pathways; Crassulacean acid metabolism; Factors affecting CO₂ 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. Experimental demonstration of Hill's reaction.
3. To study the effect of light intensity on the rate of photosynthesis.
4. Effect of carbon dioxide on the rate of photosynthesis.
5. To compare the rate of respiration in different parts of a plant.
6. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.
7. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
8. Demonstration of fluorescence by isolated chlorophyll pigments.
9. 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.

MJ 502: Plant Anatomy

Unit 1: Introduction and scope of Plant Anatomy (4 Lectures)

Applications in systematics, forensics and pharmacognosy.

Unit 2: Structure and Development of Plant Body (6 Lectures)

Internal organization of plant body: The three tissue systems, types of cells and tissues.

Development of plant body: Polarity, Cytodifferentiation and organogenesis during embryogenic development.

Unit 3: Tissues (12 Lectures)

Classification of tissues; Simple and complex tissues (no phylogeny); cytodifferentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Wall ingrowths and transfer cells, adcrustation and incrustation, Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.

Unit 4: Apical meristems (15 Lectures)

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; Structure of dicot and monocot stem. Origin, development, arrangement and diversity in size and shape of leaves; Structure of dicot and monocot leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.

Unit 4: Vascular Cambium and Wood (15 Lectures)

Structure, function and seasonal activity of cambium; Secondary growth in root and stem.

Axially and radially oriented elements; Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. Development and composition of periderm, rhytidome and lenticels.

Unit 5: Adaptive and Protective Systems (8 Lectures)

Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni-and multicellular, glandular and nonglandular, two examples of each), stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

Practical

1. Study of anatomical details through permanent slides/temporary stain mounts/ macerations/ museum specimens with the help of suitable examples.
2. Apical meristem of root, shoot and vascular cambium.
3. Distribution and types of parenchyma, collenchyma and sclerenchyma.
4. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
5. Wood: ring porous; diffuse porous; tyloses; heart- and sapwood.
6. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
7. Epidermal system: cell types, stomata types; trichomes: non-glandular and glandular.
8. Root: monocot, dicot, secondary growth.
9. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels.
10. Leaf: isobilateral, dorsiventral, C4 leaves (Kranz anatomy).

11. Adaptive Anatomy: xerophytes, hydrophytes.
12. Secretory tissues: cavities, lithocysts and laticifers.

Suggested Readings

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

MJ 503: Plant systematics

Unit 1: Significance of Plant systematics

Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences from palynology, cytology, phytochemistry and molecular data. Function of Herbarium; Important herbaria and botanical gardens of the world and India; Documentation: Flora, Monographs, Journals.

Unit 2: Taxonomic hierarchy

Concept of taxa (family, genus, species); Categories and taxonomic hierarchy.

Unit 3: Botanical nomenclature

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

Unit 4: Systems of classification

Major contributions and classification system of Hutchinson, Engler and Prantl (upto series), Bentham and Hooker (upto series) and Takhtajan; Brief reference of Angiosperm Phylogeny Group (APG IV) classification.

Unit 5: Biometrics, numerical taxonomy and cladistics

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

Unit 6: Plant families

Diagnostic characteristics, systematic phylogeny and economic importance of families: Brassicaceae, Apocynaceae, Asteraceae, Solanaceae, Lamiaceae, Euphorbiaceae, Liliaceae, Poaceae.

Practical

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification): Brassicaceae, Apocynaceae, Asteraceae, Solanaceae, Lamiaceae, Euphorbiaceae, Liliaceae, Poaceae.
2. Field visit (local) – Subject to grant of funds from the university.
3. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

Suggested Readings

1. Singh, (2012). *Plant Systematics: Theory and Practice* Oxford & IBH Pvt. Ltd., New Delhi. 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.

Semester-VI

MJ 601: Economic Botany

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)

Listing of important medicinal plants of Jharkhand. 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:** Wheat (habit sketch, L.S/T.S. grain, starch grains, micro-chemical tests), 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 (habit and sections).
5. **Beverages:** Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
6. **Sources of oils and fats:** Coconut- T.S. nut, Mustard–plant specimen, seeds; tests for fats in crushed seeds.
7. **Essential oil-yielding plants:** Habit sketch of *Rosa*, *Vetiveria*, *Santalum* and *Eucalyptus* (specimens/photographs).
8. **Rubber:** specimen, photograph/model of tapping, samples of rubber products.

9. **Drug-yielding plants:** Specimens/Photographs of *Centella asiatica*, *Asparagus racemosus*, *Justicia adhatoda* and *Andrographis paniculata*.
10. **Tobacco:** Photographs/specimen and products of Tobacco.
11. **Woods:** *Tectona*, *Pinus*: Specimen, Section of young stem.
12. **Fiber-yielding plants:** Cotton (specimen, whole mount of seed to show lint and fuzz; whole mount of fiber and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fiber).

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.

MJ 602: Molecular Biology

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, mitochondria and chloroplast DNA. The Nucleosome, Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Unit 3: The replication of DNA (10 lectures)

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

Unit 4: 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 5: 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 6: 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. Isolation of genomic DNA from *E.Coli*.
3. DNA isolation from cauliflower head.
4. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
5. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
6. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
7. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
8. 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.

MJ 603: Plant Physiology

Unit 1: Plant-water relations (10 lectures)

Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap-cohesion-tension theory. Transpiration and factors affecting transpiration, anti-transpirants, 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, uniport, 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, Abscissic acid, Ethylene, Brassinosteroids and Jasmonic acid.

Unit 6: Physiology of flowering (6 lectures)

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

Unit 7: Phytochrome, cryptochromes 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 wind velocity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).
7. To study the effect of different concentrations of IAA on *Avena* coleoptile elongation (IAA Bioassay).
8. To study the induction of amylase activity in germinating barley grains.

Demonstration experiments

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

Suggested Readings

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

3. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.

MJ 604: Embryology

Unit 1: Introduction (4 lectures)

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

Unit 2: Reproductive development (6 lectures)

Induction of flowering; flower as a modified determinate shoot. 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, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.

Unit 4: Ovule (10 lectures)

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

Unit 5: Pollination and fertilization (6 lectures)

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

Unit 6: Self incompatibility (10 lectures)

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

Unit 7: Embryo, Endosperm and Seed (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; Unusual features; Embryo development in *Paeonia*. Seed structure, importance and dispersal mechanisms.

Unit 8: Polyembryony and apomixis (6 lectures)

Introduction; Classification; Causes and applications.

Practical

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehiscent anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, pseudomonads, polyads, pollinia (slides/photographs, fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test; germination: Calculation of percentage germination in different media using hanging drop method.
3. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).
4. Female gametophyte through permanent slides/photographs: Types, ultrastructure of mature egg apparatus.
5. Intra-ovarian pollination; Test tube pollination through photographs.
6. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
7. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

Suggested Readings

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

Semester-VII

MJ 701: Plant Ecology and Environmental Biology

Unit 1: Introduction (4 lectures)

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

Unit 2: Soil (8 lectures)

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

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; Water table.

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

Variations; adaptations of plants to their variation.

Unit 5: Biotic interactions (2 lectures)

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

Unit 6: Population ecology (4 lectures)

Characteristics and Dynamics. Ecological Speciation

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: Ecosystems (4 lectures)

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

Unit 9: Functional aspects of ecosystem (8 lectures)

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

Unit 10: Phytogeography (12 lectures)

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

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/Lovibond comparator and pH paper)
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
4. Determination of organic matter of different soil samples by Walkley & Black rapid titration method.
5. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
6. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
7. (a). Study of morphological adaptations of hydrophytes and xerophytes (four each).
(b). Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanch*) Epiphytes, Predation (Insectivorous plants).
8. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
9. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.

10. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
11. Field visit to familiarise students with ecology of different sites.

Suggested Readings

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

MJ 702: Plant Biotechnology

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 (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines;

Industrial enzymes (Aspergillase, Protease, Lipase); Genetically 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.
4. Construction of restriction map of circular and linear DNA from the data provided.
5. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
6. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.
7. Isolation of plasmid DNA.
8. Restriction digestion and gel electrophoresis of plasmid DNA.

Suggested Readings

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

MJ 703: Analytical Techniques in Plant Sciences

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 (8 lectures)

Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, CsCl₂ gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3: Radioisotopes (4 lectures)

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

Unit 4: Spectrophotometry (4 lectures)

Principle and its application in biological research.

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. Demonstration of ELISA.
3. To separate nitrogenous bases by paper chromatography.
4. To separate sugars by thin layer chromatography.
5. Isolation of chloroplasts by differential centrifugation.
6. To separate chloroplast pigments by column chromatography.
7. To estimate protein concentration through Lowry's methods.
8. To separate proteins using PAGE.
9. To separation DNA (marker) using AGE.
10. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
11. 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.

MJ 704: Bio-informatics**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.
2. Sequence retrieval from databases.
3. Sequence alignment.
4. Sequence homology and Gene annotation.
5. Construction of phylogenetic tree.

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.

Semester-VIII

RC 801: Biostatistics

Unit 1: Basics of Biostatistics – definition. Statistical methods - basic principles. Variables - measurements, functions, limitations and uses of statistics. (8 lectures)

Unit 2: Collection of data primary and secondary - types and methods of data collection procedures - merits and demerits. Classification - tabulation and presentation of data – sampling methods. (12 lectures)

Unit 3: Measures of central tendency - mean, median, mode, merits & demerits of harmonic and geometric mean. Measures of dispersion - range, standard deviation, mean deviation, standard error, skewness and kurtosis, quartile deviation –merits and demerits; Co- efficient of variations. (13 lectures)

Unit 4: Correlation - types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression. (10 lectures)

Unit 5: Statistical inference - hypothesis - simple hypothesis - student's T test - chi square test, F-test, Z-test (15 lectures)

Unit 6: Basic concept of probability, Introduction to binomial, poisson and Normal distribution; Uses of advance software's (MS-excel, SPSS, Sigma plot and R) in modern biostatistics. (6 Lectures)

Suggested Readings:

1. Bishop, O.N., (1967). *Statistics for Biology*. Boston, Massachusetts: Houghton Mifflin Company.
2. Campbell, R.C. (1998). *Statistics for Biologists*. Cambridge, U.S.A.: Cambridge University Press.
3. Danniel, W.W. (1987). *Biostatistic*. New York, NY: John Wiley Sons.
4. Freedman, P. (1949). *The Principles of scientific research*. New York, NY: Pergamon Press.
5. Khan, I.A., Khanum, A. (2004). *Fundamentals of Biostatistics*, 5th edition. Hyderabad: Ukaaz publications.
6. Pandey, M. (2015). *Biostatistics Basic and Advanced*. New Delhi, Delhi: M V Learning.
7. Selvin, S., (1991). *Statistical Analysis of epidemiological data*. New York, NY: New York University Press.

RC 802: Research Proposal

Topic of the research may be chosen from any area of Botany related to their special papers and may be laboratory based, field based or both or computational, with emphasis on originality of approach. It should be duly signed by the Supervisor / Research guide and the Head of the Department and submitted for evaluation.

RC 803: Research Report

The report to be submitted should include:

1. Introduction
2. Review of Literature
3. Materials and Methods
4. Results and Discussion
5. Summary and Conclusion
6. References

AMJ 801: Plant Breeding

Unit 1: Plant Breeding (10 lectures)

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

Unit 2: Methods of crop improvement (20 lectures)

Introduction: Centers of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self-pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.

Unit 3: Quantitative inheritance (10 lectures)

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

Unit 4: Inbreeding depression and heterosis (10 lectures)

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

Unit 5: Crop improvement and breeding (10 lectures)

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

Suggested Readings

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

AMJ 802: Stress Physiology

Unit 1: Defining plant stress (2 lectures)

Acclimation and adaptation.

Unit 2: Environmental factors (20 lectures)

Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis–related (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates.

Unit 3: Stress sensing mechanisms in plants (20 lectures)

Calcium modulation, Phospholipid signaling

Unit 4: Developmental and physiological mechanisms that protect plants against environmental stress (12 lectures)

Adaptation in plants; Changes in root: shoot ratio; Aerenchyma development; Osmotic adjustment; Compatible solute production.

Unit 5: Reactive oxygen species–Production and scavenging mechanisms. (6 lectures)

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.

AMJ 803: Ethnobotany

Unit 1: Ethnobotany

Definition, scope and methods of study; major and minor ethnic groups or tribals of India; major and minor ethnic groups or tribals of Jharkhand.

Unit 2: Ethnobotany of indigenous communities in Jharkhand

Preliminary knowledge about ethnobotany of Santhal, Oraon, Munda and Ho.

Unit 3: Indigenous/ traditional knowledge

Traditional/indigenous knowledge and its importance. Plants used by ethnic groups as food, medicines (Ethnomedicine), beverages, fodder, fibre, resins, oils, fragrances and other uses. NWFP (Non-Wood Forest Products). Plants used in rituals by Tribal and Folk communities of Jharkhand.

Unit 4: Ethnobotany and legal aspects

Role of Ethnobotany in conservation and sustainable development. Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights.

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.

AMJ 804: Algal Biotechnology

Unit 1: Cyanobacteria in human welfare: Production of tiny chemicals polysaccharides, bioactive molecules pigments, and lipids. Effects and Solution of Bioremediation.

Unit 2: Recent Biotechnological developments with algae as experimental material. Role of algae in biological nitrogen fixation.

Unit 3: Culture of algae: Media preparation. Methods of collection, isolation and cultural procedure for green algae and blue green algae.

Unit 4: Economic importance of Algae as: (i) Food (ii) Feed (iii) Biofertilizer (iv) Algae in agriculture & industry (v) Hydrogen production by algae.

Unit 5: Molecular biotechnology with special reference to blue green algae.

Unit 6: Applied Phycology- Nutrient regulated phytoplankton growth: Common methods for mass cultivation of micro-algae, Eutrophication: Causal factor, algal blooms, Commercial production of *Spirulina*, *Scenedesmus*, *Chlorella*.

Unit 7: Paddy field Cyanobacteria: Qualitative and quantitative assessment and their biodiversity using molecular tools, their use as bio-fertilizer.

Unit 8: Diversity and conservation of algae: Algal diversity of different habitats, Importance of conservation: in-situ and ex-situ conservation.

Suggested Reading:

- 1 Lee, R.E. (2008). Phycology, Cambridge University Press. Cambridge, 4th Edition.
- 2-Algae-Anatomy. Biochemistry and biotechnology. Barsanti. L. and Gualtieri. P. (2006)
- 3· Algal Ecology-Fresh & Marine Benthic Ecosystems. Ed by R.J. Stevensons. M.L. Bothwell. R.L. Lowe. Academic Press (1996)

Multi-disciplinary Course

Unit 1: Structural organization in plants

Morphology and anatomy of flowering plants

Unit 2: Structure and functions of cell

Cell- the unit of life, cell cycle and cell division

Unit 3: Plant Physiology

Transport in plants, mineral nutrition, photosynthesis in higher plants, respiration in plants, plant growth and development.

Unit 4: Genetics

Principles of inheritance and variation, molecular basis of inheritance.

Unit 5: Biology in human welfare

Microbes in human welfare, biotechnology

Unit 6: Ecology

Ecosystem, biodiversity and conservation.

SUGGESTED READINGS

1. Campbell, N.A. and Reece, J. B. (2008) Biology 8th edition, Pearson Benjamin Cummings, San Francisco.
2. Raven, P.H et al (2006) Biology 7th edition Tata McGrawHill Publications, New Delhi

3. Griffiths, A.J.F et al (2008) Introduction to Genetic Analysis, 9th edition, W.H. Freeman & Co. NY
4. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
5. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.

Minor Courses (Vocational)

MVC 201: Biofertilizers and Organic farming

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

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.

Unit 3: Cyanobacteria (blue green algae), Azolla & Anabaena azollae association, nitrogen fixation. Factors affecting growth, blue green algae and Azolla in rice cultivation

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

Unit 5: Organic farming--Green manuring and organic fertilisers.

Recycling of biodegradable municipal, agricultural & Industrial wastes—biocompost making methods, types and method of vermicomposting—field Application

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 Venniculture 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

MVC 401: Mushroom Cultivation

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

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.

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

Unit 4: Food Preparation: Types of foods prepared from mushroom. Research Centres—National level and Regional level. Cost benefit ratio -Marketing in India and abroad, Export Value.

Suggested Readings

1. Marimuthu T Krishnamoorthy, A.S.Sivaprakasam, K. and Jayarajan. R (1991). Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural Univ. Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing & 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.

MVC 601: Medicinal Plants

Unit 1. General aspects of Medicinal Plants

Definition, history, present and future needs. Introduction of plant parts (fruit, leaves, roots, stem, seeds and their modification), Cultivation and harvesting practices, Processing and storage practices, Marketing of medicinal products, Role in human health and balanced diet, Basic idea of quality control and contribution of national research laboratories like CDRI, CIMAP, NBRI, etc. Precautions during use of herbal medicinal products.

Unit 2. Important Indian Medicinal Plants

Plant parts used as powder: Identification and utilization of Amla (*Embelica officinalis*), Behra (*Terminalia bellerica*), Harad (*Terminalia chebula*), Turmeric (*Curcuma longa*), Garlic (*Allium sativum*), Bitter guard (*Momordica charantia*), Black plum (*Syzygium cumini*), Fenugreek (*Trigonella foenum-graecum*), Cinnamon (*Cinnamomum verum*), Sarpagandha (*Raulfia serpentina*), Black pepper (*Piper nigrum*), Ashwagandha (*Withania somnifera*), Psyllium husk (*Plantago ovata*).

Plant parts used as juice/ decoction: Identification and utilization of Amla (*Embelica officinalis*), Ginger (*Zingiber officinale*), Onion (*Allium cepa*), Bottle guard (*Lagenaria siceraria*), Basil (*Oscimum santum*), Arjun (*Terminalia arjuna*), Neem (*Azadiracta indica*), Gwarpatha (*Aloe vera*), Brahmi (*Bacopa monnieri*), Giloy (*Tinospora cordifolia*), Shankhpushpi (*Convolvulus prostrate*), Bael (*Aegle marmelos*).

Plant Parts Used as Lotion and Ointments: Identification and utilization of Gwarpatha (*Aloe vera*), Fenugreek (*Trigonella foenum-graecum*), Pot marigold (*Calendula officinalis*), Neem (*Azadiracta indica*).

Plant Parts Used as Oil: Clove (*Syzygium aromaticum*), Neem (*Azadiracta indica*), Coconut (*Coccus nucifera*), Nilgiri (*Eucalyptus sp.*)

Plant Parts Used as Surgical Fibres, Sutures and Dressings: Identification and utilization of cotton (*Gossypium sp.*), Jute (*Corchorus capsularis*), Bana (*Musa sp.*)

Plant Parts Used as Poultice: Identification and utilization of Turmeric (*Curcuma longa*), Nilgiri (*Eucalyptus sp.*), Ginger (*Zingiber officinale*), Garlic (*Allium sativum*), Onion (*Allium cepa*), Dhatura (*Dhatura sp.*), Aak (*Calotropis sp.*), Arandi (*Ricinus communis*).

Suggested Readings:

1. Panda H., Hand Book of Ayurvedic Medicines, National Institute of Industrial Research, Delhi.
2. SIR - Cultivation and Utilization of Medicinal Plants.
3. Brahmavarchas, Ayurved ka Pran: Vanoshadhi vigyan, Vedmata Gayatri Trust Shaktikunj Haridwar 2004.
4. Chaudhry R. D., Herbal Drug Industry, Eastern Publication.
5. Atal and Kapoor, Cultivation and Utilization of Medicinal Plants, RRL Jammu Tawi^[1]1982
6. Raphael Ikan, Natural Products: A Lab Guide, Academic Press, 1991, 2nd edition.
7. Dutt Ashwin, An Introduction to Medicinal Plants, Adhyayan Publishers distributors, 2009, 1st edition.

MVC 801: Herbal Technology

Unit 1: Pharmacognosy - Definition and history, Indian systems of medicine - Siddha, Ayurveda, and Unani systems. Taxonomy of locally available medicinal plants, their chemical constituents

and medicinal uses. Pharmacognosy - systematic position & medicinal uses of the following herbs in curing various ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka.

Phytochemistry - active principles and methods of their testing - identification and utilization of the medicinal herbs; *Catharanthus roseus* (cardiotonic), *Withania somnifera* (drugs acting on nervous system), *Clerodendron phlomoides* (anti-rheumatic) and *Centella asiatica* (memory booster).

Unit 2: Classification of medicinal plants - Vernacular name and family - Geographical source, cultivation, collection, and processing for market and commerce in crude drugs, Morphological and histological studies, chemical constituents - Therapeutic and other pharmaceutical uses. Underground stem - ginger, Alpinia - Roots - Rauolfia - Belladonna - Aerial parts - Bark - Cinchona.

Unit 3: Leaves - Adathoda, Eucalyptus; Flower - Clove fruits seeds - Nux vomica Nutmegs, Gooseberry - unorganized drugs - Gum - Acacia - Resin - Turpentine, fixed oil - castor oil.

Unit 4: Herbal medicines for Human ailments - Drugs acting on cardiac diseases, cerebral diseases, Nasal, diseases - Blood pressure Drugs acting on Nervous system Depressants, - stimulants - Respiration and Drugs - Urogenital system and drugs

Unit 5: Propagation of medicinal plants - Micro and macro propagation conservation of rare medicinal plants Role of biotechnology in medicinal plants banks - cultivation of medicinal and aromatic plants. Herbal food - Food processing - packaging - Herbal sale and Export of medicinal plants - marketing - Intellectual property rights

Suggested readings

- Arber, A. (1999). Herbal plants and Drugs. Mangal Deep Publications.
- Chopra, R.N., Nayar S.L. and Chopra, I.C. (1956). Glossary of Indian Medicinal Plants, C.S.I.R., New Delhi.
- Green, A. (2000). Principles of Ayurveda, Thomsons, London.
- Kokate, C.K. (1999). Pharmacognosy, Nirali Prakashan.
- Miller, L. and Miller, B. (1998). Ayurveda and Aromatherapy. Banarsidass, Delhi.
- Sivarajan V.V. and Balachandran I. (1994). Ayurvedic drugs and their plant source. Oxford IBH publishing Co.

Minor Courses (Traditional)

MN- 101: Biodiversity (Microbes, Algae, Fungi & Archegoniate)

Unit 1: Microbes

Viruses -Discovery, general structure, replication (general account), DNA virus (T- phage); Lytic & lysogenic cycle, RNA virus (TMV); Economic importance; Bacteria -Discovery, General characteristics & cell structure; Reproduction -vegetative, asexual & recombination (conjugation, transformation and transduction); Economic importance

Unit 2: Algae

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

Unit 3: Fungi

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) *Penicillium* (Ascomycota), *Agaricus* (Basidiomycota); Symbiotic Associations-Lichens: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance

Unit 5: Bryophytes

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*. Alternation of generation

Unit 6: Pteridophytes

General characteristics, classification, Early land plant (*Rhynia*). Classification (up to family), morphology, anatomy and reproduction of *Selaginella*, *Pteris*. (Developmental details not to be included). Heterospory and seed habit, stellar evolution. Ecological and economical importance of Pteridophytes.

Unit 7: Gymnosperms

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

Practical

1. EMs/Models of viruses—T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
2. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary Fission; Conjugation; Structure of root nodule.
3. Gram staining
4. Study of vegetative and reproductive structures of *Nostoc*, *Chlamydomonas* (electron micrographs), *Oedogonium*, *Vaucheria*, *Fucus** & *Polysiphonia* through temporary preparations and permanent slides. (* *Fucus* -Specimen and permanent slides)
5. *Rhizopus* and *Penicilium*: Asexual stage from temporary mounts and sexual structures through permanent slides.
6. *Agaricus*: Specimens of button stage and full grown mushroom; Sectioning of gills of *Agaricus*.
7. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
8. Mycorrhiza: ecto mycorrhiza and endomycorrhiza (Photographs)
9. *Marchantia*-morphology of thallus, w.m. rhizoids and scales, v.s. thallus through gemma cup, w.m. gemmae (all temporary slides), v.s. antheridiophore, archegoniophore, Ls. sporophyte (all permanent slides).
10. *Funaria*-morphology; w.m. leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, L.S capsule and protonema.
11. *Selaginella*-morphology, w.m. leaf with ligule, t.s. stem, w.m. strobilus, w.m. microsporophyll and megasporophyll (temporary slides), L.S strobilus (permanent slide)
12. *Pteris*-morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores (temporary slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide).
13. *Cycas*-morphology (coralloid roots, bulbil, leaf), t.s coralloid root, t.s. rachis, v .s. leaflet, v.s. microsporophyll, w.m. spores (temporary slides), l.s ovule, t.s. root (permanent slide).
14. *Pinus*-morphology (long and dwarf shoots, w.m. dwarf shoot, male and female), w.m.dwarf shoot, t.s. needle, t.s. stem, , l.s./t.s. male cone, w.m. microsporophyll, w.m. microspores (temporary slides), Ls. female cone, t.l.s. & r.Ls. stem (permanent slide).

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 & 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

MN-301: Plant Ecology and Taxonomy

Unit 1: Introduction to the Biosphere

Inter-relationships between the living world and the environment, the components and dynamism, homeostasis.

Unit 2: Ecological factors

Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance. Adaptation of hydrophytes and xerophytes

Unit 3: Plant communities

Characters; Ecotone and edge effect; Succession; Processes and types

Unit 4: Ecosystem

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

Principle biogeographical zones; Endemism

Unit 6: Basics of taxonomy

Introduction to plant taxonomy Identification, Classification, Nomenclature.

Unit 7: Identification

Herbarium techniques and functions of Herbaria, important herbaria and botanical gardens of the world and India.

Unit 8: Botanical nomenclature

Principles and rules (ICN); ranks and names; binominal system, typification, author citation valid publication, rejection of names, principle of priority and its limitations.

Unit 9: Classification

Types of classification artificial, natural & phylogenetic. Bentham and Hooker (upto series), Engler & Prantl (upto series).

Practical

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum & minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH & analysis of two soil samples for carbonates, chlorides, nitrates, sulphites, organic matter & base deficiency by rapid field test.
3. Comparison of bulk density, porosity and rate of infiltration of water in soil of three habitats.
4. (a) study of morphological adaptations of hydrophytes and xerophytes (four each).
(b) study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobancha*), Epiphytes, Predation (Insectivorous plants)
5. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. (species to be listed)
6. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law
7. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formulae and systematic position according to Bentham & Hooker's system of classification): Brassicaceae, Asteraceae, Solanaceae, Lamiaceae and Liliaceae.
8. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book).

Suggested Readings

1. 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.
4. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition

MN-501: Plant Anatomy and Embryology

Unit 1: Meristematic & permanent tissues

Root and shoot apical meristems; Simple and complex tissues

Unit 2: Organs

Structure of dicot and monocot root stem and leaf.

Unit 3: Secondary Growth

Vascular cambium -structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood)

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

Unit 5: Structural organization of flower 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

Pollination mechanisms and Double fertilization; Seed-structure appendages and dispersal mechanisms.

Unit 7: Embryo and endosperm

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

Unit 8: Apomixis and polyembryony

Definition, types and Practical applications

Practical

- 1 Study of meristems through permanent slides and photographs
- 2: Tissues (parenchyma, collenchyma and sclerenchyma, Phloem (Permanent slides, photographs)
- 3 Stem: Monocot: Zea mays; Dicot: Helianthus ; Secondary: Helianthus (only Permanent slides).
- 4.Root: Monocot: Zea mays; Dicot: Helianthus (only Permanent slides).
5. Leaf: Dicot and Monocot leaf (only permanent slides)
6. Adaptive anatomy: Xerophyte (Nerium leaf) ; Hydrophyte (Hydrilla stem)
7. Structure of anther (young & mature), tapetum (amoeboid and secretory) (permanent slides)
- 8.Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous
- 9.Female gametophyte: Polygonum (monosporic) type of Embryo sac Development (permanent slides / photographs).
- 10.Ultrastructure of mature egg apparatus cells through electron micrographs.
- 11.Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) (Photographs & specimens)
- 12.Dissection of embryo/endosperm from developing seeds
- 13.Calculation of percentage of germinated pollen in a given medium

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.

MN-701: Plant Physiology and Metabolism

Unit 1: Plant-water relations

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

Unit 2: Mineral nutrition

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.

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

Unit 4: Photosynthesis

Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration.

Unit 5: Respiration

Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate Oxidative Pentose Phosphate Pathway.

Unit 6: Nitrogen metabolism

Biological nitrogen fixation; Nitrate and ammonia assimilation.

Unit 7: Plant growth regulators

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

Unit 8: Plant response to light and temperature

Photoperiodism (SDP, LDP, Day neutral plants); Vernalisation

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. Demonstrate the activity of catalase and study the effect of pH and enzyme concentration.
6. To study the effect of light intensity and bicarbonate concentration on O₂ evolution in photosynthesis.
7. Comparison of the rate of respiration in any two parts of a plant.
8. Separation of amino acids by paper chromatography.

Demonstration experiments (any four)

1. Bolting.
2. Effect of auxins on rooting.
3. Suction due to transpiration.
4. R.Q.
5. Respiration in roots

Suggested Readings

1. Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th 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.