

**University of Rajasthan
Jaipur**

SYLLABUS

M.Sc.

(BOTANY)

2015-2016 (I & II SEMESTER)

2016-2017 (III & IV SEMESTER)

UNIVERSITY OF RAJASTHAN
JAIPUR

M. Sc. BOTANY
SYLLABUS SEMESTER SCHEME

2015-2017

M. Sc. Botany Semester Scheme 2015-17


Asst. Registrar (Acad-I)
University of Rajasthan
JAIPUR

   
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- M. Sc. (Botany) semester scheme will be spread over two academic years consisting of four semesters, two semesters each in M. Sc. Previous (Semester I and Semester II) and M. Sc. Final (Semester III and Semester IV). The course of all the four semesters shall be of 136 credits i.e., each semester of PG course shall offer 34 credits. The candidate is required to earn a minimum of 120 credits.
- In theory, 15 hrs of theory teaching will be equivalent to one credit.
- In practical, 45 hrs of laboratory work will be equivalent to 2 credits.
- Practical classes will be of 4 hours duration /day.
- Each semester will have continuous assessment which will include internal assessment in theory and practical by internal examination (70 marks) and overall performance assessed by seminar/oral examination- viva voce. Attendance /Classroom Participation/Quiz/Home Assignment etc. (30 marks) and the maximum marks will be 100.
- Syllabi tour during III semester shall be compulsory. Students are required to submit 10 herbarium sheets of plant collection made in the excursion. This will carry 10 marks to be allotted out of 15 marks assigned for records.

FIRST- SEMESTER

S. No.	SUBJECT CODE	Course Title	Course Category	Credit	Contact hours per week			EoSE duration (Hrs.)	
					L	T	P	Theory	P
1.	BOT 101	Algae, Fungi and Bryophyta	CCC	4.5	4	0.5	0	3	0
2.	BOT 102	Cell Biology	CCC	4.5	4	0.5	0	3	0
3.	BOT 103	Microbiology	CCC	4.5	4	0.5	0	3	0
4.	BOT 104	Plant Ecology	CCC	4.5	4	0.5	0	3	0
5.	BOT 111	Practical-I (BOT 101, BOT 102)	CCC	8	0	0	12	0	4
6.	BOT 112	Practical-II (BOT 103, BOT 104)	CCC	8	0	0	12	0	4

EoSE: End of Semester Examination

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SECOND- SEMESTER

S.No.	SUBJECT CODE	Course Title	Course Category	Credit	Contact hours per week			EoSE duration (Hrs.)	
					L	T	P	Theory	P
1.	BOT 201	Genetics and Plant Breeding	CCC	4.5	4	0.5	0	3	0
2.	BOT 202	Pteridophyta, Gymnosperm and Paleobotany	CCC	4.5	4	0.5	0	3	0
3.	BOT 203	Principles of Plant Pathology	CCC	4.5	4	0.5	0	3	0
4.	BOT 204	Plant Physiology and Metabolism	CCC	4.5	4	0.5	0	3	0
5.	BOT 211	Practical-I (BOT 201, BOT 202)	CCC	8	0	0	12	0	4
6.	BOT 212	Practical-II (BOT 203, BOT 204)	CCC	8	0	0	12	0	4

THIRD- SEMESTER

S. No.	SUBJECT CODE	Course Title	Course Category	Credit	Contact hours per week			EoSE duration (Hrs.)	
					L	T	P	Theory	P
1.	BOT 301	Molecular Biology	CCC	4.5	4	0.5	0	3	0
2.	BOT 302	Taxonomy of Angiosperms	CCC	4.5	4	0.5	0	3	0
3.	BOT 303	Plant Morphology and Developmental Anatomy	CCC	4.5	4	0.5	0	3	0
4.	BOT 304 A-F	Core Elective Course	ECC	4.5	4	0.5	0	3	0
5.	BOT 311	Practical-I (BOT 301, BOT 302 & BOT 303)	CCC	12	0	0	18	18	6
6.	BOT 312	Practical-II (BOT 304)	ECC	4	0	0	6	6	4

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FOURTH- SEMESTER

S. No.	SUBJECT CODE	Course Title	Course Category	Credit	Contact hours per week			EoSE duration (Hrs.)	
					L	T	P	Theory	P
1.	BOT 401	Plant Reproductive Biology	CCC	4.5	4	0.5	0	3	0
2.	BOT 402	Plant Resource Utilization and Ethnobotany	CCC	4.5	4	0.5	0	3	0
3.	BOT 403	Plant Biotechnology and Genetic Engineering	CCC	4.5	4	0.5	0	3	0
4.	BOT 404 A-F	Core Elective Courses	ECC	4.5	4	0.5	0	3	0
5.	BOT 411	Practical-I (BOT 401, BOT402 & BOT 403)	CCC	12	0	0	18	0	6
6.	BOT 412	Practical-II (BOT 404)	ECC	4	0	0	6	0	4

❖ Out of 6 elective papers, Candidates will be allotted one elective papers based on choice cum merit basis.

Elective Core Courses:

Specialization Clusters

- A. Advanced Plant Pathology
- B. Seed Science and Technology
- C. Ecosystem Ecology & Environmental Biology
- D. Advanced Plant Physiology
- E. Advanced Morphology & Morphogenesis
- F. Biosystematics of Angiosperm

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Scheme of Examination

- Each theory paper shall carry 100 marks and will be of 3 hrs duration. Minimum passing marks shall be 36.
- The theory question paper will be divided into two parts A and B. Part A of question paper shall be compulsory and contain 10 (ten) very short answer type questions covering entire syllabus. Each carrying 2 (two) marks, with a total of 20 marks.
- Part B of question paper will have 4 questions having 100% internal choice. Each question will carry 20 marks, with a total of 80 marks.
- Each Practical examination will be of four six hour duration and involve laboratory experiments/ exercises, and viva-voce examination and record in the ratio of 75: 25 (i.e. 15% for record and 10% for viva). Syllabi tour during III semester shall be compulsory. Students are required to submit 10 herbarium sheets of plant collection made in the excursion. This will carry 10 marks to be allotted out of 15 marks assigned for records.
- Practical Examinations (BOT-111, 112, 211 & 212) shall be of 100 marks each, BOT-311 & 411 shall be of 150 marks and BOT 312 & 412 shall be of 50 marks each.

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BOT 101: ALGAE, FUNGI AND BRYOPHYTA

ALGAE (20 Hours)

- Algae in diversified habitats (terrestrial, freshwater and marine), thallus organization, cell ultra-structure, reproduction (vegetative asexual and sexual) classification of algae: based on pigments, cell wall composition, reserved food material and flagellation . Salient features of cyanopyta, chlorophyta, bacillariophyta, xanthophyta, pyrrhophyta, phaeophyta and rhodophyta with special reference to *Spirulina*, *Scytonema* , *Dunaliella*, *Pinnularia*, *Gonyaulax*, *Laminaria*, *Gelidium* and *Batrachospermum*:
(15 Hours)
- Economic importance of algae specially in industries, food, fodder, biofertilizers, Biofuels and algal bloom, isolation and culture of algae.
(5 Hours)

FUNGI (20 Hours)

- General characters, substrate relationship, cell ultra-structure, thallus organization, cell wall composition, nutrition (saprobic, biotrophic and symbiotic), reproduction (asexual and sexual).
(5 Hours)
- Heterothallism, heterokaryosis, Brachymeosis, parasexuality, sex hormones and recent trends in classification of fungi, phylogeny of fungi.
(5 Hours)
- General account of mastigomycotina , zygomycotina, ascomycotina, basidiomycotina and dueteromycotina with special reference to *Rhizopus*, *Peronospora* *Neurospora*, *Polyporus*, *Drechslera* and *Colletotrichum*.
(6 Hours)
- Economic importance of fungi in industries, medicines and as food, fungi as biocontrol agents, poisonous fungi, mycorrhizae.
(4 Hours)

BRYOPHYTA (20 Hours)

- Distribution, Morphology, structure, reproduction and classification of bryophytes.
(4 Hours)
- General account of marchantiales, jungermanniales, anthocerotales, sphagnales, funariales and polytrichales with special reference to *Plagiochasma*, *Notothylus*, *Sphagnum*, *Physcomitrella patens* and *Polytrichum*. (6hours)
- Fossil Bryophytes, evolutionary trends in Bryophytes. (3 Hours)
- Economic importance of Bryophyta (3 Hours)
- Role of Bryophytes in plant succession. (4 Hours)

Suggested Laboratory Exercises:

Morphological study of representative members of algae, fungi and bryophytes present in your locality in their natural habitat with special reference to:

- **Algae:** *Microcystis, spirulina, Scytonema, Ribularia, Duniella, Aulosira, Spirogyra, Pediastrum, Hydrodictyon, Ulva, Pithophora, Stigeoclonium, Gelidium* and *Batrachospermum*: Isolation and culture of algae.
- **Fungi:** *Stemonites, Paronospora, Pythium, Albugo, Rhizopus, Polobolus, Yeast, Emericella, Chaetomium, Pleospora, Morchella, Melampsora, Phallus, Polyporus, Drechslera, Curvularia, Phoma, Penicillium, Aspergillus, Colletotrichum, Fusarium* and *Alternaria*:
- Isolation and culture of fungi using moistened blotters, PDA and Sabouraud's Dextrose Agar media.
- **Bryophyta :** *Plagiochasma, Pogonatum, Pellia, Notothylus, Andreaea* and *polytrichum*

Suggested Readings:

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996). *Introductory Mycology*, John Wiley & Sons ind.
2. Anderson, R.A. (2005) *Algal Culturing Techniques*. Physiological Society of America. Elsevier Academic Press, USA.
3. Fritsch, F.E. (1993, 1945). *The structure and Reproduction of Algae Vols. I*. Cambridge University Press, Cambridge, UK.
4. Fritsch, F.E. (1945). *The Structure and Reproduction of Algae. Vol II*. University Press, Cambridge, UK.
5. Caves, F. *Inter-relationship of the Bryophyta*, *New Phytologist*, Reprint No.4.1911, Indian Reprint, S.R. Technico, Book House, Patna, 1981, pp. 212.
6. Kashyap, S.R. (1932) *Liverworts of Western Himalayas and Punjab Plains (VII. I & II)* Reserchco Publications, New Delhi, pp/ 137, pp. 129.
7. Richardson, D.H.S. *Biology of Mosses*. (1981). Blackwell Scientific Publications, Oxford, pp.220.
8. Bold, H. C., Alexopoulos, C.J. and Delevoryas. T. (1980) : *Morphology of plant and fungi* (4th Ed.) Harper & Foul Co., New Work.
9. Ghemawat, M.S., Kapoor J.N., and Narayan, H.S. (1976) : *A test book of Algae*. Ramesh book Depot, Jaipur.
10. Gilbert, M Smith. *Cryptogamic Botany, Vol. I & II* (2nd Ed.)(1985). Tata McGraw Hill. Publishing Co. Ltd., New Delhi.
11. Puri, P. *Bryophytes*. (1985). Atmaram & sons. Delhi. Lucknow.
12. Sharma, P.D. (1996). *Introduction to Bryophytes* Ramesh Book Depot, Jaipur.

BOT 102: Cell Biology

The Dynamics of cell, shape and motility: Structural organization of the plant cell, Cytoskeleton, microtubules and microfilaments, motor and flagellar movements.

(3)

Cell wall, plasma membrane and plasmodesmata: Structure and functions, biogenesis, growth models and functions, ion carriers, channels and pumps, receptors. Role in movement of

molecules and macromolecules across membranes, comparison with gap junctions. (4)

Other Cellular organelles: Structure and functions of micro-bodies, Golgi apparatus, ribosomes, lysosome, endoplasmic reticulum.

Plant vacuole: Structure and function (6)

Chloroplast and mitochondria: Fine Structure and function of the organelles, their electron transport systems, import of nuclear encoded proteins, ATP synthases, structure, organization and function of mitochondrial and chloroplast genomes, mechanism of organelle gene expression, diversity and evolution of organelle genomes. (6)

Nucleus: Structure, nuclear envelope (karyotheca), nuclear pores, nuclear lamina, nucleolus and nuclear matrix. (2)

Chromatin organization : Chromosome structure and packaging of DNA, nucleosome organization, molecular organization of centromere and telomere, nucleolus and ribosomal RNA genes, euchromatin and heterochromatin, specialized types of chromosomes, polytene, lampbrush, B-chromosomes, supernumerary chromosomes, molecular basis of chromosome pairing. (6)

Cell Cycle and Mechanics of cell division: Cell cycle control mechanisms -Negative and Positive intra & extra cellular controls, Role of cyclins & cyclin depended kinases (CDKs). Cytokinesis and cell plate formation; The events of m phase, CDK & cyclin B leading to Metaphase. The spindle assembly check points leading to Anaphase. DNA damage check point controlled by P 53 protein. Map & mitogen-activated protein kinase (MAPK) : Erk1 & Erk2, Ras (mitogen activated protein kinases). (8)

Mechanism at different stages of mitosis: Cohesins and condensins in chromosome segregation, Microtubules in spindle assembly, Structure of kinetochore, centrosome and its functions, Sister Chromatid separation. Cytokinesis actin & myosin in the generation of contractile ring, somatic metaphase. (5)

Meiosis- Significance, Chiasma formation- Synaptonemal complex, Recombination during meiosis- Recombination nodules. (2)

Apoptosis: Apoptosis (Programmed cell death): Mechanism of apoptosis, Apoptosis triggered by internal & external signals, Apoptosis inducing factors, cancer, oncogenesis & its mutations. (4)

Cell communication and Signal transduction: Overview of extra cellular signaling signal molecules- hormones, neurotransmitter proteins, environmental factors

Second messengers and their role in signal transduction - lipid and phosphatidyl inositol derived second messengers & Role of calcium as second messenger (6)

Cell surface receptors in signal transduction: G-protein coupled receptor – structure and function, Ion channel receptors, Tyrosine kinase linked receptors, Receptors with intrinsic enzyme activity (RTK). (5)

Interaction and regulation of cell signaling pathways - bacterial and plant two component signaling system, bacterial chemotaxis and quorum sensing and Biofilm. (4)

Suggested Laboratory Exercises

kp Archer PL 22 WA

1. EM study of cell organelles
2. Fluorescence staining with FDA for cell viability.
3. Cell wall staining with calcofluor white
4. Study of stages in cell cycle
5. Mitosis and Meiosis
6. Histochemical localization of protein, carbohydrate, fats, starch, lignin, nucleic acids
7. Isolation of mitochondria and the activity of its marker enzyme, succinate dehydrogenase (SDH).
8. Isolation of chloroplast and study of its percentage intactness
9. Isolation of chloroplast and study of light reaction system.
10. Demonstration of SEM and TEM.
11. Karyotype analysis.
12. Polytene, lampbrush, B-chromosomes and sex chromosomes,
13. Preparation of Polytene chromosome from *Chironomous larva/Drosophila larva*
14. Orcein and Feulgen staining of the salivary gland chromosomes of *Chironomas* and *Drosophila*.
15. Characteristics and behavior of B chromosomes using maize or any other appropriate material.
16. Any other practical based on theory syllabus.

Suggested readings:

1. Krishnamurthy, K.V. (2000). *Methods in Cell Wall Cytochemistry*. CRC Press, Boca Raton, Florida.
2. Reeve, ECR. (2001). *Encyclopedia of Genetics*, F. D. Publication, Chicago, USA
3. De, DN. (2000). *Plant Cell Vacuoles: An Introduction*. CSIRO Publication, Collingwood, Australia.
4. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. (VIII Edition). Lippincott Williams and Wilkins, Philadelphia.
5. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. (V Edition).. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
6. Becker. W.M., Kleinsmith, L.J., Hardin, J. and Bertoni, G. P. (2009). *The World of the Cell*. (VII Edition). Pearson Benjamin Cummings Publishing, San Francisco.
7. Kleinsmith, L.J. and Kish, V.M. (1995). *Principles of Cell and Molecular Biology* (2nd Edition). Harper Collins College Publishers, New York, USA.
8. Harris, N. and Oparka, K.J. (1994). *Plant Cell Biology: A Practical Approach*. IRL Press, at Oxford University Press, Oxford, U.K.
9. Gunning, B.E.S. and Steer, M.W. (1996). *Plant Cell Biology: Structure and Function*. Jones and Bartlett Publishers. Boston, Massachusetts.
10. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley & Sons. Inc.

11. Griffiths, A.J.F. et. al.(2000). An introduction to genetic analysis, W. H. Freeman and Company, New York, USA.
12. Rana, S.V.S., (2012). Biotechniques, theory and practices (Third edition). Rastogi publications, Meerut.
13. Hall, J.E. and Moore, A.L. (1983). Isolation of Membranes and Organelles from Plant Cells. Academic Press, London, UK.
14. Roy, S.C. and De, K.K. (1999). Cell Biology. New Central Book Agency (P) Ltd., Calcutta.
15. Hartl, D. L. (1994). Genetics. Jones and Bartlett Publishers International, USA.

BOT 103: Microbiology

Introduction and classification:

History, scope and developments since 20th century. Bergey's manual of systematic bacteriology. Nutritional classification of microorganisms. Modern trends in classification (ribotyping, nucleic acid hybridization, RNA fingerprinting, molecular chronometer).

8 hrs.

Microbial diversity: Occurrence, salient features of following: Gram negative bacteria, spirochaetes, aerobic, anaerobic and microaerophilic bacteria, rickettsias and anoxygenic phototrophs, oxygenic phototrophs, mycobacteria, actinomycetes, chlamydias, mycoplasma, archebacteria, methanogens, extremophiles- halophiles and thermophiles.

10 hrs.

Microbial toxins: Pathogenic types of toxins (exotoxin, endotoxin and entrotoxin), non specific and specific defense mechanisms.

2 hrs.

Morphology, ultra structure and cultivation of bacteria: Morphology and ultra structure of bacteria, cytoplasmic inclusions, plasmids and endospores, anareobic and aerobic culture media, growth curve, growth kinetics, batch, continuous culture, growth measurements and pure culture techniques.

10 hrs.

Viruses: Classification and nomenclature with cryptograms, properties and structure of viruses, life cycle and pathogenesis of following: RNA viruses-retero, rhabdo, hepatitis, swine flu: DNA viruses- Pox, herpes, measles: Plant viruses-cauliflower mosaic and turnip yellow mosaic.

8hrs.

Immunology: General account of immunity, properties of antigens and antibodies, antibody structure and function, affinity and antibody specificity, monoclonal antibodies and their uses, antibody engineering, serology, vaccination and vaccines, interferon.

6 hrs.

Microbial association: symbiotic nitrogen fixation, syntrophy, bioluminescence, mycorrhiza, VAM fungi and plant growth promoting rhizobacteria (PGPR).

4 hrs.

Application of microbiology : Agriculture and waste management: Food microbiology: specially in contamination and spoilage of food products, application of microbial enzymes in food industries, microbiology of fermented milk products and food preservation methods. Industrial microbiology: industrial production of alcohols, organic acids, amino acids, enzymes, antibiotics, mineral recovery, Biodegradation, bioremediation and biodeterioration. Preliminary account of biofilms, biochips, biosensors and biosurfactants.

12 hrs.

Suggested Laboratory Exercises

1. Preparation of culture media-liquid and solid media, enrichment, selective, preparation of slant, deep tube and plate culture.
2. Isolation of pure culture by pour plate, serial dilution and streak plate method.
3. Study of growth curve.
4. Effect of pH, temp, osmolarity and Oxygen, UV, dessication on growth of bacteria.
5. Sterilization methods.
6. Methods of quantitative estimation of microorganisms.
7. Total counts (haemocytometer method), viable counts (plate count), WBC and RBC counts.
8. Methods of staining bacteria (simple staining, Gram's staining, negative staining)
9. Endospore staining.
10. Fermentative production of ethyl alcohol by Yeast.
11. Extraction and detection of aflatoxin in infested foods.
12. Blood grouping and Rh factor.
13. Haemoglobin estimation.
14. To study spontaneous mutations by replica plating.
15. To study induced mutations in bacteria.
16. Antibiotic bioassay (gradient plate technique and disc method).
17. Testing of milk by MBRT, turbidity test for milk.
18. Qualitative estimation of Phosphorus and Calcium in milk.
19. Determination of most probable number (MPN).
20. Coliform test for milk water.
21. Isolation of microorganisms from air, water, soil and rhizosphere microflora.

Suggested readings:

1. Frazier, W.C. and Westhoff, D.C. (1998). Food Microbiology, Tata Mc Graw Hill Publishing Company Ltd, New Delhi.
2. Reed, G. 2004 (5th Ed.) Industrial Microbiology, CBS Publishers, AVI Publishing Company New Delhi.
3. Edward, D. Schroeder, Juana, B. Eweis, 1998. Bioremediation principles, Tata Mc Graw Hill, Publishing Company Ltd, New Delhi.

4. Stanier, R.Y., Ingraham, John L. and Mark L. Wheelispagex. 1992. General Microbiology. Mc Millan Press, UK.
5. Atlas, Ronald, M. 1997 Principles of Microbiology. Tata Mc Graw Hill, Publishing Company Ltd. New Delhi.
6. Peleczar, Michael J., Chan, E.L.S. and Krieg, N.R. 1996 Microbiology, Tata Mc Graw Hill, Publishing Company Ltd., New Delhi.
7. Michael, J. Madigan, Martinko, John M. and Parker, Jack 2010 (13th Ed.) Brock's Biology of Microorganisms. Prentice Hall, US.
9. Black, J.G. 1995. Microbiology principles and applications. John Wiley, Prentice Hall, U.S.
10. Michael, R. 1999. Introduction of Environmental Microbiology. ASM books, Washington Dc.
11. Graham, Sir, Wilson, S. and Miles, Sir Ashley. Vol.I. Principles of Bacteriology, Virology & Immunity. 1975 (6th Ed.). Edward Arnold Publishers Ltd., London.
12. Collins, C.H. and Patricia, M. Lyne 1976. Microbiological methods. Butter worth and co. publisher Ltd., Bostan. US.
13. Maier, Raina M. Pepper, Lan L, Gerba, Charles P., 2009 (IIND edition) Environmental Microbiology. Academic press Elsevier. London. UK.

BOT 104: Plant Ecology

Science of Ecology: Introduction to ecology, evolutionary ecology, ecological models:
Population: Characteristics of population, population size and exponential growth, limits of population growth, population dynamics, life history pattern, fertility rate and age structure, population growth, Competition and coexistence, intra-specific interactions, interspecific interactions, scramble and contest competition model, mutualism, commensalism and allelopathy, prey-predator interactions.

25 hours

Vegetation organization: Concepts of community and continuum, community coefficients, interspecific associations, ordination, species diversity and pattern diversity in community, concept of habitat and ecotone, ecological niche.

Vegetation development: Temporal changes (cyclic and non-cyclic), mechanism of ecological succession (relay floristic and initial floristic composition), succession models (facilitation, tolerance and inhibition models), Changes in ecosystem properties during succession, concept of climax.

20 hours

Ecosystems: Nature and size of ecosystem, components of an ecosystem (producers, consumers and decomposers), Grazing (grassland) and Detritus food chain in freshwater ecosystems, food webs, Ecological energetic: Solar radiation and energy intakes at the earth's surface, energy flow models, Productivity of various ecosystems of the world and global biogeochemical cycles of carbon and nitrogen, Ecosystem Management: Homeostasis and cybernetics of ecosystem, Resilience of ecosystem, Restoration of degraded ecosystems, ecology of plant invasion, Ecosystem services. **20 hours**

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Biomes, Biodiversity & Conservation: Major biomes of the world and Impact of changing climate on biomes. Biodiversity assessment (local, national and global), loss of diversity, conservation (ex-situ and in situ) and management. International Conservational organizations, biodiversity act of India and related international conventions. Diversity indices, sustainable development, natural resource management in changing environment, molecular ecology, genetic analysis of single and multiple population, molecular approach to behavioural ecology, conservation genetics. **25hours**

Suggested Readings

1. Smith, R.L. 1996. Ecology and Field Biology. Harper Collins, New York.
2. Muller-Dombois, D. and Ellenberg, H. 1974. Aims and Methods of Vegetation Ecology, Wiley, New York.
3. Begon, M. Harper, J.L. and Townsend, C.R. 1996. Ecology, Blackwell Science, Cambridge, U.S.A.
4. Ludwig, J. and Reynolds, J.F. 1988. Statistical Ecology, John Wiley & Sons.
5. Odum, E.P. 1971. Fundamentals of Ecology. Saunders, Philadelphia.
6. Odum, E.P. 1983. Basic Ecology, Saunders, Philadelphia.
7. Barbour, M.G., Burk, J.H. and Pitts, W.D. 1987. Terrestrial Plant Ecology, Benjamin/Cummings Publication Company, California.
8. Kormondy, E.J., 1996. Concepts of ecology, Prentice-Hall of India Pvt. Ltd., New Delhi.
9. Chapman, J.L. and Reiss, M.J. 1988. Ecology, Principles and Applications. Cambridge University Press, Cambridge, U.K.
10. Molan, B. and Billharz, S. 1997. Sustainability Indicators, John Wiley Sons, New York.
11. Heywood, V.H. and Watson, R.J. 1985. Global Biodiversity Assessment, Cambridge University Press.
12. N.S. Subrahmanyam and A.V. S.S. Sambamurty, 2000. Ecology, Narosa Publishing House, Delhi
13. S.K. Maiti, 2004. Handbook of Methods in Environmental Studies Vol. 1 &2. ABD Publisher, Jaipur.
14. J. L. Chapman and M. J. Reiss, 1995. Ecology principles and applications, Cambridge University Press.
15. C. Faurie, C. Ferra, P. Medori and J. Devaux, 2001. Ecology Science & Practice, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
16. G.T. Miller Jr. 2005. Essentials of Ecology, III Edition, Thomson, Brooks/Cole

Suggested Laboratory Exercises

1. To determine minimum size and number of quadrat required for reliable estimate of biomass in grasslands
2. To compare protected and unprotected grassland stands using community coefficients (similarity indices).
3. To estimate IVI of the species in a grassland woodland using quadrat method.
4. To determine gross and net phytoplankton productivity by light and dark bottle method.

5. To determine soil moisture content, porosity and bulk density of soils collected from varying depths at different locations.
6. To determine the Water holding capacity of soils collected from different locations.
7. To determine percent organic carbon and organic matter in the soils of cropland, grassland and forest.
8. To estimate the dissolved oxygen content in eutrophic and oligotrophic water samples by azide modification of Winkler's method.
9. To estimate chlorophyll content in SO_2 fumigated and unfumigated plants leaves.
10. To estimate rate of carbon dioxide evolution from different soils using soda lime or alkali absorption method.
11. To study environmental impact of a given developmental activity using checklist as a HIA method.

BOT 201 : Genetics and Plant Breeding

Gene Structure and expression: Genetic fine structure, Operon concept, Introns and Exons, cis-trans test, fine structure analysis of eukaryotes, introns and their significance, Gene family. (5)

Inheritance and allelism: Mendelian and non-Mendelian inheritance, Gene interaction: Complementary genes (9:7 ratio); Supplementary genes (9:3:4 & 9:6:1 ratios), Epistasis (12:3:1, 15:1 ratios), Duplicate genes (15:1) co-dominance, Lethal Genes, Polygenic inheritance, Extra nuclear inheritance: Cytoplasmic male sterility, inheritance of mitochondrial and chromosomal plant genes, Hardy-Weinberg Law, Gene frequency and genotype frequency, Sex determination, Mechanism, sex linked inheritance, sex limited characters and sex reversal, multiple alleles and blood groups in man, Genome imprinting (9)

Genetic recombination: Homologous and non-homologous recombinations; independent assortment and crossing over; molecular mechanism of recombination, Holiday junction, site-specific recombination, FLP/FRT and cre-lox recombination, role of Rec A and Rec BCD enzymes and other recombinations. (5)

Mutation and types of DNA damage: Mutagens and their effects – Physical (Radiations) and Chemical (Base analogues, Intercalating agents, Alkylating agents and others). Types of mutation- Spontaneous and induced mutations, lethal, conditional, biochemical, loss and gain of function, base substitution, frame-shift mutation, germinal verses somatic mutation, Mutations induced by transposons. (4)

Repair mechanisms of mutational DNA damages- Direct reversal of damages (Photoreactivation and Dealkylation), Excision Repair mechanisms (NER and BER), Post-replication repair mechanisms (Mismatch repair and Recombination repair), SOS repair, Inherited diseases and defects in DNA repair. (5)

Mutagenesis: Insertional mutagenesis, site-directed mutagenesis, *in vitro* mutagenesis and deletion techniques, Ames test for mutagenesis. Ploidy and their genetic implications.

(5)

Chromosome mapping: Linkage map, mapping with genetic markers including RAPD, QTL, construction of molecular maps, restriction mapping- concept and technique, correlation of genetic and physical maps. mapping by using somatic cell hybrids.

(6)

Structural and numerical alterations in chromosomes : Origin, meiosis and breeding behaviour of duplication, deficiency, inversion and translocation heterozygotes. Origin, occurrence, production and meiosis of haploids, aneuploids and euploids; origin and production of autopolyploids; chromosome and chromatid segregation, allopolyploids types; genome constitution and analysis. Evolution of major crop plants, induction and characterization of trisomics and monosomics.

(8)

Molecular cytogenetics : Nuclear DNA content, C-value paradox, cot curve and its significance, multigene families and their evolution, in situ hybridization - concept and techniques, computer assisted chromosome analysis, chromosome microdissection and microcloning, flow cytometry and confocal microscopy in karyotype analysis. An idea about Proteomics, Genomics and Epigenomics.

(7)

Plant Breeding

Genetic system and breeding methods: Selection and breeding strategies for self-pollinated, cross-pollinated and clonally propagated crop plants, breeding for crop quality, biotic and abiotic stresses, gene pyramiding for multi-trait incorporation. Genetic control and manipulation of breeding systems including male sterility and apomixis.

(6)

Suggested Laboratory Exercises:

1. Study of Hardy-Weinberg Law using simulations.
2. Linear differentiation of chromosomes through banding techniques, such as G-banding, C-banding and Q-banding.
3. Silver banding for staining nucleolus-organizing region, where 18S and 28S rRNA are transcribed.
4. Working out the effect of mono- and trisomy on plant phenotype.
5. Induction of polyploidy using colchicine.
6. Different applications of Colchicine.
7. Study of variations in plants due to numerical alterations in chromosomes.

8. Isolation of chlorophyll mutants following irradiation and treatment with chemical mutagens.
9. Numericals based on inheritance and gene interactions.
10. Flow cytometry and confocal microscopy
11. Any other practical based on theory syllabus.

Suggested Readings:

1. Atherly, AG., Girton. JR. and McDonald, JF. (1999). The Science of Genetics. Saunders College Publishing, Fort Worth, USA.
2. Burnham, CR. (1962). Discussions in Cytogenetics. Burgess Publishing Co. Minnesota.
3. Busch, H. and Rothblum, L. (1982). Volume X. The Cell Nucleus rDNA Part A. Academic Press.
4. Hartl, DL. and Jones, EW. (1998). Genetics: Principles and Analysis (4th edition). Jones & Bartlett Publishers, Massachusetts, USA.
5. Khush, GS. (1973). Cytogenetics of Aneuploids. Academic Press, New York, London.
6. Russel, P.J. (1998). Genetics (5th edition). The Benjamin/Cummings Publishing Company INd., USA.
7. Fukui, K. and Nakayama, S. (1996). Plant Chromosomes: laboratory Methods. CRC Press, Boca ratan, Florida.
8. Sharma, AK. and Sharma, A. (1999). Plant Chromosome Analysis, Manipulation and Engineering. Hoarwood Academic Publisher. Australia.
9. Acquaah G. (2007). Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd.USA
10. Allard RW (1999). Principles of Plant Breeding (2nd Edition), John Wiley and Sons,
11. Gardner, EJ., Simmons, MJ., Snustad, DP. (2008). Principles of Genetics (VIII ed). John Wiley & Sons.
12. Snustad, D.P. and Simmons, M.J. (2009). Principles of Genetics (V Edition). John Wiley and Sons Inc. USA.
14. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics (XI Edition). Benjamin Cummings Publishing Company INd., USA.
15. Russell, P. J. (2009). Genetics - A Molecular Approach.(III Edition). Benjamin Cummings Publishing Company INd., USA.
- 15 .Griffiths, AJF., Wessler. SR., Lewontin, RC. and Carroll, SB. (2008). Introduction to Genetic Analysis (IX Edition). W. H. Freeman & Co.
16. Pevsner, J. (2009). Bioinformatics and Functional Genomics (II Edition). John Wiley & Sons.

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BOT 202: Pteridophytes, Gymnosperms and Paleobotany

Pteridophytes: Distribution, classification by International Committee of Botanical Nomenclature (ICBN), Economic importance of Pteridophytes.

General account of fossil Pteridophytes, Psilopsida, Lycopsidea, Sphenopsida and Pteropsida classes.

Morphology, anatomy, reproduction, classification, life history of: *Tmesipteris*, *Lycopodium*, *Gleichenia*, *Isoetes*, *Ophioglossum* and *Azolla*.

Origin and evolution of stele, heterospory and seed habit. **20 hrs**

Gymnosperms: Distribution, morphology, anatomy, reproduction; classification, life history and evolution. Cycadales (*Zamia*), Ginkgoales (*Ginkgo*), Coniferales (*Pinus*, *Taxus*, *Araucaria* and *Biota*), Welwitschiales (*Welwitschia*), Gnetales (*Gnetum*).

20 hrs

Paleobotany: History of paleobotany, formation and types of fossils, techniques of study of fossils, Geological time scale. Brief account of Pteridospermales (*Lygenopteris*, *Medullosa*, *Caytonia* and *Glossopteris*). Brief account of Cycadeoidales (Cycadeoidea), Cordaitales (Cordaitea).

Paleobotany and the evolution of vascular plants.

Applied aspects of paleobotany, use in coal and petroleum exploration. **20 hrs**

Suggested Laboratory Exercises:

Morphological and anatomical study of representative members of Pteridophytes and Gymnosperms in their natural habitat found in your locality with special reference to, *Lycopodium*, *Isoetes*, *Gleichenia*, *Ophioglossum* and *Azolla* in Pteridophytes.

Zamia, *Ginkgo*, *Pinus*, *Taxus*, *Araucaria*, *Biota* and *Gnetum* in Gymnosperms.

Collection and study of fossils.

Suggested Readings:

1. Parihar, N.S. 1996. Biology & Morphology of Pteridophytes. Central Book Depot, Allahabad.

2. Sporne, K.K. 1991. The Morphology of Pteridophytes. B.I. Publishing Pvt. Ltd., Bombay.

3. Stewart, W.N. and Rathwell, G.W. 1993. Paleobotany and the Evolution of Plants. Cambridge University Press, UK.

4. Bhatnagar, S.P. and Moitra, A. 1996. Gymnosperms. New Age International Pvt. Ltd., New Delhi.

5. Singh, H. 1978. Embryology of Gymnosperms. Encyclopaedia of Plant Anatomy X. Gebruder Borntraeger, Berlin, Germany.

- 6 Smith, G.M. 1955. Cryptogamic Botany Vol II Tata McGraw Hill Book Co, NY.
- 7 Pandey, B.P.1993. College Botany. Vol. II. S. Chand and Company Ltd., New Delhi.
- 8 Arnold, Chester, A. 2000. An Introduction to Paleobotany. Agrobios, (India).
- 9 Rashid.A.2001.An introduction to Pteridophyta(II edition). Vikas publishing house, Pvt. Ltd., New Delhi.
- 10 Sunderrajan,S (2007), Introduction to Pteridophyta, New Age International Publishers, New Delhi.

BOT 203: Principles of Plant Pathology

- **Plant diseases:** Introduction and General Account of disease development History of plant pathology Nature and concept of Plant Disease and evolution of parasitism. Symptoms of Plant Diseases caused by plant pathogen. **(13 Hrs)**
- **Pathogenesis:** Biotic and Abiotic factors in pathogenesis, pathogen factors in disease development. Penetration, infection. Enzymes and Toxin in Plant Disease –Host specific and non-host specific toxin, Concept of Effectors. **(15Hrs)**
- **Disease Development:** Modes of infection, Mechanism of Penetration of Pathogens. Protective and defense mechanism in plants-Morphological and Biochemical(10Hrs)
- **Management of Plant disease:** Physical ,Chemical and Biological Biopesticides, Plant Disease Clinics **(12Hrs)**
- **Symptomology, Identification and Control of Following Plant Diseases: (20Hrs)**
 - Fungal diseases:**
 - Wheat - Flag smut, Karnal bunt.
 - Rust of Linseed
 - Tikka disease of Groundnut
 - Bacterial diseases:**
 - Wheat: Tundu disease
 - Black rot of Crucifer
 - Viral diseases:**
 - ,Cadang –Cadang disease of Coconut
 - Leaf Curl of Tomato
 - Nematode disease:**
 - Root Knot of Brinjal.
 - Ear Cockle of Wheat
 - Non-Parasitic Diseases**
 - Black Heart of Potato
 - Mango necrosis

Suggested Laboratory Exercises:

- Isolation of antibiotic resistant colonies by antibiotic disc method gradient plate method.
- Hanging drop method.
- Grams stain for different bacteria
- Negative staining technique of bacteria
- Determination of growth curve of bacteria
- Identification of fungal cultures
- Isolation of microorganism from soil
- Study of following disease
 1. Tikka disease of groundnut
 2. Black rot of crucifer
 3. Tundu disease of wheat
 4. Leaf curl of Tomato
 5. Root knot of Brinjal
 6. Ear cockle of wheat
 7. Mango necrosis

Suggested Readings:

1. Agrios, G.N. 2005. Plant Pathology, 5th edition. Academic Press, New York, USA.
2. Alexopoulos, C.J., C.W. Mims and M. Blackwell. 1996. Introductory Mycology, 4th edition. John Wiley and Sons, Inc., New York, USA
3. Khan, J.A. and J. Dijkstra. 2002. Plant Virus as Molecular Pathogens. The Haworth Press Inc. USA.
4. Mehrotra, R.S. and A. Agarwal. 2003. Plant Pathology. 2nd Edition. LATA McGraw Hill, Pub. Company Ltd. New Delhi.
5. Singh, R.S. 1982. Plant Pathogens: The Fungi. Oxford and IBH Publishing Company, New Delhi, India
6. Singh, R.S. 1989. Plant Pathogens: The Prokaryotes. Oxford and IBH Publ. Company, New Delhi, India.
7. Trigliano, R.N., M.F. Windham and A.S. Windham. 2008. Plant Pathology: Concepts and Laboratory Exercises, 2nd edition. CRC Press.
8. Vidhyasekram, P. 2004. Concise Encyclopedia of Plant Pathology. Food product Press and Haworth Press Inc. Binghamton, Ne

BOT 204: Plant Physiology and Metabolism

Water relations to plants: Solutions & Buffers, Chemical potential, water potential, Stomatal regulation of transpiration, Antitranspirants, Membrane transport: Passive non-mediated transport, Nernst equation, passive mediated transport, ATP-drive active transport, uniport, symport, antiport, ion channels. 10Hrs

Biomolecules: General structure, classification, properties, distribution and functions of primary metabolites (carbohydrates, proteins, amino acids, lipids) and secondary metabolites (flavonoids, alkaloids, steroids) and their role in plant defense mechanism. Ramachandran Plot for amino acids. **15Hrs**

Carbohydrate metabolism: Synthesis of carbohydrate: Photosynthetic pigments, absorption and transformation of radiant energy, (Light-harvest complex LHC) photo-oxidation, Red drop effect, Emerson enhancement effect, Photosynthetic quantum yield, Photorespiration, CAM, factors affecting photosynthesis, Industrial Photosynthesis.

Degradation of Carbohydrate: Glycolysis, Krebs cycle, Electron Transport System (ETS), Pentose phosphate pathway, Hexose monophosphate shunt, glyoxylate pathway, Glycogenesis, gluconeogenesis, Respiratory inhibitors, High energy compounds, their synthesis and utilization. **15Hrs**

N₂ metabolism - N₂ fixation symbiotic and asymbiotic, Nodule development Amino Acid Metabolism

Fat metabolism: Synthesis of long chain fatty acids, lipid biosynthesis, & oxidation. **10Hrs**

Enzymes-Discovery and nomenclature, characteristics of enzymes, Concept of holozymes, apozymes, coenzyme, Regulation of enzyme activity, mechanism of action, Michaelis, Menton equation. **5Hrs**

Plant growth regulators : (Natural and synthetic)

Chemical nature, bioassay, physiological effects and mode of action of Auxins, Gibberelins, cytokinins, abscisic acid and ethylene, Morphactins, Methylhydrazide, Strigolactones, Salicylic acid, Brassinosteroids. **5 Hrs.**

Bot 301: Molecular Biology

Genes and DNA

Evidences of DNA and RNA as the genetic material for bacteria, virus and eukaryotes Double helical structure of DNA, DNA supercoiling, Coding DNA, gene mutations, ORF, gene structure, Exons and Introns, Non-coding DNA & RNA. **05**

DNA replication, damage and repair

Initiation, Elongation and Termination, Replicons-linear, circular and D-loops, DNA polymerases, helicase, and other enzymes and proteins used in replication, coordinating synthesis of the leading and lagging strands, Okazaki fragments, topoisomerase activity, causes of DNA damage and molecular mechanisms of repair - excision repair system in bacteria and eukaryotes, base excision, recombination repair systems and SOS. **10**

Transcription, post transcriptional changes

mRNA structure, prokaryotic and eukaryotic RNA polymerases, Transcriptional factors, promoter sequences, binding sites for RNA polymerase, transcription initiation, promoter

clearance and elongation, termination, attenuation and antitermination. Role of Enhancers, repressors, mediators and silencers, transcription inhibitors.

RNA splicing and processing - capping, polyadenylation, splicing, spliceosome, mRNA stability, group I introns and transesterification, ribozymes, RNA editing. **15**

Translation

Structure of tRNA, ribosome, Genetic Code, Translation-formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, aminoacylation of tRNA, aminoacyl tRNA synthetase, and termination in Prokaryotes and Eukaryotes, translational inhibitors, Co and post translational modification of proteins. **10**

Gene regulation

Lac and Trp operones, cis and trans acting elements, eukaryotic transcription regulation: Differential gene expression, Regulation of chromatin structure (Histone modification, DNA methylation, Epigenetic Inheritance), Regulation of Transcription Initiation (Role of Transcription Factors, Enhancers), Post transcriptional regulation, gene silencing (RNA interference: effect of miRNA and siRNA), Epigenome & epigenetics **12**

DNA Cloning and Characterization

Restriction and other enzymes, Expression vectors, basic steps in gene cloning, genomic and c-DNA libraries, electrophoresis, blotting techniques (Southern, Northern and Western), gene sequencing methods (Sanger's methods & Maxam Gilbert's method), nick translation, DNA finger printing, PCR and RT-PCR, DNA microarrays, DNA- protein interaction (DNA footprinting, yeast two-hybrid system) & Cluster analysis. **08**

Suggested Readings:

1. Lewis, B. 2001. Genes X Oxford University Press, New York.
2. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1999. Molecular Biology of the Cell, Garland Publishing, Inc., New York.
3. Wolfe, S.L. 1993. Molecular and Cellular Biology. Wadsworth Publishing Co., California, USA.
4. Rost, T. et al. 1998. Plant Biology. Wadsworth publishing Co., California, USA.
5. Buchanan, B.B., Gruissem, W., and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists, Maryland, USA.
6. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J. 2000. Molecular Cell Biology (4th Edition). W.H. Freeman and Co., New York, USA.
7. Glick, B.R. and Thompson, J.E. 1993. Methods in Plant Molecular, Biology and Biotechnology. CRC Press, Boca Raton, Florida.
8. Glover, D.M. and Hames, B.D. (Eds.), 1995. DNA Cloning I: A Practical Approach, Core Techniques, 2nd edition, P.A.S. IRI Press at Oxford University Press Oxford
9. Hackett, P.B., Fuchs, J.A. and Messing, J.W. 1988. An Introduction to Recombinant

DNA Techniques: Basic Experiments in Gene Manipulation. The Benjamin Cummings Publishing Co. Inc., Menlo Park, California.

10. Shaw, C.H. (Ed.). 1988. Plant Molecular Biology: A Practical Approach. IRL Press Oxford.

11. Albert B. Bray, D., Lewis, J., Raff, M., Robert, K. and Watson, J.D. 1989., Molecular Biology of the Cell (2nd edition), Garland Publishing Inc., New York.

12. Malacinski, G.M. and Freifelder, D. 1998 : Essentials of molecular Biology (3rd edition), Jones and Bartlett Publishers, Inc., London.

See the following Review Journals:

Annual Review of Plant Physiology and Molecular Biology.

Current Advances in Plant Sciences.

Trends in Plant Sciences.

Nature Reviews: Molecular and Cell Biology

Current Biology

Suggested laboratory Exercises

1. Isolation of nuclei and identification of histones by SDS-PAGE.
2. Isolation of plant DNA and its quantitation by a spectrophotometric method.
3. Isolation of DNA, and preparation of 'cot' curve.
4. Restriction digestion of plant DNA, its separation by agarose gel electrophoresis and visualization by ethidium bromide staining.
5. Isolation of RNA and quantitation by a spectrophotometric method.
6. Polymerase Chain reaction
7. Southern blot analysis using a gene specific probe.
8. Determination of Size of DNA by comparison with DNA Ladder electrophoretically.
9. Immunological techniques: Ouchterlony method, ELISA and western blotting.

BOT 302: Taxonomy of Angiosperms

Biosystemic studies: Population concept, methods of biosystematics, biosystematics categories – Ecads, Ecotypes, coenospecies, evolution and differentiation of species – various models.
(4 Hours)

International code of botanical nomenclature: principles, rules and recommendations, Taxonomic concept: Hierarchy, species, genus, family and other categories.
(10 Hours)

Taxonomic literature: Flora, Monograph, Icones, Library, Manuals, Journals, Periodicals, Index.
(4 Hours)

Taxonomic tools and techniques: Herbarium: preparation, maintenance, utility, important national, international and local herbaria, serological, Molecular technique, GIS and Mapping biodiversity.
(10 Hours)

Taxonomic evidences: Morphology, Anatomy, Palynology, Embryology, Cytology, Phytochemistry and Genome analysis. (10 Hours)

Classification: Phenetic system: Phylogenetic- Cronquist, Dahlgren, Thorne and APG system with merits and demerits of these systems. (6 Hours)

Salient features of the groups: Polypetalae, Gamopetalae, Monochlamydae and Monocotyledons including their important families. (10 Hours)

Phylogeny of Angiosperm: Ancestors of angiosperms with special reference to *Amborella*, time and place of origin of Angiosperms, Habit of Angiosperm, primitive living angiosperm, inter relationship among the major groups of Angiosperm. (6 Hours)

Suggested Readings:

1. Cole, A.J. Numerical Taxonomy, Academic Press, London
2. Davis, P.H. and Heywood, V.H. 1973. Principles of Angiosperms Taxonomy, Robert E. Kreiger Pub. Co., New York.
3. Grant, V. 1971. Plant Specimen, Columbia University Press London.
4. Grant, W.L. 1984. Plant Biosystematics, Academic Press London.
5. Harrison, H.J. 1971. New Concepts in Flowering Plant Taxonomy, Rieman Educational Book Ltd, U.K.
6. Heslop- Harrison, J. 1967. Plant Taxonomy, English Language Book Soc. & Edward Arnold Pub. Ltd, U.K.
7. Heywood, V.H. And Moore, D.M. 1984. Current Concepts in Plant Taxonomy, Academic Press, London.
8. Jones, A.D. and Wilbins, A.D. 1971. Variations and Adaptations in Plant Species, Hiemand & Co., New York.
9. Jones, S.B. Jr and Luchsinger, A.E. 1986. Plant Systematic (2nd Edition), Mc.Graw-Hill Book Co., New York.
10. Nordenstam, B., El Gazaly, G. and Kassas, M. 2000 Plant Systematic For 21st Century, Portland Press Ltd, London
11. Radford, A.F. 1986. Fundamentals of Plant Systematics, Harper & Row Pub., USA.
12. Singh, H. 1978. Embryology of Gymnosperms, Encyclopedia of Plant Anatomy X, Gebruder Borntraeger, Berlin.
13. Solbrig, O.I. And Solbrig, D.J. 1979. Population Biology and Evolution, Addison-Wesley Publishing Co. Ind USA.
14. Solbrig, O.I. 1970. Principles and Methods of Plant Biosystematics, The Macmillan Cocollier- Macmillan Ltd., London.
15. Stabbings, G.L. 1974. Flowering Plant- Evolution above Species Level, Edward Arnold Ltd, London.
16. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2nd Edition) Edward Arnold Ltd, London.
17. Takhtajan, A.I. 1997. Diversity and Classification of Flowering Plants, Columbia University Press, New York.
18. Woodland, D.W. 1991. Contemporary Plant Systematic, Prentice Hall, New Jersey.

Suggested Laboratory Exercises:

1. Description of a specimen from representative, locally available families.

List of Locally Available Families

(1) Ranunculaceae, (2) Cappariaceae, (3) Portulacaceae, (4) Caryophyllaceae, (5) Malvaceae, (6) Tiliaceae, (7) Sterculiaceae, (8) Zygophyllaceae, (9) Rhamnaceae, (10) Sapindaceae, (11) Leguminosae, (12) Combretaceae, (13) Myrtaceae, (14) Cucurbitaceae, (15) Umbelliferae - Apiaceae, (16) Rubiaceae, (17) Asteraceae, (18) Primulaceae, (19) Plumbaginaceae, (20) Asclepiadaceae, (21) Convulvulaceae, (22) Solanaceae, (23) Boraginaceae, (24) Polemoniaceae, (25) Acanthaceae, (26) Pedaliaceae, (27) Martyniaceae, (28) Bignoniaceae, (29) Labiatae, (30) Nyctaginaceae, (31) Polygonaceae, (32) Chenopodiaceae, (33) Amaranthaceae, (34) Aizoaceae, (35) Molluginaceae, (36) Euphorbiaceae, (37) Commelinaceae and (38) Cyperaceae.

2. Description of a species based on various specimens to study intraspecific variation: a collective exercise.

3. Description of various species of a genus, location of key characters and preparation of keys at generic level.

4. Location of key characters and use of keys at family level.

5. Field trips within and around the campus, compilation of field notes and preparation of herbarium sheets of such plants, wild or cultivated, as are abundant.

6. Training in using floras and herbaria for identification of specimens described in the class.

7. Demonstration of the utility of secondary metabolites in the taxonomy of some appropriate genera.

8. Comparison of different species of a genus and different genera of a family to calculate similarity coefficients and preparation of dendrograms.

BOT 303: Plant Morphology and Developmental Anatomy

Introduction: Unique features of plant development, differences between animal and plant development. **4**

Seed germination and seedling growth: Metabolism of proteins and mobilization of food reserves, tropisms during seed germination and seedling growth, hormonal control of seedling growth, gene expression, use of mutants in understanding seedling development. **15**

Shoot development: Organization of the shoot apical meristem (SAM), cytological and molecular analysis of SAM, control of cell division and cell to cell communication, Stem cell in plants, Primary and Secondary tissue differentiation, control of tissue differentiation, especially xylem and phloem, secretory ducts and laticifers, wood development in relation to environmental factors. **15**

Leaf growth and differentiation: Inception, phyllotaxy, control of leaf form (leaf meristems and other factors), differentiation of epidermis (with special reference to stomata and trichomes) and mesophyll, Kranz anatomy, Leaf traces and leaf gaps, transfer cells. **14**

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Root development: Organization of root apical meristem (RAM), vascular tissue differentiation, lateral roots, root hairs, root-microbe interactions. 6

Seed coat development: External and internal morphology of seed, seed appendages, ontogeny of seed coat in various families, mature structure, spermoderm patterns. 6

Suggested Readings:

1. Atwell, B.J. Kriedermann, P.E. and Jumbull, C.G.N. (eds). 1999. Plants in Action : Adaption in Nature Performance, in Cultivation, MacMillan Education. Sydney, Australia.
2. Bewley. J.D. and Black, M. 1994. Seeds: Physiology of Development and Germination, Plenum Press. New York.
3. Burgess, J. 1985. An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.
4. Fahn, A. 1982. Plant Anatomy. (3rd edition). Pergamon Press, Oxford. New York.
10. Raven, P.H., Evert, R.F. and Eichhorn, S. 1992. Biology of Plants (5th edition). Worth, New York.
11. Salisbury, P.B. and Ross, C.W. 1992. Plant Physiology (4th edition). Wadsworth Publishing, Belmont, California.
12. Steeves, T.A. and Sussex, I.M., 1989. Patterns in Plant Development (2nd edition). Cambridge University Press, Cambridge.
13. Waisel, Y., Eshel, A. and Kafkaki, U. (eds.). 1996. Plant Roots : The Hidden Hall (2nd edition). Marcel Dekker, New York.

Suggested Laboratory/Field Exercises

1. Study of living shoot apices by dissections using plants such as *Tabernaemontana*, *Albizia*
2. Study of cytohistological zonation in the shoot apical meristem (SAM) in sectioned and double-stained permanent slides of a suitable plant . Examination of shoot apices in a monocotyledon in both T.S. and L.S. to show the origin and arrangement of leaf primordia.
3. Study of alternate and distichous, alternate and superposed, opposite and superposed, opposite and decussate leaf arrangement. Examination of rosette plants (*Launaea*, *Mollugo*, *Raphanus*, *Hyosecyamus* etc.) and induction of bolting under natural conditions as well as by GA treatment.
4. Microscopic examination of vertical sections of leaves such as *Eucalyptus*, *Ficus*, *Mango*, *Nerium*, maize, grass and wheat to understand the internal structure of leaf tissues and trichomes, glands etc. Also study the leaf anatomy C3 and C4 of plants.
5. Study of epidermal peels of leaves such as *Coccinia*, *Tradescantia* etc. to study the development and final structure of stomata and prepare stomatal index.

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6. Study of types of stomata in plants belonging to different families.
7. Study of whole roots in monocots and dicots.
8. Examination of L.S. of root from a permanent preparation to understand the organization of root apical meristem and its derivatives. (use maize, aerial roots of banyan etc.)
9. Study of lateral root development.
10. Study of leguminous roots with different types of nodules.
11. Study of primary and secondary tissue differentiation in roots and shoots.
12. Study of seed coat types- *Pisum*, *Cucurbita*, wheat.
13. Study of vascular tissues by clearing technique

BOT: 304 A - Advanced Plant Pathology I

Plant Pathology: History & Scope : Parasitism and disease development, Host-Parasite interaction , pathogenicity, (5 Hrs)

Dispersal of plant pathogens –Direct ,Indirect and Biological Transmission (5 Hrs)

Host Factors in Disease Development: Inoculum Potential, Protective and defense mechanisms in plants. Phytoalexins .Genetics of plant disease .Phenomenon of resistance and susceptibility. Gene for gene hypothesis. (10 Hrs)

Alteration in plant physiological method due to plant pathogen interaction. (5 Hrs)

Symptomology, Identification and Control of following plant diseases (35 Hrs)

Fungal Diseases:

- Crucifers –*Alternaria* blight
- Paddy – Paddy blast
- Leaf rot and Foot rot of Pan (*Piper beetle*)
- Red rot of Sugarcane, Flax rust,

Bacterial diseases

- Brown rot of Potato,
- Blight of Rice,
- Crown Gall disease of stone fruits
- Angular leaf spot of Cotton.

Phytoplasma Disease:

- Little leaf of Brinjal.
- Sesame Phyllody.

Plant Galls: Classification, developmental anatomy, host- parasite interaction and physiology of Insect induced plant galls of Rajasthan. Economic significance of galls

Plant Galls : Galls of *Pongamia*, *Cordia*, *Prosopis* and *Salvodora*

Nematology: General account of nematode disease, Symptoms caused by nematodes. Methods used in Nematology. Control of plant parasitic nematodes, Inter relationship between nematode and other Plant pathogens

Nematode Disease: Molya disease of Wheat and Barley, Soybean Cyst nematode

Suggested practical :-

Histopathology of nematode infected roots

Study of following disease

- Red rot of Sugarcane
- Paddy Blast
- Flax rust,
- Crown Gall disease of stone fruits
- Angular leaf spot of Cotton.
- Little leaf of Brinjal,
- Sesame Phyllody,
- Galls of Pongamia , *Cordia* , *Prosopis*, *Salvadora*
- Molya disease of wheat and Barley
- Soyabean cyst nematodes

Suggested Readings:

1. Agrios, G.N. 2005. Plant Pathology, 5th edition. Academic Press, New York, USA.
2. Alexopoulos, C.J., C.W. Mims and M. Blackwell. 1996. Introductory Mycology. 4th edition, John Wiley and Sons, Inc., New York, USA
3. Khan, J.A. and J. Dijkstra. 2002. Plant Virus as Molecular Pathogens. The Haworth Press Inc. USA.
4. Mehrotra, R.S. and A. Agarwal. 2003. Plant Pathology. 2nd Edition. TATA McGraw Hill. Pub. Company Ltd. New Delhi.
5. Singh, R.S. 1982. Plant Pathogens: The Fungi. Oxford and IBH Publishing Company, New Delhi. India
6. Singh, R.S. 1989. Plant Pathogens: The Prokaryotes. Oxford and IBH Publ. Company, New Delhi, India.
7. Trigiano, R.N., M.T. Windham and A.S. Windham. 2008. Plant Pathology: Concepts and Laboratory Exercises. 2nd edition. CRC Press.
8. Vidhyasekram, P. 2004. Concise Encyclopedia of Plant Pathology. Food product Press and Haworth Press Inc. Binghamton, Ne

BOT 304 B: Seed Science and Technology -I

History of seed testing and its importance to agriculture, aims of seed testing, Seed- definition and its types. Sampling of seeds. purity analysis (physical and genetical), seed moisture content, germination test, rapid test of viability and evaluation, seedling evaluation, various methods of seed separation, cleaning, drying and Seed processing plant and its process. 12

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Gross architecture of seed structure of angiosperms, identification and structure of seeds of important crop plants with special reference to Rajasthan (wheat, pearl millet, mustard, gram, pea, spices) and Identification of designated objectionable weeds at seed level. 12

Principles of seed production. seed production in self and cross pollinated crops; hybrid seed production. Production of foundation and certified seeds; synthetic seed, terminator seed technology, Physiology of seed germination; seed and seedling vigour. 12

Seed storage methods. principles for safe seed storage, effects of storage, mycotoxins, Deterioration of seeds in storage by micro-organisms, insects and rodents; detoxification, control of seed deterioration. 12

Seed certification standards and quarantine regulations. International cooperations, International Seed Testing Association - Rules and recommendations, Certificates, other seed certificates; Indian Seeds Act and recent amendments, National and Regional Seed Corporations of India - their organisation, aims and functions. National and International Co-operation in Seed Pathology. Sanitary and phytosanitary (SPS) agreements of WTO. 12

List of suggested Practical exercises:

1. Structure of seeds of some crop plants (wheat, pearl millet, mustard, gram, and pea).
2. Preparation of inventory of designated objectionable weeds at seed level and identification.
3. Identification of seed coat cracking.
4. Study of physical purity of seed sample.
5. Study of seed germination, seedling abnormality and seedling index.
6. Determination of moisture content of seeds.
7. TZ test for seed viability
8. Assay of enzymes in crop seeds.
9. Preparation of synthetic seeds.
10. Localization of starch, protein, lipids, tannins, phenols and lignin in seed sections.
11. Isolation and identification of storage fungi.
12. Preparation of phytosanitary certificate etc. of seed lot.

Suggested Readings:

1. Agarwal. V.K. and Sinclair. J.B. (1987). Principles of Seed-pathology, II edition
CRC Lewis Publishers, Boca Raton, New York, London.
2. Agrawal. R.L. 1980. Seed Technology. Oxford and IBH Publishing Co. Pvt. Ltd.
New Delhi.

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3. Anonymous (1985, 2014). International rules for seed testing. International Seed Testing Association (ISTA). <http://www.seedtest.org/en/home.html>; <http://www.seedtest.org/en/international-rules-content---1--1083.html>
4. Bewley, J.D. and Black, M. 1983. Physiology and Biochemistry of Seeds in Relation to Germination. Volume I & II. Springer-Verlag, Berlin, Heidelberg, New York.
5. Copeland, L.O. 1976. Principles of Seed Sci. and Technology Minnesota, USA.
6. Khare, D. and Bhale, M.S. (2014). Seed Technology. Scientific Publishers (India), Jodhpur. Revised 2nd Ed.
7. Kulkarni, G.N. 2002. Principles of Seed Technology. Kalyani Publishers, New Delhi.
8. Neergaard, P. 1986. Seed- A horse of hunger or a source of life. Revised print of Danish Government Institute of Seed Pathology for Developing Countries. Hellerup, Denmark.
9. Winton, A. L. and Winton, K. B. (1932-1939): The structure and composition of foods. Vol I and II: John Wiley and Sons, Inc., New York.

BOT 304 C: Ecosystem Ecology

Grassland Ecosystems - Characteristics of grasslands, stratification, grasslands and grazing, grasslands and drought, grassland and animal life. Grasslands types with special reference to Prairie and Savannah, Indian grasslands. 10 hours

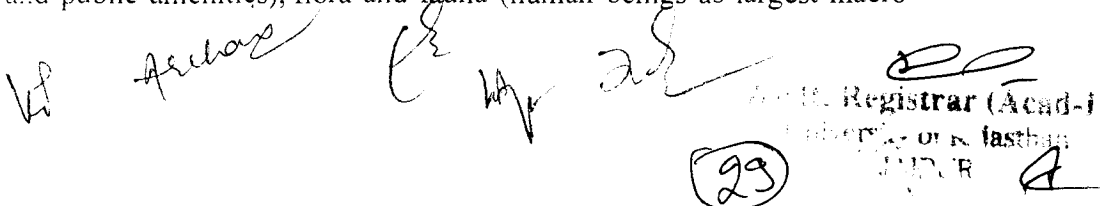
Freshwater Ecosystems -Classification of Freshwater Habitats, Lentic: Lakes & Ponds: Temperature and Oxygen stratification. Zonation based on light penetration, Flora and fauna, Productivity classes of lakes, Marshes and Swamps, Bogs
Lotic: Springs, Streams and Rivers. 10 hours

Marine and Estuarine Ecosystems - Characteristics of marine environment: Salinity, Temperature and pressure, Zonation and Stratification. Tides, Estuarine ecosystem: Types of Estuaries, Flora and fauna, Estuarine productivity. Coral reef ecosystem, Mangrove ecosystem

10 hours

Forest Ecosystems - Stratification of the forest, Forest types -Boreal, Temperate and Tropical forests, Forest animal life 5 hours

Urban Ecosystem -Urban environment and Climatic conditions, additional physical complexes (modified surfaces including parking lots, roofs, and landscaping, buildings, transportation networks, infrastructure and public amenities), flora and fauna (human beings as largest macro



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consumer). Implications of urbanization: problems of air pollutants, drinking water supply, floods, waste disposal.

5 hours

Rural ecosystems: Rural environment and climate, physical complexes (fields, agricultural implements and machinery). Flora and fauna. Problems of discharge of chemical fertilizers, pesticides and drinking water. Management of waste. Principle: Social Forestry.

5 hours

Desert Ecosystem: Desert: Definition, classification (hot and cold), physiography, desert features, flora, fauna and water, formation, topography, distribution and characteristics of world deserts: **Thar desert:** Sand dunes: types, origin and morphology of sand dunes; Vegetation types and plant communities, biological production, conservation of flora and fauna, wild life. Succession in vegetation of western Rajasthan and coastal sand dunes, economic importance of desert plants (general economic plants, medicinal, famine food plants and crops); **Saline Arid zones:** Saline tracts of Rajasthan and plants of saline arid zones (Halophytes), Economic and social considerations in the management of salt affected soils, afforestation in salt affected soils, Importance of halophytes. **15 hr**

Suggested Readings

1. P. L. Jaiswal, A. M. Wadhvani and E. N. Chhabra (Eds.), 1983. Desertification and its Control. ICAR, New Delhi.
2. Smith, R.L. 1996. Ecology and Field Biology. Harper Collins, New York.
3. Subrahmanyam, S. S. and A. V. S. S. Sambamurthy 2000. Ecology. Narosa Publishing House, New Delhi.
4. G. M. Masters and W. P. Fla. 2008. Introduction to environmental engineering and sciences. PHI Learning Private Limited, New Delhi.
5. W. P. Cunningham and M. A. Cunningham. 2003. Principles of Environmental Science: Inquiry and Applications. Tata McGraw-Hill Publishing Company Limited, New Delhi.

Suggested Laboratory Exercises

- Find out stomatal index of Xerophytes (*Nerium*, *Calotropis*, *Zizyphus*.) growing in your locality.
- Study of trichomes of xerophytes (*Zizyphus*, *Lantana*, *Calotropis*, *Acacia*) growing in your locality.
- Study spread of root system of a perennial species in the soil
- Study ecological adaptations of halophytes in your nearby area.
- Seed Viability by T.C. method
- Dormancy (seed) & temperature of in seeds.
- Soil moisture and temperature at different depths
- Salinity of soil sample.
- Study of Canopy and Basal Cover of trees in your study area
- Estimate primary productivity of a water body by light and dark bottle method
- Mean leaf area of 2 plant Species growing in your area by graph method
- Relative humidity by hair hygrometer
- Light intensity by lux meter
- Mark hot and cold desert on world map.

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BOT 304 D : Advanced Plant Physiology I

Proteins and Enzymes: Techniques of protein purification, protein sequencing and proteomics. Enzyme kinetics, Michaelis-Menten equation and significance of K_m value, negative and positive co-operativity, enzyme nomenclature and I.C. number. Catalytic mechanisms: Acid-Base catalysis, covalent catalysis, metal ion catalysis, electrostatic state bonding. Lysozyme as model enzyme for catalytic mechanism. Regulation of enzyme activity: feedback and allosteric regulation, active sites, cozymes, activators and inhibitors. **20Hrs**

Nucleotides metabolism: Biosynthesis of Ribonucleotides and of Deoxy-ribonucleotides-salvage and denovo pathways, nucleotide degradation. **15Hrs**

Vitamins: Water and fat soluble vitamins, biochemical functions of thiamine, riboflavin, nicotinic acid, pantothenic acid, pyridoxine, biotin, folic acid, vitamin B12, ascorbic acid, Vitamin A and Vitamin D. **10Hrs**

Secondary Metabolites: Detailed account of Coumarins, Lignins, Insecticides (pyrethrins and rotenoides), Tannins, Flavonoids, Alkaloids and Steroid. **15Hrs**

Suggested Readings

1. Lehninger AL, Nelson DL, Cox MM : Principles of Biochemistry, 3rd edition. Macmillan Publishers, Worth New York, 2000.
2. Jain JL: Fundamental of Biochemistry, 2nd ed., S. Chand & Co. Ltd., New Delhi, 1990.
3. Voet D, Voet JG : Biochemistry, 2nd edition. Wiley, New York, 1995.

Suggested Laboratory Exercise

1. Quantitative estimation of proteins in the given plant material by Lowry's method.
2. Desalting of proteins by Gel Filtration chromatography using sephadax.
3. Isolation of casein from milk and its quantification.
4. Effect of pH and enzyme concentration on rate of reaction of enzyme. Ex.- Acid Phosphatase, Nitrate reductase.
5. Quantification of Vitamin C.

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6. Extraction and identification of flavonoids and alkaloids through TLC.
7. Preliminary detection of flavonoids, alkaloids and steroids.

BOT 304 E : ADVANCED MORPHOLOGY AND MORPHOGENESIS-I

Floral anatomy and its role in explaining the morphology of the Stamen and Carpel, seed and pericarp and their taxonomic significance. 10

Anther-organizational relationship of anther tissues, ultrastructure aspects of microsporogenesis, pollen-sporoderm pattern, pollen analysis, pollen fertility and sterility, allergy due to pollen, Viability, storage and germination of pollen. 12

Embryo sac - basic types and their inter-relationships, ultrastructural aspects of embryo sac development, Pollen-pistil interaction, cytology of style and stigma, role of pollen ultrastructural studies of pollen tube growth in the pistil, chemotropism, fertilization. 13

Endosperm - Inter-relationship of the major types of endosperms, cytology and role, in embryo development. 5

Embryo- Embryogenic laws Major types of embryogenesis, cell lineages, Apomixis – types, agri-horticultural importance. 10

Embryological features of the following families : Santalaceae, Loranthaceae, Podostemaceae, Onagraceae, Cyperaceae, Elocarpaceae, Boraginaceae, Campanulaceae and Tropeolaceae.10

Suggested Readings

1. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition). Vikas Publishing House, New Delhi.
2. Fahn, A. 1982. Plant anatomy. (3rd edition). Pergamon Press, Oxford, New York.
3. Leins, P., Tucker, S.C. and Endress, P.K. 1988. Aspects of Floral Development, J. Cramer, Germany.
4. Proctor, M. and Yeo, P. 1973. The Pollination of Flowers. William Collins Sons, London.
5. Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.
6. Shivanna, K.R. and Sasidhary, V.K. (eds.) 1997. Pollen Biotechnology for Crop Production and Improvement. Cambridge University Press, Cambridge.
7. Shivanna, K.R. and Sasidhary, N.S. 1992. Pollen Biology: A Laboratory Manual. Springer-Verlag, Berlin-Heidelberg (and references therein).

• Suggested practical/Field exercises:

- 1. Study of floral anatomy by cutting serial transverse sections.


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- 2. Study different types of placentation.
- 3. Transverse sections of different stages of developing anthers to see development of wall layers and sporogenesis.
- 4. Spermoid development of pollen grains
- 5. Make acetolytic preparations of pollen grains to study wall structure.
- 6. Pollen viability tests using different salt and sugar concentrations.
- 7. Endosperm histology
- 8. Stages in embryo development in plants like *Raphanus* and Legumes etc.

BOT-111: BIOSYSTEMATICS OF ANGIOSPERMS-I

Aims, components, and principles of taxonomy: Alpha and omega taxonomy, documentation and scope. (4 Hours)

Evolutionary taxonomic classifications with their merits and demerits: system of Hutchinson, Takhtajan, Cronquist, Dahlgren, Thorne and APG. (8 Hours)

International and national botanical gardens, plant geography, Indian plant geographical regions. (6 Hours)

Taxonomic literature: Herbarium, flora, monograph, icons, index, library, manuals, taxonomic keys for plant identification. (6 Hours)

ICBN: Principles, rules, nomenclature, recommendation, Nomenclature of hybrids and cultivars, concept of biotype. (10 Hours)

Biosystemic procedure: specimen diagnosis, Cytology- chromosomes morphology and number, polyploidy, aneuploidy, chromosome bands, G-C Bands.

Histochemistry - lipids, carotenoids, ascorbic acid, tannins, phenols, proteins, Molecular systematics (RAPD, RFLP analysis). (12 Hours)

Biosystematic tools: palynology – pollen characters in detail related to taxonomy; embryology - embryological characters of taxonomic importance. (8 Hours)

Numerical Taxonomy- Principles, concepts, operational taxonomic units (OTU), data processing and taxonomic studies, taximetric methods for study of population variation and similarity - coding, cluster analysis, cladistics and cladogram. (6 Hours)

Suggested Readings:

1. Cole, A.J. Numerical Taxonomy, Academic Press, London
2. Davis, P.H. and Heywood, V.H. 1973. Principles of Angiosperms Taxonomy, Robert E. Krieger Pub. Co., New York.
3. Grant, V. 1971. Plant Specimen, Columbia University Press London.
4. Grant, W.F. 1981. Plant Biosystematics, Academic Press London.
5. Harrison, H.J. 1980. New Concepts in Flowering Plant Taxonomy, Rieman Educational Book Ltd, U.K.

6. Heslop-Harrison, J. 1967. Plant Taxonomy, English Language Book Soc. & Edward Arnold Pub. Ltd. U.K.
7. Heywood, V.H. And Moore, D.M. 1984. Current Concepts in Plant Taxonomy. Academic Press, London.
8. Jones, A.D. and Wilkins, A.D. 1971. Variations and Adaptations in Plant Species, Hiemand & Co. New York.
9. Jones, S.B. Jr. and Richsinger, A.E. 1986. Plant Systematic (2nd Edition), Mc.Graw-Hill Book Co., New York.
10. Nordenstam, B. and Gazmy, G. and Kassar, M. 2000 Plant Systematic For 21st Century. Portland Press, London.
11. Radford, A.E. 1950. Fundamentals of Plant Systematics, Harper & Row Pub., USA.
12. Singh, H. 1978. Embryology of Gymnosperms. Encyclopedia of Plant Anatomy X. Gebruder Borntraeger, Berlin.
13. Solbrig, O.T. and Solbrig, D.J. 1979. Population Biology and Evolution. Addison-Wesley Publishing Co. Inc. USA.
14. Solbrig, O.T. 1970. Principles and Methods of Plant Biosystematics. The Macmillan Cocollier- Macmillan Ltd., London.
15. Stabbings, G.I. 1974. Flowering Plant- Evolution above Species Level. Edward Arnold Ltd. London.
16. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2nd Edition) Edward Arnold Ltd. London.
17. Takhtajan, A.I. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.
18. Woodland, D.A. 1991. Contemporary Plant Systematic. Prentice Hall, New Jersey.

Suggested Laboratory Exercises:

1. Description of a specimen from representative, locally available families.

List of Locally Available Families

- (1) Ranunculaceae, (2) Capparidaceae, (3) Portulacaceae, (4) Caryophyllaceae, (5) Malvaceae, (6) Tiliaceae, (7) Sterculiaceae, (8) Zygophyllaceae, (9) Rhamnaceae, (10) Sapindaceae, (11) Leguminosae, (12) Combretaceae, (13) Myrtaceae, (14) Cucurbitaceae, (15) Umbelliferae - Apiaceae, (16) Rubiaceae, (17) Asteraceae, (18) Primulaceae, (19) Plumbaginaceae, (20) Asclepiadaceae, (21) Convulvulaceae, (22) Solanaceae, (23) Boraginaceae, (24) Polemoniaceae, (25) Acanthaceae, (26) Pedaliaceae, (27) Martyniaceae, (28) Bignoniaceae, (29) Fabiaceae, (30) Nyctaginaceae, (31) Polygonaceae, (32) Chenopodiaceae, (33) Amaranthaceae, (34) Aizoaceae, (35) Molluginaceae, (36) Euphorbiaceae, (37) Commelinaceae and (38) Cyperaceae.
2. Description of 2 species based on various specimens to study intraspecific variation: a collective exercise.
3. Description of various species of a genus, location of key characters and preparation of keys at generic level.
4. Location of key characters and use of keys at family level.

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5. Field trips within and around the campus, compilation of field notes and preparation of herbarium sheets of such plants, wild or cultivated, as are abundant.
6. Training in using floras and herbaria for identification of specimens described in the class.
7. Demonstration of the utility of secondary metabolites in the taxonomy of some appropriate genera.
8. Comparison of different species of a genus and different genera of a family to calculate similarity coefficients and preparation of dendrograms.
9. Molecular taxonomy

BOT 401 : PLANT REPRODUCTIVE BIOLOGY

Reproduction : Vegetative options and sexual reproduction, flower development, genetics of floral organ differentiation. homeotic mutants in *Arabidopsis* and *Antirrhinum*, sex determination. **5**

Male gametophyte : Structure of anthers, microsporogenesis, role of tapetum, pollen development and gene expression, male sterility, sperm dimorphism and hybrid seed production, pollen germination, pollen tube growth and guidance, pollen storage, pollen allergy, pollen embryos. **13**

Female gametophyte : Ovule development, megasporogenesis, organization of the embryo sac, structure of the embryo sac cells. **5**

Pollination, pollen-pistil interaction and fertilization : Floral characteristics, pollination mechanisms and vectors. structure of the pistil, pollen-stigma interactions, sporophytic and gametophytic self-incompatibility (cytological, biochemical and molecular aspects), double fertilization, in vitro fertilization. **13**

Seed development and fruit growth : Endosperm development, embryogenesis, cell lineages during late embryo development, storage proteins of endosperm and embryo **6**


Polyembryony, apomixis, embryo culture, dynamics of fruit growth, biochemistry and molecular biology of fruit maturation. **5**

Latent life - dormancy: importance and types of dormancy, seed dormancy, overcoming seed dormancy, bud dormancy. **5**

Senescence and programmed cell death (PCD) : Basic concepts, types of cell death, PCD in the life cycle of plants, metabolic changes associated with senescence and its regulation, influence of hormones and environmental factors on senescence. **8**

Suggested Readings

1. Atwell, B.J. Kriedermann, P.E. and Jumbull, C.G.N. (eds). 1999. Plants in Action : Adaption in Nature Performance, in Cultivation. MacMillan Education. Sydney, Australia.
2. Bewley, J.D. and Black, M. 1994. Seeds: Physiology of Development and


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Germination, Plenum Press. New York.

3. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition). Vikas Publishing House, New Delhi.
4. Burgess, J. 1985. An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.
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5. Fageri, K. and Van der Pijl, L. 1979. The Principle of Pollination Ecology. Pergamon Press, Oxford.
6. Fahn, A. 1982. Plant Anatomy. (3rd edition). Pergamon Press, Oxford.
7. Fosker, D.E. 1994. Plant Growth and Development. A Molecular Approach. Academic Press, San Diego.
8. Howell, S.H. 1998. Molecular Genetics of Plant Development. Cambridge University Press, Cambridge.
9. Leins, P., Tucker, S.C. and Endress, P.K. 1988. Aspects of Floral Development, J. Cramer, Germany.
10. Lyndon, R.F. 1990. Plant Development. The Cellular Basis, Unwin Hyman, London.
11. Murphy, T.M. and Thompson, W.E., 1988. Molecular Plant Development. Prentice Hall, New Jersey.
12. Proctor, M. and Yeo, P. 1973. The Pollination of Flowers. William Collins Sons, London.
13. Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.
14. Raghavan, V. 1999. Developmental Biology of Flowering Plants. Springer-Verlag, New York.
15. Raven, P.H., Evert, R.F. and Eichhorn, S. 1992. Biology of Plants (5th edition). Worth, New York.
16. Salisbury, P.B. and Ross, C.W. 1992. Plant Physiology (4th edition). Wadsworth Publishing, Belmont, California.
17. Steeves, T.A. and Sussex, I.M., 1989. Patterns in Plant Development (2nd edition). Cambridge University Press, Cambridge.
18. Sdgely, M. and Griffin, A.R. 1989. Sexual Reproduction to Tree Crops. Academic Press, London.
19. Shivanna, K.R. and Sawhney, V.K. (eds.) 1997. Pollen Biotechnology for Crop Production and Improvement. Cambridge University Press, Cambridge.
20. Shivanna, K.R. and Rangaswamy, N.S. 1992. Pollen Biology : A Laboratory Manual. Springer-Verlag, Berlin.
21. Shivanna, K.R. and Johri, B.M. 1985. The Angiosperm Pollen : Structure and Function. Wiley Eastern Ltd., New York.
22. The Plant Cell Special Issue on Reproductive Biology of Plants. Vol. 5(10) 1993.

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The American Society of Plant Physiologists, Rockville, Maryland, USA.

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Suggested practical/Field exercises;

1. Study of microsporogenesis and gametogenesis in sections of anthers of different ages.
2. Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, *Cannabis sativa*, *Crotalaria*, *Tradescantia*, *Brassica*, *Petunia*, *Solanum melongena*, etc.)
3. Study of wall layers of anther.
4. Tests for pollen viability using stains and in vitro germination.
5. Pollen germination using hanging drop and sitting drop cultures, suspension culture and surface culture.
6. Estimating percentage and average pollen tube length in vitro.
7. Study of ovules in cleared preparations, study of monosporic, bisporic and tetrasporic types of embryo sac development through examination of permanent, stained serial sections.
8. Field study of several types of flower with different pollination mechanisms.
9. Emasculation, bagging and hand pollination to study pollen germination,.
10. Study of nuclear and cellular endosperm through dissections and staining.
11. Isolation of zygotic globular, heart-shaped, torpedo stage and mature embryos from suitable seeds
12. Polyembryony in citrus, jamun (*Syzygium cumini*) etc. by dissections.
13. Biochemical estimation (qualitative and quantitative) of metabolites of seeds.

Suggested Readings (for Laboratory Exercises)

1. Shivanna, K.R. and Rangaswamy, N.S. 1992. Pollen Biology : A Laboratory Manual, Springer-Verlag, Berlin-Heidelberg (and references therein).
2. Chopra, V.L. 2001. Plant Breeding : Theory and Practice. Oxford IBH Pvt. Ltd., New Delhi.
3. Chopra, Y.L. 2001. Plant Breeding: Field Crops. Oxford IBH Pvt. Ltd., New Delhi

BOT 402: PLANT RESOURCE UTILIZATION & ETHNOBOTANY

1. Economic importance of microbes, with special reference to Bacteria and algae of your locality and found in extreme habitats **(3 hrs)**
2. Role of fungi in industries with reference to the production of alcohol, organic acids, antibiotics and enzymes. **(3 hrs)**
3. Plant Biodiversity: Concept, status in India, utilization and concerns. Sustainable development: Basic Concepts. Origin of agriculture. **(6 hrs)**
4. World centers of primary diversity of domesticated plants: The Indo-Burmese centre, plant introductions and secondary centers. **(3 hrs)**
5. Origin, evolution, botany, cultivation and uses of (i) Food, forage and fodder crops, (ii) ornamental plants, plants used in sericulture, as petro crops, in narcotics, as mastigatories, fumitories and fiber crops. (iii) medicinal and aromatic plants and (iv) vegetables, fruits,

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spices condiments & oil-yielding crops

(10 hrs)

6. Important fire-wood and timber-yielding plants and non-wood forest products (NWFPs) such as bamboos and rattans. Raw materials for paper making, gums, tannins, dyes and resins. (5 hrs)

7. Green revolution: Benefits and adverse consequences. Recent trends of research for meeting world food demands. Plants used as avenue trees for shade, pollution control and aesthetics.

(4 hrs)

8. Principles of conservation, extinctions, environmental status of plants based on International Union for Conservation of Nature (IUCN). (4 hrs)

9. Strategies for conservation - *in situ* conservation : International efforts and Indian initiatives, protected areas in India -sanctuaries, national parks, biosphere reserves, wetlands, mangroves and coral reefs conservation of wild biodiversity. (7 hrs)

10. Strategies for conservation - *ex situ* conservation: Principles and practices, botanical gardens, Field gene banks, Seed banks, *in vitro* repositories and cryobanks. (5 hrs)

11. General account of the activities of Botanical Survey of India (BSI), National Bureau of plant Genetic Resources (NBPGR), Indian Council of Agricultural Research (ICAR), Council of Scientific and Industrial Research (CSIR), and the Department of Biotechnology (DBT) for conservation and non formal conservation efforts. (5 hrs)

12. **Ethnobotany:** Scope, Interdisciplinary approaches, ethnic groups of India, conservation practices of biodiversity, role of ethnobotany in national priorities, health care and development of cottage industries in India. (5 hrs)

Suggested Readings

1. Anonymous 1997. National Gene Bank : Indian Heritage on Plant Genetic Resources (Booklet). National Bureau of Plant Genetic Resources, New Delhi.
2. Arora, R.K. and Nayar, E.R. 1984. Wild Relatives of Crop Plants in India. NBPGR Science Monograph No. 7.
3. Baker, H.G. 1978. Plants and Civilization (3rd edn.) C.A. Wadsworth, Belmont. 41
4. Bole, P.V. and Vaghani, Y. 1986. Field Guide to Common Indian Trees. Oxford University Press, Mumbai.
5. Chandel, K.P.S., Shukla, G. and Sharma, N. 1996. Biodiversity in Medicinal and Aromatic Plants in India : Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.
6. Chrispeels, M.J. and Sadava, D. 1977. Plants, Food and People. W.H. Freeman and Co., San Francisco.
7. Cristi, B.R. (ed.) 1999. CRC Handbook of Plant Sciences and Agriculture. Vol. I. In situ conservation. CRC Press. Boca Raton, Florida, USA.
8. Conway, G. 1999. The Doubly Green Revolution : Food for All in the 21st Century. Penguin Books.

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9. Conway, G. and Barbier, E. 1990. After the Green Revolution. Earthscan Press, London.
10. Conway, G. and Barbier, E. 1994. Plant, Genes and Agriculture. Jones and Bartlett Publishers, Boston.
11. Council of Scientific and Industrial Research 1986. The Useful Plants of India. Publications and Information Directorate, CSIR, New Delhi.
12. Council of Scientific and Industrial Research (1948 - 1976). The Wealth of India. A Dictionary of Indian Raw Materials and Industrial Products. New Delhi. Raw Materials I-XII. Revised Vol. I-III (1985-1992) Supplement (200).
13. Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New York, USA.
14. Directory of Indian Wetlands. 1993. WWF INDIA, New Delhi and AWB, Kuala Lumpur.
15. Falk, D.A., Olwel, M. and Millan C. 1996. Restoring Diversity. Island Press, Columbia, USA.
16. FAO IBPGR 1989. Technical Guidelines for the Safe Movement of Germplasm. FAO IBPGR, Rome.
17. Frankel, O.H., Brown, A.H.D. and Burden, J.J. 1995. The Conservation of Plant Diversity. Cambridge University Press, Cambridge, U.K.
18. Gadgil, M. and Guha, R. 1996. Ecology and Equity : Use and Abuse of Nature in Contemporary India. Penguin, New Delhi.
19. Gaston, K.J. (Ed.) Biodiversity : a Biology of Numbers and Differences. Blackwell Science Ltd., Oxford, U.K.
20. Heywood, V. (Ed). 1995 Global Biodiversity Assessment. United Nations Environment Programme, Cambridge University Press, Cambridge, U.K. 42
21. Heywood, V.H. and Wyse Jackson, P.S. (Eds) 1991. Tropical Botanical Gardens. Their Role in Conservation and Development. Academic Press, San Diego.
22. Kocchar, S.L. 1998. Economic Botany of the Tropics. 2nd edition. Macmillan India Ltd., Delhi.
23. Kothari, A. 1997. Understanding Biodiversity: Life-Sustainability and Equity. Orient Longman.
24. Kohli, R., Arya, K.S., Singh, P.H. and Dhillon, H.S. 1994. Tree Directory of Chandigarh. Loydale Educational, New Delhi.
25. Nair, M.N.B. et. al. (Eds.) 1988. Sustainable Management of Nonwood Forest Products. Faculty of Forestry, University Putra Malaysia, 43004 PM Serdang, Selangor, Malaysia.
26. Paroda, R.S. and Arora, R.K. 1991. Plant Genetic Resources Conservation and Management. IPGRI (Publication) South Asia Office, C/o NBPGR, Pusa Campus, New Delhi.


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27. Pimentel, D. and Hall, C.W. (Eds.) 1989. Food and Natural Resources. Academic Press, London, New York.
28. Pinstrup-Anderson, P. et. al. 1996. World Food Prospects :Critical Issues for the Early 21st Century. International Food Policy Research Institute, Washington, D.C., USA.
29. Plant Wealth of India 1997. Special Issue of Proceedings Indian National Science Academy B-63.
30. Plucknett, D.L., Smith, N.J.H., William, J.T. and Murti Annishetty, N. 1987. Gene Banks and Worlds Food. Princeton University Press, Princeton, New Jersey, USA.
31. Rodgers, N.A. and Panwar, H.S. 1988. Planning a Wildlife Protected Area Network in India, Vol. I. The Report. Wildlife Institute of India, Dehradun.
32. Sahni, K.C. 2000. The Book of Indian Trees. 2nd edition. Oxford University Press, Mumbai.
33. Schery, R.W. 1972. Plants for Man. 2nd ed. Englewood Cliffs, New Jersey. Prentice Hall.
34. Sharma, O.P. 1996. Hill's Economic Botany (Late Dr. A.F. Hill, adapted by O.P. Sharma). Tata McGraw Hill Co. Ltd. New Delhi.
35. Swaminathan, M.S. and Kocchar, S.L. (Eds.) 1989. Plants and Society. Macmillan Publication Ltd., London.
36. Thakur, R.S., Puri, H.S. and Husain, A. 1989. Major Medicinal Plants of India. Central Institute of Medicinal and Aromatic Plants, CSIR, Lucknow.
37. Thomas, P. 2000. Trees: Their National History. Cambridge University Press, Cambridge.

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38. Wanger, H., Hikino, M. and Farnsworth, N. 1989. Economic and Medicinal Plant Research, Vols. 1-3. Academic Press, London.
39. Walter, K.S. and Gillett, H.J. 1998. 1997 IUCN Red List of Threatened Plants. IUCN, the World Conservation Union, IUCN, Gland, Switzerland and Cambridge, U.K.

Suggested Laboratory Exercises

The Practical course is divided into three units: (1) Laboratory work, (2) Field survey and (3) Scientific visits.

Laboratory Work

1. Food crops: Wheat, rice, maize, chickpea (Bengal gram), potato, sweet potato, sugarcane. Morphology, anatomy, biochemical tests for stored food materials.
2. Forage fodder crops: Study of any five important crops of the locality (for example fodder sorghum, bajra, berseem, khejari, Ardu, zizyphus).
3. Plant fibers and Textile fibres: cotton, jute, linen, sunn hemp, *Cannabis*.

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(b) Cordage fibres: coir (c) Fibres for stuffing: silk cotton or kapok

Morphology, anatomy (microscopic) study of whole fibres using appropriate staining procedures.

4. Medicinal and aromatic plants: Depending on the geographical location college university select five medicinal and aromatic plants each from a garden crop field (or from the wild only if they are abundantly available).

Papaver somniferum, *Catharanthus roseus*, *Adhatoda cylanica*

(syn *A. vasica*), *Allium sativum*, *Rauwolfia serpentina*, *Withania somnifera*,

Phyllanthus amarus, (*P. fraternus*), *Andrographis paniculata*, *Aloe barbadens*,

Mentha arvensis, *Rosa sp.*, *Pogostemon cablin*, *Origanum vulgare*, *Vetiveria*

zizanioides, *Jasminum grandiflorum*, *Cymbopogon sp.*, *Pandanus odoratissimus*.

Study of live or herbarium specimens or other visual materials, to become familiar with these resources.

5. Vegetable oils : Mustard, groundnut, soybean, coconut, sunflower, castor,

Morphology, microscope: structure of the oil-yielding tissues, tests for oil and iodine number.

6. Gums, resins, tannins, dyes : Perform simple tests for gums and resins. Prepare a

water extract of vegetable tannins (*Acacia*, *Terminalia*, *Tea*, *Cassia spp.*,

myrobalans) and dyes (turmeric, , Indigo, *Butea monosperma*, *Lawsonia*

inermis) and perform tests to understand their chemical nature.

7. Firewood and timber yielding plants and NWF's

Field Surveys

a. Prepare a short list of 10 most important sources of firewood and timber in your locality. Give their local names, scientific names, and families to which they belong. Mention their properties.

b. Prepare an inventory of the bamboos and rattans of your area giving their scientific and local names and their various uses with appropriate illustrations.

c. A survey of a part of the town or city should be carried out by the entire class. In batches. Individual students will select one avenue road and locate the trees planted on a graph paper. They will identify the trees, mention their size, canopy shape, blossoming and fruiting period and their status (healthy, diseased, infested, mutilated, misused or dying) and report whether or not the conditions in which they are surviving are satisfactory. The individual reports will be combined to prepare a larger map of the area, which can be used for subsequent monitoring either by the next batch of students/teachers/local communities/NGOs/ or civic authorities. The purpose of exercise in item C above is to make the students aware of the kinds of trees and value in urban ecosystems and ecological services.

Scientific Visits*

The students should be taken to one of the following.

i. A protected area (biosphere reserve, national park or a sanctuary)

ii. A wetland

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- iii. A mangrove
- iv. National Bureau of Plant Genetic Resources, New Delhi-110012 or one of its field stations.
- v. Head Quarters of the Botanical Survey of India or one of its Regional Circles.
- vi. A CSIR Laboratory doing research on plants and their utilization.
- vii. An ICAR Research Institute or a field station dealing with one major crop or crops.
- viii. A recognized botanical garden or a museum (such as those at the Forest Research Institute, dehradun, National Botanical Institute, Lucknow, Tropical Botanical Garden and Research Institute, Trivendram), which has collection of plant products.

Note : The students are expected to prepare a brief illustrated narrative of the field survey and scientific Visits. After evaluation, the grades awarded to the students by the teachers should be added to the field assessment of the practical examination

Bot 403 : PLANT BIOTECHNOLOGY AND GENETIC ENGINEERING

Plant Tissue culture: Principles, Concept, History, General methodology, culture media ingredients, preparation, methods of sterilization and disinfestations, aseptic techniques and Preparation of explants, Micropropagation in plants, Shoot morphogenesis and organogenesis, callus and suspension cultures, microspore culture for producing haploids and their importance, Somatic embryogenesis, Principles, concepts and applications, Protoplast technology: Isolation methods, purification, viability tests, culture, plating efficiency, Somatic cell hybridization, selection of protoplast fusion hybrids, Somaclonal Variation, Secondary metabolites, Overview of Plant Tissue Culture Applications. 15

Metabolic Engineering and industrial Products: Basic concept of metabolic engineering, Strategies used in metabolic engineering, Biotransformation, Cell permeabilisation, elicitation, hairy roots, Media manipulation, Manipulation of phenylpropanoids / Shikimic pathway, production of industrial enzymes, biodegradable plastics, Biopolymers and Antibiotics. 10

Vectors for plant transformation: Basic features of vectors (Promoters , terminators & sequences influencing gene expression, selectable markers & reporter genes, origin of replication, Co-integrative and binary vectors for plant transformation), Codon Optimization, Techniques for plant transformation, Biology of *Agrobacterium*, *Agrobacterium* mediated gene transfer, process of T-DNA transfer and integration, practical applications of *Agrobacterium*-mediated gene transfer, Chloroplast transformation, and clean gene technology, Direct gene transfer methods, Application of DNA based molecular markers (RFLP, RAPD, AFLP) in plant biotechnology, Genome editing, TALEN, CRISPR. 15

Heterologous gene expression in plants and Genetic manipulation of plants for Herbicide tolerance, Insect resistance, stress tolerance , disease resistance, Improvement of crop yield and quality(Post-harvest loses, longer shelf-life of fruits& flowers, color manipulation of flowers,

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Making of Golden Rice). Molecular farming for carbohydrates , lipids and proteins(Edible vaccines& Oleosin system). 10

Science and society: Public acceptance of genetically modified crops (Public concerns, current status of transgenic crops, regulation of GM crops, Cisgenic crops, and products).Introduction to Intellectual property, Biosafety guidelines, Environmental release of GMO's, Risk analysis, Risk Assessment, Risk management 05

Introduction to bioinformatics (Definition, history, applications &scope): Biological databases and Sequence analysis, BLAST and FASTA, Multiple sequence alignment, phylogenetic analysis and Bioinformatics in Drug Discovery, Bioinformatics in India.

05

Practicals:

1. Preparation of media.
2. Surface sterilization
3. Micro propagation technique
4. Organ culture.
5. Callus propagation, Organogenesis, transfer of plants to soil.
6. Anther culture, production of Haploids.
7. Preparation of synthetic seeds
8. Cytological examination of regenerated plants.
9. Isolation of protoplasts from various plant tissues and testing their viability
10. Agrobacterium culture, selection of transformants, reporter gene (GUS) assays.
11. PCR and Gel electrophoresis
12. Techniques: Biolistics, Membrane Filtration, Cell Counting
13. Hairy root cultures
14. Elicitation and precursor feeding
15. Extraction of alkaloids and flavonoids from plant material and their separation using TLC
16. Isolation of plant DNA using CTAB method.
17. BLAST
18. FASTA

Suggested Readings:

1. J.Hammond, P. McGarvey and V. Susibov (Eds.): Plant Biotechnology, Springer Verlag, 2000.
2. F.Fu, G. Singh, and W.R. Curtis(Eds): Plant Cell and Tissue Culture for the Production of Food ingredients, Kluwer Academic/Plenum Press, 1999
3. H.S. Chawla: Biotechnology in Crop improvement, International Book Distributing Company, 1998.
4. R.J. Henry: Practical Application of plant Molecular Biology, Chapman and hall, 1997
5. P.K. Gupta: Plant Biotechnology, Basogi and Co, Meerut, 2010

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6. Bhojwani, S.S. and Razdan, M.K. 1996. Plant Tissue Culture : Theory and Practice (a revised edition). Elsevier Science Publishers, New York. USA.
7. Slater A, Scott N. Fowler M: Plant biotechnology: the genetic manipulation of plants. Oxford: Oxford University Press.2010
8. Metabolic Engineering: *Stephanopoulos, Aristidou, A. A. and Nielsen J.*, Academic Press.
9. Bioprocess Engineering: *Shuler, M.L. and Kargi, F.*, PHI Learning Pvt Ltd, New Delhi.
10. Basic Biotechnology-Ratledge C, Kristainsen B, Cambridge Publication

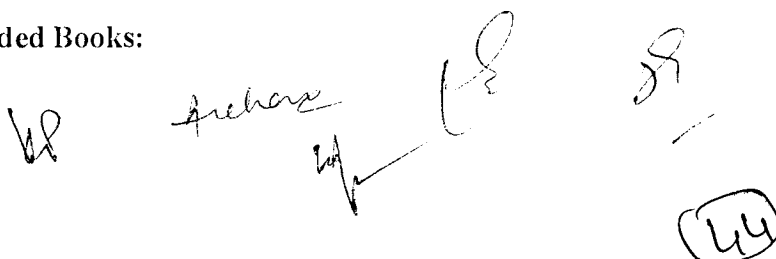
BOT 404 (A) : Advanced Plant Pathology II

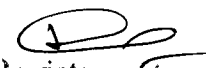
- **Plant Disease epidemiology and plant disease forecasting:** Computer simulation of epidemics ,Methods used in Plant disease forecast ,examples of Plant Disease forecasting System (10 Hrs)
- **Disease Control :**
 - Immunizing the host
 - Disease control by transgenics
 - Innovative methods of plant disease control –Pollen Management and Integrated Pest Management (15 Hrs)
- **Breeding for disease resistance-**Types of resistance .basal resistance,systemic resistance ,acquired resistance ,Gene for Gene concept ,Production of disease resistant plants, Effectors. (15 Hrs)
- **Molecular Plant Pathology:** Molecular diagnosis. Identification of genes and specific molecules in disease development, Genetics of host pathogen interaction. Molecular mechanism of resistance and Biotechnological approaches for disease (15 Hrs)
- **Application of Biotechnology and Information technology** in Plant Pathology & Integrated Pest Management. (5 Hrs)

Suggested practical:-

- Biochemistry-Altered plant physiology due to plant pathogen interaction
- Histochemistry of altered metabolites- Protein,lipids,starch,cellulose,peroxidases and polyphenol oxidase
- Virus detection through biological (indicator hosts and host range) and serological methods (ELISA, Immunodiffusion)
- Virus Indexing
- Methods of application of fungicides –seed and foliar application
- Bio-control of plant pathogens –dual culture technique
- Bioassay of fungicides – poisoned food technique,inhibition zone technique and slide germination technique

Recommended Books:




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1. Agrios, G.N. 2005. Plant Pathology. 5th edition. Academic Press, New York, USA.
2. Alexopoulos, C.J., C.W. Mims and M. Blackwell. 1996. Introductory Mycology. 4th edition. John Wiley and Sons, Inc., New York, USA
3. Khan, J.A. and J. Dijkstra. 2002. Plant Virus as Molecular Pathogens. The Haworth Press Inc. USA.
4. Mehrotra, R.S. and A. Agarwal. 2003. Plant Pathology. 2nd Edition. TATA McGraw Hill. Pub. Company Ltd. New Delhi.
5. Singh, R.S. 1982. Plant Pathogens: The Fungi. Oxford and IBH Publishing Company. New Delhi, India
6. Singh, R.S. 1989. Plant Pathogens: The Prokaryotes. Oxford and IBH Publ. Company, New Delhi, India.
7. Trigiano, R.N., M.T. Windham and A.S. Windham. 2008. Plant Pathology: Concepts and Laboratory Exercises. 2nd edition. CRC Press.
8. Vidhyasekram, P. 2004. Concise Encyclopedia of Plant Pathology. Food product Press and Haworth Press Inc. Binghamton, Ne

BOT 404 (B) : SEED SCIENCE & TECHNOLOGY –II

Introduction and importance of Seed Pathology in modern agriculture. History of Seed Pathology. Various methods for testing seed borne fungi, bacteria and viruses (Dry seed examination, seed washing test, incubation methods, cultural, biochemical, serological, nucleic acid based methods). **10**

Mechanism of seed infection and its types, environment influencing seed infection, infected/contaminated part of seed, morphology and anatomy of seeds in relation to invasion, location of inoculum of the pathogen in seed- seed coat and pericarp, endosperm and perisperm and embryo. **10**

Seed-borne diseases of some important crops with particular reference to the state of Rajasthan and India. Typical case of infection by: fungi (wheat- smuts and bunts, Sesame-charcoal rot; bacteria (Brassicac- black rot, cluster bean- bacterial blight); viruses (tomato mosaic virus, pea seed borne mosaic virus.) and nematodes (wheat- ear cockle, rice- white tip). **10**

Seed-borne inoculum, inoculum density and assessment of seed borne inoculum in relation to plant infection, epiphytotics due to seed borne inoculum, disease forecast based on infected seed samples, tolerance limits of seed borne pathogens. **10**

Transmission of seed borne disease: Systemic and non- systemic seed transmission, types of disease transmission, mode of establishment and course of disease from seed to seedling and plant, factors affecting seed transmission. **10**

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Management of seed-borne disease, principles of control, seed treatments (physical, chemical and biological), mechanism of action of seed treatments, major seed treatments for important seed borne pathogens and their methods of application. **10**

List of suggested Practical exercises:

1. Dry seed examination of seed lots.
2. Isolation and identification of seed-borne mycoflora by standard blotter method.
3. Preparation of culture media (PDA and NA).
4. Plating seeds on PDA/NA for identification of seed borne fungi and bacteria.
5. Other methods of plating e.g. deep freezing; 2,4D- blotter method.
6. Water agar test tube seedling symptom test.
7. Study of any seed borne nematode disease.
8. Detection of bacterial and viral pathogens in seeds.
9. LOPAT tests for detection of seed- borne bacteria.
10. Nucleic acid based detection of seed borne pathogens.
11. Histopathology of infected seed samples.
12. Physical control of seed-borne pathogens.
13. Antibiotic/fungicidal assay against seed-borne pathogens
14. Biological control of seed borne pathogens.
15. Field visits: Crop fields, FCI, NSC, Seed testing Labs., quarantine station (e.g. NBPGR) etc.

Suggested Readings:

1. Agarwal, P. C., Mortensen, C. N. and Mathur, S. B. (1989). Seed-borne diseases and seed health testing of rice. Technical Bull. No.3, Danish government Institute of seed Pathology for Developing Countries (DGISP), Copenhagen and CAB International Mycological Institute, (CMI) UK.
2. Agarwal, V.K. 2006. Seed Health. International Book Distributing Company, Meerut, Ghazibagh, Lucknow, India.
3. Agarwal, V.K. and Sinclair, J.B. (1987). Principles of Seed-pathology, II edition CRC Lewis Publishers. Boca Raton. New York, London.
4. Agrawal, R.L. 1980. Seed Technology. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
5. Anon, G.N. 2005. Plant Pathology. Academic Press, London., New York
6. Anonymous (1985, 2014). International rules for seed testing. International Seed Testing Association (ISTA). <http://www.seedtest.org/en/home.html>; <http://www.seedtest.org/en/international-rules-content---1--1083.html>
7. Clifton, A. 1958. Introduction to the Bacteria. McGraw Hill Book Co., New York.
8. Khare, D. and Bhale, M.S. (2014). Seed Technology. Scientific Publishers (India), Gurgaon. Revised 2nd Ed.

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9. Mandahar, C.L. 1978. Introduction to plant viruses. S. Chand & Co. Ltd., Delhi.
10. Mathur, S.B. and Cunfer, B.M. 1993. Seed-borne diseases and Seed health testing of Wheat. Danish Government Institute of Seed Pathology for Developing Countries. Hellerup, Denmark.
11. Jeergaard, P. (1977). Seed Pathology. Vol. I & II. The Mac Millan Press Ltd., London.
12. Rangaswamy, G. & Mahadevan, A. 1999. Diseases of crop plants in India (4th edition). Prentice Hall of India, Pvt. New Delhi.
13. Richardson, M. J. (1990). An annotated list of seed borne diseases 4th edn. Proc. Int Seed Test Assoc. Zurich, Switzerland.
14. Schaad, N. W. (1980). Laboratory guide for identification of plant pathogenic bacteria (edt.). Bacteriology Committee of American Phytopathological Society, St. Paul, Minnesota.
15. Schaad, N. W. (1988). Laboratory guide for identification of plant pathogenic bacteria (2nd eds.). APS Press (The American Phytopathological Society), St. Paul, Minnesota.
16. Singh, D. and Mathur, S. B. (2004). Histopathology of seed-borne infections. CRC Press, Boca Raton. London, New York, Washington DC. pp 296.
17. Singh, K.G. and Manalo, P.L. 1986. Plant Quarantine and Phytosanitary Barriers in the Asean. Asean Plant Quarantine Centre and Training Institute, Malays

BOT 404 (C) : ENVIRONMENTAL BIOLOGY

Air Pollution: Important Primary (CO, CO₂, Oxides of Sulphur & Nitrogen, H₂S, Chlorine, Particulates, Odour Producing compounds) & Secondary Air Pollutants (Smog, Acid rain, Primary Photochemical reaction, Formation of ozone and peroxyacetyl nitrate in air), Effects of air pollutants on Buildings & Monuments, plants, man and animals: Biomonitoring, Air pollution control (particulates and gaseous pollutants), Green belt, Ozone depletion, mechanism of depletion, control strategies;

12hr

Water Pollution: Eutrophication- Process and Control; Oil Pollution, Thermal Pollution, Heavy metal Pollution, Treatment, Disposal & Recycling of Wastewaters, drinking water standards, Minimum National Standards

10hr

Solid & Hazardous waste management & Resource Recovery: Solid wastes, Types, collection, Shrinking waste streams 3Rs (Reduction, Recycle & Reuse), composting, energy from waste, demanufacturing. Methods of disposal: **Land fill, Open dumps, Exporting waste;** Hazardous waste: Definition, disposal and management

08hr

Energy: Sources, Fossil fuels, Nuclear fuel, Solar Energy, Fuel Cells, Biomass, Hydropower, Wind Power, Geothermal, Tidal & Wave energy, Energy conservation



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Climate Issues: Greenhouse gases (CO₂, CH₄, N₂O, CFCs: sources, trends and role) and consequence of greenhouse effects (CO₂ fertilization, global warming, sea level rise, Biodiversity erosion), Carbon footprints, Carbon sequestration, Applications of GIS and Remote Sensing technology in environmental studies, the future of planet earth.

10 hours

Policies, Regulations & related issues: Water (Prevention and Control of Pollution) Act 1974; Air (Prevention and Control of Pollution) Act 1981; Environment (Protection) Act 1986, Wild Life Protection Act 1972, Forest (Conservation) Act 1980, Biodiversity Act 2002.

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hours

Environmental concerns: Environment auditing, Ecological footprints, Environment Impact Assessment, Bioindicator and biomarkers of environmental health; Environmental economics, Ecopolitics and green policies; Ecolabel, Rain water harvesting, Orans, Indira Gandhi Canal and its ecological implication, water logging & salinity problems- The management alternatives.

10 hours

Suggested Readings

- Treshow, M. 1985. Air Pollution and Plant Life. Wiley Interscience.
- Mason, C.F. 1991. Biology of Freshwater Pollution. Longman.
- Hill, M.K. 1997. Understanding Environmental Pollution. Cambridge University Press.
- Brij Gopal, P.S.Pathak and K.G. Saxena (Eds.). 1998. Ecology Today: An anthology of Contemporary Ecological Research. International Scientific Publications, New Delhi.
- P. K. Goel. 1997. Water Pollution: Causes, Effects and Control. New Age international Ltd., Publishers. New Delhi.
- R.K.Trivedy and P.K.Goel. 1998. An Introduction to Air Pollution. Technoscience Publications, Jaipur
- I.P.Abrol and V.V. Dhruva Narayana (Editors) 1990. Technologies for Wasteland Development. ICAR, New Delhi.
- G. M. Masters and W. P. Ela. 2008. Introduction to Environmental Engineering and Sciences. PHI Learning Private Limited, New Delhi.
- W. P. Cunningham and M. A. Cunningham. 2003. Principles of Environmental Science: Inquiry and Applications. Tata Mcgraw-Hill Publishing Company Limited, New Delhi
- S.K. Mitti. 2004. Handbook of Methods in Environmental Studies Vol. 1 &2. ABD Publisher, Jaipur.

Suggested Laboratory Exercises

- To estimate pH, DO and Secchi Disc transparency for polluted and unpolluted water bodies.
- To estimate Chemical Oxygen Demand of polluted water sample.
- To estimate Biological Oxygen Demand of polluted water sample.
- To estimate inorganic phosphorus content in water samples collected from polluted and unpolluted water bodies.
- To estimate Total hardness, calcium and magnesium content in water samples collected from polluted and unpolluted water bodies.

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- To estimate chloride content in water samples collected from polluted and unpolluted water bodies.
- To estimate Total alkalinity in water samples collected from polluted and unpolluted water bodies.
- To determine diversity indices (Shannon-Wiener, concentration of dominance, species richness, equitability and β -diversity) for polluted and unpolluted water bodies.
- Chlorophyll content of plant species growing in polluted (along JLN Marg) and unpolluted habitat (Botany Department)

BOT 404 (D) : Advanced Plant Physiology II

Signal transduction in plants: Receptors and G-Proteins, phospholipid signaling, role of cyclic nucleotides, calcium-calmodulin cascade, diversity of protein kinases and phosphate, single transduction mechanism with special reference to Actin-cytoskeleton signal transduction, sugar induced signal transduction. **20Hrs**

Stress physiology: Plant responses to biotic and abiotic stress resistance, plant defense mechanisms against water stress, salinity stress, metal toxicity, freezing, heat stress and oxidative stress. **8Hrs**

Photobiology: Photoreceptors, Phytochrome: History, discovery, physiological properties, interaction between hormones and phytochromes, role of different phytochromes in plant development and flowering. Cryptochromes and Phototropins. Physiology of flowering: Photoperiodism and Vernalization. Biological clock, physiology of seed dormancy, senescence & Abscissions. **10Hrs**

Circadian rhythms in plants: Nature of oscillator, rhythmic outputs, entrainments(inputs) and adaptive significance. **2Hrs**

Tools and Techniques: Principles and application of Spectrophotometry, principle of chromatography: Partition chromatography, Thin layer chromatography, Column chromatography--ion exchange chromatography, gas liquid chromatography, high performance liquid chromatography. gel filtration, electrophoresis, ultra centrifugation (velocity and density gradient), ELISA and RIA. **20Hrs**

Suggested Readings

- 1.Kumar,A. And Purohit,S.S.(1996).PlantPhysiology: Fundamentals and Applications. Agrobotanical Publishers, Jodhpur.
- 2.PandeyS.N and SinhaB.K.(1995).Plant Physiology.VikasPublishing house, New Delhi.
- 3 .Steward,F.C.(1959)Plant Physiology.Vol2,AcademicPress,New York.
- 4 .Kuby *Immunology Sixth Edition W.H.Freeman and Company New York.*

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Suggested Laboratory Exercises

1. Study of effect of PEG induced water stress on seed germination.
2. Effect of Red and Infrared light on seed germination and study of photo morphogenesis.
3. Hormonal regulation of leaves and petal senescence.
4. To study the rhythmic movements of plants.
5. Study of changes in starch and protein content during seed development.
6. Separation Techniques: Spectrophotometry, Chromatography, Electrophoresis, Ultra Centrifugation, ELISA.

BOF 404 E : ADVANCED MORPHOLOGY AND MORPHOGENESIS-II

Development and morphogenesis - Shoot apex the apical cell, meristem, the subcellular and biochemical structure of the meristem, the mechanism of primordium initiation, transition to flowering, growth and formation of organs. Experimental work on shoot apical meristem, meristem culture and virus free plants, histochemical studies on apical meristems. 14

The phenomenon of morphogenesis - Correlation, polarity, symmetry, differentiation, regeneration. 9

Morphogenetic factors - Physical, mechanical, chemical and genetic factors. Molecular basis of morphogenesis in plants with special reference to work done in *Arabidopsis*. 8

Somatic embryogenesis - Survey of somatic embryogenesis in angiosperms, direct somatic embryogenesis and embryogenesis from callus and protoplasts, cytology, physiology and genesis of somatic embryogenesis, nutritional factors, hormonal factors and embryo rescue in wide hybridization, endosperm and ovary culture. Micropropagation advances and synthetic seeds. Cell plating technique and isolation of mutant cell lines, auxotrophic mutants. Mechanism involved in cell culture mutants. Suspension culture and growth studies. 16

Microtechniques. Collection, killing and fixation (FAA and glutaraldehyde) of plant material, dehydration and embedding in paraffin and GMA, microtomy, (equipments and method), conventional and histochemical staining procedures. Transmission and scanning electron microscopy for internal structure and morphological development of plant organs and tissues. 13

Suggested practical/Field exercises:

1. Study of organization of vegetative shoot apices
2. Study of organization of reproductive shoot apices.
3. Localisation of different metabolites through histochemical techniques.

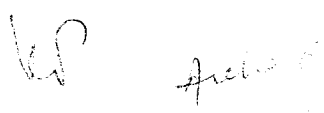

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4. Study of polarity of egg and synergids in embryo sac through permanent slides.
5. *In vitro* tissue and organ culture using different media. Preparation of media ,
6. Inoculation and somatic embryogenesis,
7. Micropropagation and endosperm culture.
8. Histological techniques:
 - Collection, killing and fixation
 - Dehydration
 - Infiltration
 - Embedding
 - Microtomy
 - Staining
9. Microtoming equipments:
 - Microtome
 - Spreading table
 - oven
 - Ribbon box
 - Block holder
10. Demonstration of SEM and TEM
11. Micrometry

Suggested Readings

1. Bhoovani S.S. W. Y. Soh . Morphogenesis in plant tissue cultures Springer 1999
2. Lyndon, R.F. 1990. Plant Development. The Cellular Basis. Unwin Hyman, London.
3. Rogalski, Jean 2009 A systematic study in plant morphogenesis . Phylotaxis : Cambridge University Press
4. Sinnott E.W. 1960. Plant Morphogenesis. McGrawhill, Book Co.
6. Sinnott E.W. 1979 Plant Morphogenesis. McGrawhill Book Co.
7. Steeves, T.A. and Sussex, I.M., 1989. Patterns in Plant Development (2nd edition). Cambridge University Press. Cambridge
8. Wardlaw Wiley C.W. 1966. Trends in plant morphogenesis
9. Zarski, V. and F. CUREKOVA. Plant Cell Morphogenesis : Methods and Protocols: 2014 Springer Protocols. Humana Press www.springer.com

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BOT 404(F) : BIOSYSTEMICS OF ANGIOSPERMS-II

Herbarium methods- Plant exploration, plant collection, pressing and drying, mounting, maintenance and importance of herbarium. Important national, international herbaria, concept of digital herbaria. (10 Hours)

Concept of species- speciation: Gradual and additive mechanism: species classification, concept of characters: analytic versus synthetic character, qualitative versus quantitative characters, good and bad characters. (10 Hours)

Concept of population - its significance, types of variation (developmental, environmental and genetical), variance analysis, isolating mechanism (10 Hours)

Ecotypes- Origin and differentiation, taxonomic significance of ecotypes, vicarians. (6 Hours)

Experimental taxonomy and hybridization- Role of hybridization in evolution, amphidiploidy, breeding barriers, epistasis and pleiotropy. (10 Hours)

Biochemical systematic- Methods and principles, systematic markers, PCR analysis, chemotaxonomy, seed proteins, technique of protein electrophoresis, chemical protein analysis procedures, genome analysis and nucleic acid hybridization. (14 Hours)

Suggested Readings:

1. Cole, A.J. 1989. Numerical Taxonomy. Academic Press, London.
2. Davis, P.H. and Heywood, V.H. 1973. Principles of Angiosperms Taxonomy. Robert E. Kreiger Pub. Co., New York.
3. Grant, V. 1971. Plant Speciation. Columbia University Press, New York.
4. Grant W.E. 1984. Plant Biosystematics Academic Press London.
5. Harrison H.J. 1971. New Concepts in Flowering Plant Taxonomy. Rieman Educational Book Ltd, London.
6. Heslop-Harrison, J. 1967. Plant Taxonomy - English Language Book Soc. & Edward Arnold Pub. Ltd U.K.
7. Heywood, V.H. and Moore, D.M. 1984. Current Concepts in Plant Taxonomy. Academic Press London.
8. Jones, A.D. and Wilkins, J.D. 1971. Variations and Applications in Plant Species. Hiemand & Co. Educational Books Ltd, London.
9. Jones, S.B. Jr. and Luchsinger, A.E. 1986. Plant Systematic (2nd edition). Mcgraw-Hill Book co., New York.
10. Nordenstam, B., El Gazaly, G. and Kassas, M. 2000. Plant Systematic for 21st century, Portland press Ltd, London.
11. Radford, A.E. 1986. Fundamentals of Plant Systematic. Harper & Row Publications, USA.
12. Singh, H. 1978. Embryology of Gymnosperms. Encyclopaedia of Plant Anatomy X. Gebruder Bortaege, Berlin.
13. Solbrig, O.T. and Solbrig, D.J. 1979. Population Biology and Evolution. Addison-Wesley Publishing Co. Inc USA.

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14. Solbrig, O.T. 1970. Principles and Methods of Plant Biosystematics. The Macmillan Coecollier- Macmillan Ltd. London.
15. Stubbings, G.L. 1974. Flowering Plant: Evolution above Species Level. Edward Arnold Ltd. London.
16. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2nd edition) Edward Arnold Ltd. London.
17. Ekhtajan, A.J. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.
18. Woodland, D.W. 1991. Contemporary Plant Systematic. Prentice Hall, New Jersey.

Suggested Laboratory Exercises:

1. Flora writing
2. Synonymy
3. Taximetries and cladistics
4. Molecular taxonomy

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