University of Rajasthan
Jaipur

SYLLABUS

M.Sc. BOTANY

(Semester Scheme)

I & II Semester Examination 2021-22

III & IV Semester Examination 2022-23

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

M.Sc. BOTANY

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 701	Algae, Fungi and Bryophyta	CCC	4	4	0	0	3	0
2.	BOT 702	Cell Biology and Evolution	CCC	4	4	0	0	3	0
3.	BOT 703	Principles of Plant Pathology & Microbiology	CCC	4	4	0	0	3	0
4.		Theory Elective-1	ECC	4	4	0	0	3	0
5.		Theory Elective-2	ECC	4	4	0	0	3	0
6.		Theory Elective-3	ECC	4	4	0	0	3	0
7.	BOT 711	General Practical Lab. (Based on BOT 701, BOT 702 & BOT 703)	CCC	6	0	0	9	0	6
8.		Elective Practical Lab-1	ECC	2	0	0	3	0	4
9.		Elective Practical Lab-2	ECC	2	0	0	3	0	4
10.		Elective Practical Lab-3	ECC	2	0	0	3	0	4

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

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 801	Genetics	CCC	4	4	0	0	3	0
2.	BOT 802	Pteridophyta, Gymnosperm and Paleobotany	CCC	4	4	0	0	3	0
3.	BOT 803	Plant Morphology & Developmental Anatomy	CCC	4	4	0	0	3	0
4.		Theory Elective-1	ECC	4	4	0	0	3	0
5.		Theory Elective-2	ECC	4	4	0	0	3	0
6.		Theory Elective-3	ECC	4	4	0	0	3	0
7.	BOT 811	General Practical Lab. (Based on BOT 801, BOT 802 & BOT 803	CCC	6	0	0	9	0	6
8.		Elective Practical Lab-1	ECC	2	0	0	3	0	4
9.		Elective Practical Lab-2	ECC	2	0	0	3	0	4
10.		Elective Practical Lab-3	ECC	2	0	0	3	0	4

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

THIRED SEMESTER

S. No.	SUBJECT CODE	Course Title	Course Category	Credit	Contact hours per week			EoSE duration (Hrs.)	
					L	T	P	Theory	P
1.	BOT 902	Biosystematics of Angiosperms	CCC	4	4	0	0	3	0
2.	BOT 903	Molecular Biology	CCC	4	4	0	0	3	0
3.	BOT 904	Plant Physiology and Metabolism	CCC	4	4	0	0	3	0
4.		Theory Elective-1	ECC	4	4	0	0	3	0
5.		Theory Elective-2	ECC	4	4	0	0	3	0
6.		Theory Elective-3	ECC	4	4	0	0	3	0
7.	BOT 911	General Practical Lab. (Based on BOT 902, BOT 903 & BOT 904)	CCC	6	0	0	9	0	6
8.		Elective Practical Lab-1	ECC	2	0	0	3	0	4
9.		Elective Practical Lab-2	ECC	2	0	0	3	0	4
10.		Elective Practical Lab-3	ECC	2	0	0	3	0	4

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

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 X01	Plant Reproductive Biology	CCC	4	4	0	0	3	0
2.	BOT X02	Plant Tissue Culture and Genetic Engineering	CCC	4	4	0	0	3	0
3.	BOT X03	Plant Ecology	CCC	4	4	0	0	3	0
4.		Theory Elective-1	ECC	4	4	0	0	3	0
5.		Theory Elective-2	ECC	4	4	0	0	3	0
6.		Theory Elective-3	ECC	4	4	0	0	3	0
7.	BOT X11	General Practical Lab. (Based on BOT X01, BOT X02 & BOT X03	CCC	6	0	0	9	0	6
8.		Elective Practical Lab-1	ECC	2	0	0	3	0	4
9.		Elective Practical Lab-2	ECC	2	0	0	3	0	4
10.		Elective Practical Lab-3	ECC	2	0	0	3	0	4

Note:-

1. Elective core courses lab. can be opted only if the respective Elective theory has been opted by the student. ECC lab. Examination will be based on ECC lab. work of above papers wherever applicable (2 credits each)
2. Department will offer minimum three and maximum six theory elective courses for the semester based on options submitted by the students and availability of Faculty to teach the course.

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

Theory Elective Courses:-

Theory Elective Clusters:-

Specialization Clusters:-

A:PP: Plant Pathology
B:PM: Plant Morphology
C:PB: Plant Biosystematics
D:MI: Plant Microbiology
E:PPH: Plant Physiology
F:PE: Plant Ecology
G:GE: Plant Genetic Engineering
H:GEN: General

Theory Elective Courses:-

Elective Course Code	Specialization	Course Title	Prerequisite	Semester In which course will be available
BOT A01	PP	Plant Pathology- Principles and Diseases		I
BOT A02	PP	Seed Science & Technology		I
BOT A03	PP	Advanced Plant Pathology	BOT A01	II
BOT A04	PP	Seed Pathology	BOT A02	II
BOT B01	PM	Angiosperm Morphology & Morphogenesis		I
BOT B02	PM	Morphogenesis & Experimental Biology	BOT B01	II
BOT C01	PB	Advanced Biosystematics of Angiosperms		I
BOT C02	PB	Angiosperm Plant Biosystematics	BOT C01	II
BOT D01	MI	Applied Phycology and Mycology		I
BOT D02	MI	Applied Microbiology		I
BOT D03	MI	Microbial Technology	D01,D02	III

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

BOT E01	PPH	Plant Biochemistry and Metabolism		III
BOT E02	PPH	Stress Biology		III
BOT E03	PPH	Advanced Plant Physiology	E01,E02	IV
BOT E04	PPH	Phytochemistry and Herbal Medicine	E01,E02	IV
BOT F01	PE	Ecosystem Ecology		III
BOT F02	PE	Conservation Biology		III
BOT F03	PE	Environmental Biology	F01,F02	IV
BOT G01	GE	Genomics & Proteomics		III
BOT G02	GE	Advance Genetic Engineering and Molecular Pharming	G01	IV
BOT H01	GEN	Principles of Plant Breeding		II
BOT H02	GEN	Bioinformatics and Biostatistics		II
BOT H03	GEN	Plant Resource Utilization	C01	IV
BOT H04	GEN	Methods in Plant sciences		IV

Laboratory Elective Courses:-

Elective Course Code	Specialization	Course Title	Prerequisite	Semester In which course will be available
BOT A11	PP	Plant Pathology- Principles and Diseases		I
BOT A12	PP	Seed Science & Technology		I
BOT A13	PP	Advanced Plant Pathology	BOT A11	II
BOT A14	PP	Seed Pathology	BOT A12	II
BOT B11	PM	Angiosperm Morphology & Morphogenesis		I
BOT B12	PM	Morphogenesis & Experimental Biology	BOT B11	II

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

BOT C11	PB	Advanced Biosystematics of Angiosperms		I
BOT C12	PB	Angiosperm Plant Biosystematics	BOT C11	II
BOT D11	MI	Applied Phycology and Mycology		I
BOT D12	MI	Applied Microbiology		I
BOT D13	MI	Microbial Technology	D01,D12	III
BOT E11	PPH	Plant Biochemistry and Metabolism		III
BOT E12	PPH	Stress Biology		III
BOT E13	PPH	Advanced Plant Physiology	E11,E12	IV
BOT E14	PPH	Phytochemistry and Herbal Medicine	E11,E12	IV
BOT F11	PE	Ecosystem Ecology		III
BOT F12	PE	Conservation Biology		III
BOT F13	PE	Environmental Biology	F11,F12	IV
BOT G11	GE	Genomics & Proteomics		III
BOT G12	GE	Advance Genetic Engineering and Molecular Pharming	G11	IV
BOT H11	GEN	Principles of Plant Breeding		II
BOT H12	GEN	Bioinformatics and Biostatistics		II
BOT H13	GEN	Plant Resource Utilization	C11	IV
BOT H14	GEN	Methods in Plant sciences		IV

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

BOT 701 -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: Acetabularia* **15**

• Economic importance of algae specially in industries, food, fodder, biofertilizers, Biofuels and algal bloom, isolation and culture of algae. **5**

FUNGI (20 Hours)

• General characters, substrate relationship, cell ultra-structure, thallusorganization,cell wall composition, nutrition (saprobic, biotropic and symbiotic), reproduction (asexual and sexual). **5**

• Heterothallism, heterokaryosis, Brachymeosis, parasexuality, sex harmones and recent trends in classification of fungi, phylogeny of fungi. **5**

• General account of mastigomycotina ,zygomycotina, ascomycotina, basidiomycotina and deuteromycotina with special reference to *Rhizopus*, *Peronospora Neurospora*, *Polyporus*, *Drechslera* and *Colletotrichum.* 6

• Economic importance of fungi in industries, medicines and as food, fungi as biocontrol agents, poisonous fungi, mycorhizae. **4**

BRYOPHYTA (20 Hours)

• Distribution, Classification of Morphology, structure, reproduction and bryophytes. **(4 Hours)**

• General account of marchantiales, jungermanniales, anthocerotales, sphagnales, funariales and polytrichales with special referenceto *Plagiochasma, Notothylus, Sphagnum, Physcomitrella patens* and*Polytrichum.* **6**

• Fossil Bryophytes, evolutionary trends in Bryophytes. **3**

• Economic importance of Bryophyta **3**

• Role of Bryophytes in plant succession. **4**

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

Suggested LaboratoryExercises:

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

- **Algae:** *Microcystis*, *Spirullina*, *Scytonema*, *Rivularia*,*Dunaliella*, *Aulosira*, *Spirogyra*, *Pediastrum*, *Hydrodictyon*, *Ulva*, *Pithophora*, *Stigeoclonium*, *Gelidium* and *Batrachospermum*: Isolation and culture of algae.

- **Fungi:** *Stemonites*, *Peronospora*, *Pythium*, *Albugo*, *Rhizopus*, *Pilobolus*,Yeast, *Emericella*, *Chaetomium*,*Pleospora*, *Morchella*, *Melamsora*, *Phallus*, *Polyporus*, *Drechslera*, *Curvularia*, *Phoma*, *Penicillium*.*Aspergillus*, *Colletotricum*, *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. Alexopoulus, C.J., Mims, C.W. and Blackwel,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 Vol.I, II. Cambridge University Press, Cambridge, UK.

4. Kashyap, S.R. (1932) Liverworts of Western Himalayas and Punjab Plains (Vll. I & II) ReserchcoPublications , New Delhi,.

5. Richardson, D.H.S. Biology of Mosses. (1981). Blackwell Scientific Publications, Oxford, ,

6. Bold, H. C., Alexopoulus, 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 Narayana, H.S. (1976) : A text 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, V. Bryophytes. (1985). Atmaram& sons. Delhi, Lucknow.

12 .Sharma, P.D.(1996). Introduction to Bryophytes. Ramesh Book Depot, Jaipur.

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

BOT 702- Cell Biology and Evolution

Credits: 4 **60 hours**

A) Structural organization and function of organelles (Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, structure & function of cytoskeleton and its role in motility).

5

B) Membrane structure and function :Structure of model membrane, lipid bilayer and membrane protein) (diffusion, osmosis, ion channels, active transport and membrane pumps. 5

C) Intracellular compartments and transport: mechanism of protein sorting in peroxisomes, nucleus, chloroplast , mitochondria & ER and regulation of intracellular transport. **8**

D) Cell division and cell cycle (Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle).

7

E) Cell signaling Hormones and their receptors, cell surface receptor,second messengers, signaling through G-protein coupled receptors, signal transduction pathways (Cyclic AMP,phospholipaseC,Ca^{+2}-Cadmodulin & Receptor Tyrosine Kinase pathway), regulation of signaling pathways

8

F) Cellular communication: general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins. **5**

G) Apoptosis: Apoptosis (Programmed cell death): Mechanism of apoptosis, Apoptosis triggered by internal & external pathways, Apoptosis inducing factors, cancer, oncogenesis. **5**

H) Emergence of evolutionary thoughts Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; Spontaneity of mutations. **4**

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

I) Origin of cells and unicellular evolution: Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers; Concept of Oparin and Haldane; Experiment of Miller (1953); The first cell; Evolution of prokaryotes; Origin of eukaryotic cells; Evolution of unicellular eukaryotes.

4

J) Paleontology and Evolutionary History: The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Origins of unicellular and multi cellular organisms; Major groups of plants and animals.

4

K).Population genetics – Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; Adaptive radiation; Isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Co-evolution.

5

Suggested Laboratory Exercises

1. EM study of cell organelles
2. Fluorescence staining with FDA for cell viability.
3. Cell wall staining with calcifluor 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. Hardy-Weinberg numerical
12. 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.

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

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. (19960. 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. Hall, J.L. and Moore, A.L. (1983). Isolation of Membranes and Organelles from Plant Cells.Academic Press, London, UK.
13. Roy, S.C. and De, KK. (1999). Cell Biology. New Central Book Agency (P) Ltd., Calcutta.
14. Hartl, D. L. (1994). Genetics. Jones and Bartlett Publishers International, USA

BOT 703- Principles of Plant Pathology& Microbiology

Plant diseases: Introduction and General Account of disease development History of plant pathology Nature and concept of Plant Disease and Symptoms of Plant Diseases caused by plant pathogen.

5

Pathogenesis: Biotic and Abiotic factors in pathogenesis, pathogen factors in disease development. Enzymes and Toxin in Plant Disease –Host specific and non-host specific toxin.

5

Disease Development: Modes of infection, Mechanism of Penetration of Pathogens. Protective and defense mechanism in plants-Morphological and Biochemical

10

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

Plant disease management: Physical, Chemical and biological means of disease control. Biotechnological approaches to disease resistance, IPR

5

Microbiology: History, scope and developments since 20th century in Microbiology. Diversity of the microbial world – Microbial taxonomy and phylogeny; Microbial nutrition, growth and metabolism; Bergey's manual of systematic bacteriology.

7

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

10

Introductory Virology: Nomenclature and general characteristics of plant viruses, ultrastructure of TMV, TYMV, and Bacteriophage. Life cycle, Economic importance of viruses.**Phytoplasma**: General characters, morphology and Identification techniques of phytoplasma

8

History, symptomology, causal organism, etiology and management of: **10**

Fungal diseases:

Wheat - Flag smut, Karnal bunt.

Rust of Linseed

Tikka disease of Groundnut

Bacterial diseases:

Crown gall of stone fruits

Black rot of Crucifer

Viral diseases:

,Cadang –Cadang disease of Coconut

Sandal spike

Nematode disease:

Root Knot of Brinjal,

Ear Cockle of Wheat

Non-Parasitic Diseases

Black Heart of Potato

Mango necrosis

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

Suggested Laboratory Exercises:

- Culture media for microorganisms
- Growth curve of bacteria
- Gram staining
- Virus indexing
- Study of following diseases:

Wheat - Flag smut, Karnal bunt.

Rust of Linseed

Tikka disease of Groundnut

Crown gall of stone fruits

Black rot of Crucifer

Cadang –Cadang disease of Coconut

Sandle spike

Root Knot of Brinjal,

Ear Cockle of Wheat

Any other practical based on theory.

Suggested Reading;

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. Mehrotra, R.S. and A. Agarwal. 2003. Plant Pathology. 2nd Edition. TATA McGraw Hill. Pub. Company Ltd. New Delhi.

4. Singh, R.S. 1989. Plant Pathogens: The Prokaryotes. Oxford and IBH Publ. Company, New Delhi, India.

5. Tortora, G. j., Funke, B. R. and case, C. L.(2010) Microbiology- An Introduction. Addison Wesley Longman, Inc. California. 10th edition

6. Prescott L, Harley J, Klein D (2005) Microbiology, 6 th edition, McGraw-Hill.

7. SubbaRao NS (1982) Advances in Agriculture Microbiology, Butterworth-Heinemann.

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

BOT 801- Genetics

Inheritance and allelism: Concept and structure of gene, cis-trans test, Mendelian and non Mendelian inheritance, Co-dominance, incomplete dominance, Gene interactions: Complementary genes, Supplementary genes, Epistasis, Duplicate genes, Polygenic inheritance, Pleiotropy, Multiple alleles and human blood group, Extra nuclear inheritance: Inheritance of mitochondrial and chloroplast genes, cytoplasmic male sterility, Sex determination mechanism, sex linked inheritance, sex limited characters and sex reversal, genomic imprinting.

Genetic recombination: Homologous and non homologous recombination, Independent assortment, crossing over; Molecular mechanism of recombination, Holiday junction, site specific recombination, FLP/FRT and Cre/lox recombination, role of RecA and RecBCD enzymes

Mutations and mutagenesis: Types and nature of mutation: Spontaneous and induced mutations, lethal, conditional, biochemical, loss and gain of function, base substitution, frame shift mutation, germinal verses somatic mutation, physical and chemical mutagens and their effect, Ames test, Mutagenesis: Inspectional mutagenesis by transposons, site directed mutagenesis, in-vitro mutagenesis and deletion technique,

Chromosome mapping: Linkage maps, tetrad analysis, mapping with genetic markers, QTL mapping, construction of molecular maps, restriction mapping, Correlation of genetic and physical maps; mapping by using somatic cell hybrids

Structural and numerical alteration in chromosome: Origen, meiosis and breeding behavior of duplication, deficiency, inversion and translocation heterozygote. Origin, occurrence, production and meiosis of Haploids, aneuploids and euploids, Induction and characterization of monosomics and trisomics; Origin, production and meiosis of autoploploids and allopolyploids; Evolution of major crop plants

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

Suggested lab exercise

Practical

1. Problems related to linkage, crossing over and gene interaction

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

2. Problems related to gene mapping
3. Construction of restriction map
4. Linear differentiation in Chromosome through banding technique
5. Isolation of chlorophyll mutants following irradiation and treatment with chemical mutagen
6. Quantitative estimation of DNA by diphenyamine method
7. Karyotype analysis
8. Induction of polyploidy
9. To study the application of colchicines treatment.
10. Selfing and crossing technique
11. Demonstration of flow cytometery and confocal microscopy
12. Presentation of chart and models related to syllabus
13. Any other exercise based on theory syllabus

Suggested Reading

- Benjamin Lewin (2000). Genes VII. Oxford university press.
- Gardner E J, Simmons M J, Snustad D P (1991). Principles of Genetics (III Edn). John Wiley and Sons Inc.
- Snustad D P, Simmons M J (2000). Principles of Genetics (III Edn). John Wiley and Sons.
- Strickberger (2005). Genetics (III Edn). Prentice Hall of India Pvt. Ltd.
- William S Klug, Michael R Cummings (1994). Concepts of Genetics. Prentice Hall.
- Robert J Brooker (2009). Genetics: Analysis and principles (III Edn). McGraw Hill.
- Daniel L Hartl, Elizabeth W Jones (2009). Genetics: Analysis of genes and genomes (VII Edn). Jones and Bartlett publishers.
- D Peter Snustad, Michael J Simmons (2010). Principles of genetics (V Edn). John Wiley and Sons.
- Acquaah G (2007). Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd.USA.
- Hartl DL and Jones EW (2007). Genetics – Analysis of Genes and Genomes, 7th edition, Jones and Barlett publishers.
- Hartwell LH, Hood L, Goldberg ML, Reynolds AE, Silver LM, Veres RC (2006). Genetics –From Genes to Genomes, 3rd edition, McGraw Hill.
- Lewin B (2008). Genes IX, Jones and Barlett Publishers.
- Singh RJ (2002). Plant Cytogenetics, 2nd edition, CRC Press.
- Strickberger MW (2008). Genetics, 3rd Edition, Pearson (Prentice Hall).
- Weising K, Nybom H, Wolff K and Kahl G (2005) DNA Fingerprinting in Plants

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

BOT 802- Pteridophyta, Gymnosperms and Paleobotany

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

General account of fossil Pteridophytes, Psilopsida, Lycopsida, 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**

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**

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 (Cordaites).

Paloeobotany and the evolution of vascular plants.

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

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.

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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 Bortraeger, 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 803- 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, secretary 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

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

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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. toshow 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, Hyoscyamus 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 1eaf 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.

6. Study of types of stomata in plants belonging to different families.

7. Study of whole roots in monocots and dicots.

8.Examinatian 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

Suggested Readings:

1. Atwll, B.J. Kriedcrmann, 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.

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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., Evrt, 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.

BOT 902- BIOSYSTEMATICS OF ANGIOSPERMS

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

4

International code of botanical nomenclature: principles, rules andrecommendations, Taxonomic concept: Hierarchy, species, genus, family and other categories **10**

Taxonomic literature: Flora, Monograph, Icones, Library, Manuals, Journals, Periodicals, Index. **4**

Taxonomic tools and techniques: Herbarium: preparation, maintenance, utility, important national, international and digital herbaria, serological, Molecular technique, GIS and Mapping biodiversity.

10

Taxonomic evidences: Morphology, Anatomy, Palynology, Embryology, Cytology, Phytochemistry and Genome analysis.

8

Classification: Phenetic system; Phylogenetic- Cronquist, Dahlgren, Thorne and APG system with merits and demerits of these systems.

6

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Salient features of the groups: Polypetalae, Gamopetalae, Monochlamydae and Monocotyledons. Study of the following families - Ranunculaceae, Caryophyllaceae, Sterculiaceae, Rhamnaceae, Leguminosae Cucurbitaceae, Apiaceae, Rubiaceae, Asteraceae, Asclepiadaceae, Apocynaceae, Convulvulaceae, Solanaceae, Acanthaceae, Lamiaceae, Polygonaceae, Chenopodiaceae, Amaranthaceae, Euphorbiaceae, Cyperaceae and Poaceae . 7

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

Ethnobotany: Scope, Interdisciplinary approaches, ethinic groups of India, conservation practices of biodiversity, role of ethanobotany in national priorities, health care in India. **5**

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.E. 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. Portlend Press Ltd., London
11. Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row Pub., USA.
12. Singh, H. 1978, Embryology of Gymnosperms. Encyclopedia of Plant Anatomy X. GebruderBortraeger, Berlin.
13. Solbrig, O.T. And Solbrig, D.J. 1979. Population Biology and Evolution, Addison-WeslleyPublicating Co. Ind USA.

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14. Solbrig, O.T. 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.L. 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) 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) 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) Lamiaceae, (30) Nyctaginaceae, (31) Polygonaceae, (32) Chenopodiaceae, (33) Amaranthaceae, (34) Aizoaceae, (35) Molluginaceae, (36) Euphorbiaceae, (37) Commelinaceae (38) Cyperaceae and (39) Poaceae

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 coeffecients and preparation of dendrograms.

9. Ethnobotany: Map of ethic groupd in Rajasthan and India

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BOT 903- MOLECULAR BIOLOGY

Genes and DNA

Genome, Gene, Evidences ofDNA and RNA as the genetic material for bacteria, virus and eukaryotes, Double helical structure of DNA, Denaturation & Renaturation of DNA, DNA supercoiling, Coding DNA, ORF, Gene structure, Non-coding DNA & RNA.

5

DNA replication

Mechanisms of prokaryotic DNA replication: Initiation, Elongation and Termination; Replicons-linear, circular and D-loops; DNA polymerases, helicase, other enzymes and accessory proteins involved in DNA replication. Fidelity of replication and coordinating synthesis of the leading and lagging strands, Okazaki fragments.

DNA damage and repair: Causes of DNA damage and molecular mechanisms of repair - excision repair system in bacteria and eukaryotes, base excision, recombination repair systems and SOS repair.

10

Transcription and post transcriptional changes

Types of RNA, 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, silencers & inhibitors in transcription regulation.

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

13

Translation & protein targetting

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

Protein sorting and targeting of proteins into chloroplasts, mitochondria, vacuoles and peroxisomes. Protein trafficking.

10

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Gene regulation

Regulation of gene expression in prokaryotes: Basic models : Lac ,arabinose and Tryp operons.. Positive and negative controls. Regulation in viruses :. Lytic and lysogenic cycle.

Regulation of gene expression in eukaryotes: 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

Techniques of gene expression analysis

Electrophoresis, blotting techniques (Southern, Northern and Western), gene sequencing methods(Sanger's methods , Maxam Gilbert's method, Automated and Pyrosequencing), nick translation, DNA finger printing, RNase protection assay, PCR (semi and quantitative) and Reverse Transcription-PCR, DNA microarrays, DNA-protein interaction (DNA footprinting), Protein-protein interaction (yeast two-hybrid system).

10

Suggested laboratory Exercises

1. Building of a model of B-DNA
2. Demonstration of linking number in supercoiled B-DNA.
3. Isolation of nuclei and identification of histones by SDS-PAGE.
4. Isolation of plant DNA and its quantitation by a spectrophotometric method.
5. Isolation of DNA, and preparation of 'cot' curve.
6. Separation and visualization of DNA fragments by Agarose gel electrophoresis.
5. Determination of Size of DNA by comparison with DNA Ladder electrophoreticaly.
6. Determination of denaturation and renaturation of DNA double helix.
7. Isolation of RNA and quantitation by a spectrophotometric method.
8. Polymerase Chain reaction.
9. Southern blot analysis using a gene specific probe.
10. Immunological techniques: Ouchterlony method, ELISA and western blotting.

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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, lnc., 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 1: A Practical Approach,

Core Techniques.2nd edition. PAS, IRL 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 editions), Garland Publishing Inc., new York.

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

Jones and B Artlet Publishers, Inc., London.

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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

BOT 904- Plant Physiology and Metabolism

Water relations to plants: Properties of water, properties of Solutions, Chemical potential , water potential, Soil- Plant- Atmosphere continuum, Transpiration, Stomatal regulation of transpiration, Antitranspirants. Translocation of water and solute, mechanism of water transport Cohesion- Tension theory, Pressure flow model.

Membrance transport: Passive non-mediated transport, Nernst equation, passive mediated transport, ATP- drive active transport, ion channels. Mineral nutrition: macro and micro nutrients and their role in plants

15

Biomolecules: General structure, classification, properties, distribution and functions of primary metabolites(carbohydrates, proteins, amino acids, lipids) and secondary metabolites (flavonoids, alkaloids, steroids)

Enzymes- Discovery and nomenclature, characteristics of enzymes.Concept of holzymes, apozymes, coenzyme, ribozyme, abzyme and artificial enzyme.Regulation of enzyme activity, mechanism of action. Michaelis-Menten equation **15**

Carbohydrate metabolism: Synthesis of carbohydrates: Photosynthetic pigments, absorption and transformation of radiant energy, (Light harvest complex LHC) photo-oxidation, Red drop effect, Emersion enhancement effect, Photosynthetic quantum yield, Photorespiration, CAM, impact of changing environment effect , Photosynthetic, Industrial Photosynthesis, Allocation, translocation and partitioning of photoassimilate.

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

15

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N_2 metabolism – N_2 fixation symbiotic and asymbiotic, Nodule development Amino Acid Metabolism.

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

Plant growth regulators: Chemical nature, bioassay, physiological effects and mode of action of Auxins, Gibberelines, cytokinines, abscisic acid and ethylene, Salicylic Acid Strigolactones, Jasmonic Acid 15

Suggested Practical exercises

1 Effect of temperature and different solvents on membrane permeability of beet root.
2 Study of stomatal regulation.
3 Estimation of lipids
4 Separation of chlorophyll by paper chromatography.
5 Separation of amino acids by paper chromatography.
6 Separation of chlorophyll by liquid-liquid chromatography.
7 Test of phenols, steroids alkaloids and terpenoids.
8 Isolation of VAM fungi.
9 Determination of amylase activity.
10 Separation of aliphatic wax components by thin layer chromatography (TLC)
11 Isolation of root nodule bacteria from roots of legume plant.
12 Quantification of protein in given plant sample.
13 Demonstration of Physiological effects of growth regulator.
14 Quantification of carbohydrates in given sample.
15 Demonstration of plasmolysis in *Rheo discolor* leaf peel.
16 The effect of temperature on enzyme activity.
17 The effect of pH on enzyme action.
18 To determine total soluble carbohydrates in given plant material.
19 To determine proline in given plant material.

Suggested Readings

1. Taiz L and Zeiger E. (2006) Plant Physiology, 4th Edition, Sinauer Associates Inc. Publishers, Massachusetts, USA.
2. Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology. Asia Ltd. Singapore.
3. Devlin, R.M. and Witham, F.H. 1986. Plant Physiology, 4th Ed. CBS Pub. Delhi.
4. Verma, S K. A Textbook of Plant Physiology, Biochemistry & Biotechnology. S. Chand & Co. 768 pages
5. Hopkins WG & Huner NPA. 2004. Introduction to Plant Physiology. John Wiley & Sons
6. Voet, D and Voet J.G. 1995. Plant Biochemistry, John Wiley, New York.
7. Lehnenger, A.L. 1982. Principles of biochemistry, CBS Publication

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BOT X01- PLANT REPRODUCTIVE BIOLOGY

Flower development and differentiation: Flower development, genetics of floral organ differentiation, homeotic mutants in **Arabidopsis** and **Antirhinum**, 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, ultrastuctural aspects of embryosac development.

8

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

13

Endosperm and Embryo development: Endosperm development, embryogenesis, storage proteins of endosperm and embryo, Polyembryony, apomixis, dynamics of fruit growth, biochemistry and molecular biology of fruit maturation. Embryo rescue in wide hybridization, Introduction to embryo culture, endosperm and ovary culture.

10

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

4

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.

7

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Suggested Readings

1. Atwll, B.J. Kriedcrmann, 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 andGermination, 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 Deihi.

4. Burgess, J. 1985. An Introduction to Plant Cell Development. Cambridge University Press, Cambridge.

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 Developmem.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, UnninByman, 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. CambridgeUniversity Press, Cambridge.

14. Raghavan, V. 1999. Developmental Biology of Flowering Plants. Springer-Verlag, New York.

15. Raven, P.H., Evrt, R.F. and Eichhorn, S. 1992. Biology of Plants (5th edition).Worth, New York.

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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, VK. (eds.) 1997.Pollen Biotechnology for CropProduction 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. 19R5. The Angiosperm Pollen : Structure andFunction. Wiley Eastern Ltd.. New York.

22. The Plant Cell Special Issue on Reproductive Biology of Plants. Vol. 5(10) 1993. The American Society of Plant Physiologists, Rockville, Maryland. USA.

Suggested practical/Field exercises:-

1. Study of microsporogenesis and gametogenesis in sections of anthers of different ages.
2. Examinatian of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, Cannabis sativa, Crotoloria, Tradescantia, Brassica. Petunia, Solanummelongena, 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 (Syzygiumcumini) etc. by dissections.
13. Endosperm, ovary and embryo culture.
14. Biochemical estimation (qualitative and quantitative) of metabolites of seeds.

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Suggested Readings (for Laboratory Exercises)

1. Shivanna, K.R. and Rangaswamy, N.S. 1992. Pollen Biology : A Laboratory Mannual, 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 X02- PLANT TISSUE CULTURE AND GENETIC TRANSFORMATION

Historical perspectives: Concept of Cell culture, development of Tissue culture, Root tip culture, Embryo culture, Stem tip culture, Role of Auxin, Discovery of cytokinin, hormonal control of organ formation ,Improvement of media ,Preparation of &cloning of single cell culture. Contribution of various Scientists, Recent Advances.

Laboratory facilities, operation & Management: Organization of laboratory, Equipments commonly used, media composition, preparation and handling, aseptic manipulation and preparation of explants.

Cellular totipotency: Process and mechanism, concept of differentiation, dedifferentiation & dedifferentiation

Cell culture and cell cloning; Isolation of single cells, growth & subculture of suspension cultures, Types & culture medium for cell suspensions, synchronization & measurement of growth in suspensions, Viability of cultured cells, culture techniques and applications such as isolation and characterization of mutant plant cell cultures.

15

Virus free plants, Shoot tip culture, thermotherapy & meristem culture,Cryotherapy, Chemotherapy, Virus Indexing, Micropropagation: Proliferation of axillary buds, steps & advantages. Embryo culture and Embryo rescue for wide cross hybrids

Somatic embryogenesis: requirements, protocol in Dicots & Monocots, Problems, Induction and controlling factors, Practical applications. Artificial Seeds: synthesis method & Applications.

Organogenesis: Direct and from callus & suspension cultures, Process and controlling factors.

Anther culture for Double Haploid Production; Androgenic and gynogenesis; Technique, Factors influencing anther culture, Pathways for development of Androgenic Haploids, Isolated Pollen culture method, genetic stability and variability of pollen-derived plants diplodisation of haploid plants, application of haploids in Plant Breeding.

Ovary and Endosperm culture.

15

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Somatic hybridization: Isolation ,Viability and culture of Protoplast, culture techniques, Protoplast fusion; types, methods, selection of somatic hybrids &cybrids by various methods, Somaclonal and gametoclonal variation and their selection: Causes of Variation, Induction of variation, detection and Isolation of variant, application in Plant breeding.

Methods of plant transformation: Direct gene transfer methods, *Agrobacterium*-mediated gene transfer, Biology of *Agrobacterium*, mechanisms of T-DNA transfer and integration, Chloroplast transformation and clean gene technology.

Secondary metabolites-.Why do Plants Produce Secondary Metabolites? Process, methods and applications of Secondary Metabolites, Medium Composition and Effect of Nutrients, Elicitor-Induced Production of Secondary Metabolites, Effect of Environmental Factors, Biotransformation Using Plant Cell Cultures.

15

Microtechniquesand analytical procedures used for Plant Cultures: Histological techniques, TEM and SEM, Staining procedures for chromosome analysis, ELISA to certify pathogen free plants.

Role of Plant tissue culture in Biodiversity conservation and economic development.*In vitro* conservation method, conservation of endangered plant species, Cryopreservation for germplasm collection, Pollen and spore gene banks.

Floriculture: APEDA, Status in India, Economics, and Case studies: *Dianthus*

Tissue culture studies in medicinal plants, for rapid propagation of trees, for biomass Energy production, forestry, for fruit trees and for improvement in cereal production.

Agencies funding projects on Tissue culture: CSIR, DBT, UGC, ICAR, DST &MoEF.

Low cost options for tissue culture technology in developing countries- Integration of technology from lab to land, Green House features.

15

Suggested Readings:

M.K.Razdan 2003..An Introduction to Plant Tissue Culture. Oxford & IBH Publishing Co.Pvt.Ltd.

Bhojwani, Sant Saran, Dantu, Prem Kumar. Plant Tissue Culture: An Introductory Text.

Robert N. Trigiano, Dennis J. Gray.Plant Tissue Culture, Development, and Biotechnology.CRC Press.

Roberta Smith .2012. 3rd Edition.Plant Tissue Culture.Academic Press.

TimirBaranJha andBiswajitGhosh .2016.Plant Tissue Culture : Basic and Applied. Universities Press.

David A Evans, William.R.Sharp and Philip V. Ammirato.1990. **Handbook of plant .Macmillan .4-1Volumes ,cell culture**

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University of Rajasthan
Jaipur

S.K.Nandi, L.M.S Palni and A.Kumar. 2002.Role of Plant Tissue culture in Biodiversity conservation and economic development.GyanodayaPrakashan ,Naintal, India.

Suggested Laboratory Exercises:

1. Preparation of media for PTC.
2. Surface sterilization technique for preparation of explants.
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. Single cell culture techniques: Bergmann plating technique, hanging drop & nurse cell culture.
11. Hairy root cultures
12. Elicitation and precursor feeding
13. Extraction of alkaloids and flavanoids from plant material and their separation using TLC.

BOT X03- 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.

15

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. **15**

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Jaipur

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,

15

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.

15

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. 2005. Fundamentals of Ecology, Saunders, Philadelphia.
6. Odum, E.P. 2005. 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 Wily Sons, New York.
11. Heywood, V.H. and Watson, R.T. 1985. Global Biodiversity Assessment. Cambridge University Press.
12. N.S. Subrahmanyam and A.V. S.S. Sambamurty. 2000. Ecology. Narosa Publishing House, Delhi

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Jaipur

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 Wrinkler'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 EIA method.

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Jaipur

TheoryElective Courses

Specialization Clusters

Cluster: PP- Plant Pathology

BOT A01:PP: Plant Pathology-Principles and Diseases

History & Scope of Plant Pathology: Early developments and important landmarks in the history of plant pathology, Some Historical and Present Examples of Losses Caused by Plant Diseases **5**

Dispersal of plant pathogens –Direct, Indirect and Biological Transmission **5**

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.Effect of pathogens on physiology of host plant. **15**

Symptomology, Identification and Control of following plant diseases **15**

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, Galls of *Pongamia*, *Cordia*, *Prosopis* and *Salvodora* **10**

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 **10**

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Elective Practical Lab BOT A11: Plant Pathology-Principles and Diseases

Suggested Laboratory Exercises:

Histopathology of nematode infected roots

Study of following diseases

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

Any other practical based on theory.

Recommended Books:

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 (1973). Plant Disease. Oxford and IBH Pub.Co. New Delhi.

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

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BOT A02:PP: Seed Science & Technology

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

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).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; synthethetic 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, Seed

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

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Elective Practical Lab BOT A12: Seed Science & Technology

Suggested Laboratory 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. Isolaton and identification of storage fungi.
12. Preparation of phytosanitary certificate etc. of seed lot.

Suggested Readings:

Agarwal, V.K. and Sinclair, J.B. (1987).Principles of Seed-pathology, II edition CRC Lewis Publishers, Boca Raton, New York, London.

1. Agrawal, R.L. 1980. Seed Technology. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
2. 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
3. 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.
4. Copeland, L.O. 1976. Principles of Seed Sci. and Technology Minnesota, USA.
5. Khare, D. and Bhale, M.S. (2014). Seed Technology. Scientific Publishers (India), Jodhpur. Revised 2nd Ed.
6. Kulkarni, G.N. 2002. Principles of Seed Technology. Kalyani Publishers, New Delhi.
7. 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.

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University of Rajasthan
Jaipur

8. 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.

BOTA03 :PP: Advanced Plant Pathology

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

Elective Practical Lab BOT A13: Advanced Plant Pathology

Suggested Laboratory Exercises:

- Biochemistry-Alterated 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

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Jaipur

Recommended Books:

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 A04:PP: Seed Pathology

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 (Brassicas- 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

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Jaipur

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

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

Elective Practical Lab BOT A14: Seed Pathology

Suggested Laboratory 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. Charbagh, Lucknow, India.

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

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. Agrios, 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. Cliffton, 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), Jodhpur. Revised 2nd Ed.

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. Neergaard, 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 Hill 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

Dy. Registrar (Academic-I)
University of Rajasthan
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Cluster: PM- Plant Morphology

BOT B01: PM: Angiosperm Morphology & Morphogenesis

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 ,ultrastructural 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 embryosacdevelopment.Pollen pistil interaction, morphology of style and stigma, ultrastructural studies on pollen tube growth in the pistil, fertilization. **13**

Endosperm - Major types of endosperms and their development, endosperm haustoria, cytology of endosperm, role in embryo development. **5**

Embryo- Embryogenic laws, Six major types of embryogenesis, development of Dicot and Monocot embryos, Apomixis- types and significance. **10**

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

Elective Practical Lab BOT B11: Angiosperm Morphology & Morphogenesis

Suggested Practical/Field Exercises:-

1. Study of floral anatomy by cutting serial transverse sections.
2. Study different types of placentation.
3. Transverse sections of different stages of developing anthers to see development of wall layers and sporogenesis.
4. Spermoderm patterns of pollen grains
5. Make acetolysis preparations of pollen grains to study wall structure.
6. Pollen viability tests using different salt and sugar concentrations.
7. Endosperm haustoria
8. Stages in embryo development in plants like *Raphanus* and Legumes etc.

Dy. Registrar (Academic-I)
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Suggested Readings

1. Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition). Vikas Publishing House, New Deihi.
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 Sawhney, VK. (eds.) 1997. Pollen Biotechnology for Crop Production and Improvement. Cambridge University Press, Cambridge.
7. Shivanna, K.R. and Rangaswamy, N.S. 1992. Pollen Biology : A Laboratory Mannual, Springer-Verlag, Berlin-Heidelberg (and references therein).

BOT B02: PM: Morphogenesis & Experimental Biology

Development and morphogenesis - Shoot apex the apical cell, meristem, the subcellular and biochemical struture of the meristem.the mechanism of primordium initaition, 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**

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Jaipur

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**

Elective Practical Lab BOT B12: Morphogenesis & Experimental Biology

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.
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

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Suggested Readings

1. Bhojwani S.S. W, Y. Soh , Morphogenesis in plant tissue cultures Springer 1999
2. Lyndon, R.F. 1990. Plant Development. The Cellular Basis, Unnin Byman, London.
3. Rogar V. Jean 2009 A systematic study in palnt morphogenesis , Phylotaxsis : Cambridge University Press
4. Sinnott E.W. 1960. Plant Morphogenesis,. McGrawhill,Book Co.
6. Sinnott E.W. 1979 Plant Morphogenesis McGrawhillBook 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. Zarsky V. and F. Curekova. Plant Cell Morphogenesis :Methods and Protocols:2014Springer Protocols, Humana Press www.springer.com

Cluster: PB- Plant Biosystematics

BOT C01: PB: Advanced Biosystematics of Angiosperms

Aims, components, and principles of taxonomy; Alpha and omega taxonomy, documentation and scope. Concept of characters: analytic versus synthetic character, qualitative verses quantitative characters , good and bad characters. **10**

Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson de Candolle and Bentham and Hooker.Evolutionary taxonomic classifications with their merits and demerits of Hutchinson, Takhtajan, Cronquist, Thorne.Brief reference of Angiosperm Phylogeny Group (APG III) classification. **10**

Taxonomic literature: Flora & e-flora, monograph, icons, index, library, manuals, taxonomic keys for plant identification. Botanical nomenclature: ICBN Principles, rules and recommendation,typification, author citation, valid publication, rejection of names, principle of priority and its limitations, Nomenclature of hybrids and cultivars, concept of biocode. **16**

Biosystemic procedures: Serum diagnosis, Cytology- chromosomes morphology & number, polyploidy, aneuploidy, chromosome bands, G-C Bands. Chemotaxonomy. Palynology-pollen characters in detail related to taxonomy, Embryology-embryological characters of taxonomic importance. **18**

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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**

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.E. 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. Portlend Press Ltd., London
11. Porter C.L. Taxonomy of Flowering Plants, Radford, A.E. 1986. Fundamentals of Plant Systematics. Harper & Row Pub., USA.
12. Solbrig, O.T. And Solbrig, D.J. 1979. Population Biology and Evolution, Addison-WesslleyPublicating Co. Ind USA.
13. Solbrig, O.T. 1970. Principles and Methods of Plant Biosystematics. The Macmillan Cocollier- Macmillan Ltd., London.
14. Stabbings, G.L. 1974. Flowering Plant- Evolution above Species Level. Edward Arnold Ltd. London.
15. Stace, C.A. 1989. Plant Taxonomy and Biosystematics (2nd Edition) Edward Arnold Ltd. London,
16. Takhtajan, A.L. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.
17. Woodland, D.W. 1991. Contemporary Plant Systematic. Prentice Hall. New Jersey.
18. Singh Gurcharan,2014 Taxonomy of Angiosperms

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Elective Practical Lab BOT C11: Advanced Biosystematics of Angiosperms

Suggested Laboratory Exercises:

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

(1) Ranunculaceae, (2) Capparidaceae, (3) Portulacaceae, (4) Caryophyllaceae, (5) Malvaceae, (6) Tiliaceae, (7) Sterculiaceae, (8) Zygophyllaceae, (9) Rhamnaceae, (10) Sapindaceae, (11) Fabaceae (12) Combretaceae, (13) Myrtaceae, (14) Cucurbitaceae, (15) Apiaceae, (16) Cyperaceae and (17) Poaceae

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. Training in using floras and e-flora for identification of specimens described in the class.

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

7. Comparison of different species of a genus and different genera of a family to calculate similarity coeffecients and preparation of dendrogramsandcladogram.

8. Demonstration of the principle of priority.

9. Demonstration of the rejection of names according to ICBN.

10. Developed NPC formula and identified different species.

BOT C02: PB: Angiosperm Plant Biosystematics

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

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

Concept of population – itssignificance, types of variation (developmental, environmental and genetical), variance analysis, isolating mechanism. **10**

Ecotypes- Origin and differentiation, taxonomic significance of ecotypes, vicarians. **6**

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

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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**

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 wilbins, a.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 Bortaeger, Berlin.
13. Solbrig, O.T. and Solbrig, D.J. 1979. Population Biology and Evolution, Addison-Weslley Publicating Co. Ind USA.
14. Solbrig, O.T. 1970. Principles and Metods 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.L. 1997. Diversity and Classification of Flowering Plants. Columbia University Press, New York.
18. Woodland, D.W. 1991. Contemporary Plant Systematic. Prentice Hall. New Jersey.

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Elective Practical Lab BOT C12: Angiosperm Plant Biosystematics

Suggested Laboratory Exercises:

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

Cluster: MI- Plant Microbiology

BOT D01: MI: APPLIED PHYCOLOGY AND MYCOLOGY

Applied Phycology: Use of algae as food, fodder and industrial applications of algae (Alginic acid, Agar, Carrageenan),Algal Biofertilizers with special reference to Cyanobacteria. Algal blooms and Water Pollution, Toxic Algae,Biofouling and Control.Algal biofuels – algal biodiesel, bio-ethanol and biological hydrogen production.Algae in global warming – carbon capture by algae. **12**

Isolation, Purification and Culture of algae; Mass cultivation of microalgae with special reference to *Spirullina* and *Dunaliella* and their applications in human welfare. Cryopreservation, aquaculture (micro and macro algae cultivation). **7**

Importance of algae in production of algal pigments, important bioactive molecules, role of algae in sustainable environment, role of algae in bioremediation, recent developments and future of algal biotechnology. **5**

Applied Mycology: Application of fungi in food industry (Flavour& texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Fungi in agriculture (biofertilizer) and remediation of contaminated soils.Mycotoxins; Fungalendophytes of plants and their applications: Endophytic fungi, colonization and adaptation of endophytes. Endophytes as latent pathogens and biocontrol agents. **10**

Fungi as Biological control agents (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides). Fungi in plant disease control- Selection, production and formulation of fungal biopesticides and commercial use of biocontrolagents.Introduction and importance of Keratinophilic fungi. **8**

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield. Biology of vesicular arbuscularmycorrhizal (VAM) fungi: signaling, penetration and colonization inside

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Jaipur

roots, isolation and inoculum production of VAM, and its influence on growth and yield of crop plants and in forestry, recent advances in the field of mycorrhiza. A general account of Phosphate solubilizing fungi (PSF).Overview of Lichens. **8**

Mushroom cultivation- General account of Oyster, white button, paddy straw, Morels, Truffles & Poisonous mushrooms. Cultivation of mushrooms (*Agaricusbisporus, Pleurotus* and *Volvoriella)*, Medicinal and nutritional value of edible mushrooms, Effect of environmental, nutritional and chemical factors on mushroom cultivation (intensive and extensive cultivation methods). **10**

Suggested Readings:-

1. Kumar, H.D. Introductory Phycology , Affiliated East West Pvt. Ltd. , New Delhi
2. Fritsch, F.E (1945). The structure and Reproduction of Algae Vols. I & II. Cambridge University Press, UK
3. Anderson, R.A. (2005) Algal Culturing Techniques. Physiological Society of America. Elesvier Academic Press, USA.
4. Ghemawat, M.S., Kapoor J.N., and Narayan,H.S. (1976) : A text book of Algae. Ramesh book Depot, Jaipur.
5. Alexopoulus, C.J., Mims, C.W. and Blackwel, M. (1996). Introductory Mycology, John Wiley & Sons ind.
6. Verma, A & Hock, B. 1999. Mycorrhizae. Springer Publishers
7. Powel, C and D. J. Bagyaraj - V.A. Mycorhizae
8. Change. S.T. and P.G. Miles - Edible mushrooms and their cultivation
9. Handbook of Industrial mycology. Edited by Zhiqiang An, CRC Press.
10. Mycotechnology: Present status and future prospects. Edited by MahendraRai. I.K., International Publishing House Pvt. Ltd.; 2007.
11. Agrios, G.N. 1999. Plant Pathology. Academic Press
12. Mehrotra, R.S. 1991. Plant Pathology. Tata Mcgraw – Hill Publishing Company Ltd

Elective Practical Lab BOT D11: Applied Phycology and Mycology

Suggested Laboratory Exercises:-

1. Isolation and culture of algae.
2. Identification of Algal biofertilizers.
3. Identification of toxic algae.
4. Identification of bloom forming algae.
5. Making an algal bloom.
6. Phytoplankton identification from local water bodies.
7. Isolation, culture and identification of fungi using moistened blotters, PDA and Sabouraud's Dextrose Agar media

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Jaipur

8. Cultivation of *Spirullina* and *Dunaliella.*
9. Estimation of pigments in microalgae.
10. Study of Mushroom specimens
11. Mushroom cultivation.
12. Demonstration of antagonistic fungi a) Antibiosis b) Competition c) Mycoparasitism
13. Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs)
14. Study of Mycorrhizal colonization in roots of *Parthenium* and *Tagetus.*
15. Isolation and identification of AM Fungi and estimation of root colonization.

BOT D02: MI: APPLIED MICROBIOLOGY

Food and Dairy Microbiology: Microbial spoilage of food products including cereals, fruits, vegetables, meat, fish, and dairy products, Factors influencing microbial growth in foods - extrinsic and intrinsic.

Principles of food preservation, Food preservatives and their uses, Fermented food, wine, bakery products, cereals, and milk products, Bacteriocins and their application in food preservative (Nisin, Lactococcuslactis), food additives. Nutritional value of fermented foods

Microbiological examination of milk and milk products, source of their contamination and control. **12**

Applications of Microbes in Waste Treatment: Solid waste treatment (Landfills, incineration, composting, anaerobic digestion and pyrolysis). Waste water treatment: Pretreatment, primary, secondary (activated sludge, surface aerated basins, fluidized bed reactors, trickling filter, biotower, rotating biological contactors, membrane bioreactors and secondary sedimentation) and tertiary treatment, disinfection and odor control; Application of biofilm in waste water treatment. Microorganisms as indicators of water quality. **10**

Role of Microbes in Environment: Biodegradation of recalcitrant compounds – Pesticides, Petroleum, Polychlorinated biphenyls and other organopollutants; Lignin degradation: Lignocellulolytic microorganisms, enzymes and their applications in: Biopulping, Biobleaching, Textiles, Biofuels, Animal feed production. **6**

Bioremediation: *In situ&Ex situ* remediation, Concept of bioremediation technologies, Microbial consortium, Microbial remediation of oil spills, paper and pulp mill effluents and textile effluents; Biostimulation and Bioaugmentation.Bioaccumulation of metals and detoxification.Genetically Modified Organisms released and its environmental impact assessment; Molecular approach to environmental management, Degradative plasmids, Genetic exchange in xenobiotic chemicals. **12**

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Jaipur

Biodeterioration of buildings and monuments of heritage value, Microbial deterioration of paper, leather, wood, textiles, metal surfaces– mode of deterioration, organisms involved, its disadvantages and methods of prevention. Bioleaching of copper, gold and uranium from ore by microbes. Bio-recovery of petroleum.Microbial plastics, Biodiesel. **8**

Biofertilizer for sustainable agriculture- Rhizobium, Azospirillium, Azotobacter, Azolla, BGA -mass production methods - application methods of biofertilizers - significance of biofertilizers. **6**

Mycorrhizal fungi: Diversity of endo and ectomycorrhizal fungi, culturing and benefits, role in bioremediation of soil. Fungal endophytes as biocontrol agents. Agriculturally important fungi in sustainable agriculture with special emphasis on Biopesticides, Mycoweedicides and Mycoinsecticides.

6

Suggested Readings:-

1. Alexander, M. Microbial ecology. John Wiley and Sons, New York.
2. Singh, B.D. Biotechnology, Kalyani Publishers, New Delhi
3. Agrios, G.N. 1999. Plant Pathology. Academic Press
4. Kale, V. and Bhusari, K. Applied Microbiology, Himalaya Publishing House.
5. Aneja K.R., Jain P. and Aneja R., 2008, A textbook of basic and applied microbiology, New Age Int. Publications, New Delhi.
6. Eldowney, S., and Waites, S. Pollution: Ecology and biotreatment. Longman, Harlow.
7. Baker, K.H. and Herson, D.S. Bioremediation. McGraw- Hill, New York. .
8. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
9. Mitchell, R. and Gu, J.D. Environmental microbiology. Wiley-Blackwell, New Jersey.
10. Evans, G.M. and John, J.C.F. Environmental biotechnology: Theory and applications. John Wiley and Sons, New York.
11. Waste Water Microbiology 2nd Edition by Bitton.
12. Satyanarayana, T., Johri, B.N. and Prakash, A. Microorganisms in environmental management: Microbes and environment. Springer Verlag, New York.
13. Adams M.R and Moss M.O: Food microbiology: Royal society of chemistry

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University of Rajasthan
Jaipur

14. Dennis Allsopp and Seal, K.J. 1986. Introduction to Biodeterioration. E Edward Arnold Ltd

15. Cappucino, J. and Sherman, N. Microbiology: A laboratory manual. Benjamin Cummings Publishing Company, San Francisco.

16. Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. McGraw-Hill, New York.

17. Singer, S. Experiments in applied microbiology. Academic Press, New York.

18. Pepper, I.L., Gerba, C.P. and Brendecke, J.W. Environmental microbiology: A laboratory manual. Academic Press, San Diego.

Elective Practical Lab BOT D12: Applied Microbiology

Suggested Laboratory Exercises:-

1. Microbiological examination of food.
2. Detection of number of bacteria in milk by standard plate count (SPC).
3. Assay of quality of milk sample using MBRT test.
4. Adulteration tests for milk.
5. Isolation and identification of Lactobacillus from fermented dairy products.
6. Isolation and identification of microorganisms from contaminated food and dairy samples.
7. Sampling and analysis of microbial load on food contact surfaces.
8. Micro organisms degrading oil/ textile dyes/ petrol.
9. Biodeterioration of paper/textiles.
10. Bacteriological examination of water (Potable/hospital waste): Presumptive test; Confirmed Test and Completed Test.
11. Design and operation of multistage reactor for degradation of waste water.
12. Isolation of xenobiotic compound degrading bacteria by enrichment culture technique.

Dy. Registrar (Academic-I)
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Jaipur

BOTD03:MI: MICROBIAL TECHNOLOGY

Pre-requisite of industrial microorganisms; Strategies for screening, selection and improvement of industrial strains; Methods of preservation & maintenance of microbial strains & their stability; Formulation of fermentation media; methods of sterilization; culturing techniques of microbial strains; inoculum preparation and inoculum development. Overview of upstream and Downstream processing, *In situ* recovery of products. **12**

Microbial Fermentations :Metabolic pathways and metabolic control mechanisms, industrial production of citric acid, lactic acid, enzymes (alpha-amylase, lipase, xylase, pectinases, proteases), acetone- butanol, Amino acid (lysine and glutamic acid), Vitamins (Riboflavin, cyanocobalamine). **8**

Microbial Production of Therapeutic and Pharmaceutical Compounds: Microbial production of therapeutic compounds (β lactam, aminoglycosides, Ansamycins (Rifamycin), peptide antibiotics Quinolinones), biotransformation of steroids, Fermentative production of antibiotics (penicillins, erythromycins); Vaccines, recombinant vaccines. **10**

Biofuels: Useful features of bio-fuels, The substrate digester and the microorganisms in the process of biogas production (biomethanation), Production of bioethanol from sugar, molasses, starch and cellulosic materials. Ethanol recovery, Microbial production of hydrogen gas, biodiesel from hydrocarbons. **10**

Modern trends in Microbial Production: microbial production of bioplastics (PHB, PHA), bioinsectices (thuricide), biopolymer (dextran, alginate, xanthan, pullulan), Biofertilizers (Rhizobia, BGA, Azotobacter, Phosphate solubilizing microorganisms), Single Cell Protein and production of biological weapons with reference to anthrax. **10**

Advances in Microbial Technology: Recombinant fermentations, strategies for fermentation with recombinant organisms and stability issues of recombinants; Applications of immobilized/co-immobilized cells/enzymes in fermentation industry; Overview of nanomaterials and biosynthesis of silver and gold nanomaterials from microbes. **10**

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Elective Practical Lab BOT D13: Microbial Technology

Suggested Laboratory Exercise:

1. Screening of industrial microbes
2. Collection and identification of important bacterial/fungal strains of industrial importance
3. Determination of specific cell growth rate.
4. Production and characterization of citric acid using A. niger.
5. Microbial production of glutamic acid.
6. Production of rifamycin using Nocardia strain.
7. Comparison of ethanol production using various Organic wastes /raw Material [Free cells/ immobilized cells].
8. Laboratory scale production of Biofertilizers [Nitrogen fixer/Phosphate Solubilizers].
9. Microbial production of dextran by Leuconostocmesenteroides
10. Microbial production of hydrogen gas by algae/bacteria
11. Laboratory production of vinegar.
12. Demonstration & operation of ultrasonicator
13. Enzymatic production of high fructose syrup from inulin
14. Production of alkaline phosphatase in lab scale Fermenter
15. Biochemical tests for identification of bacteria.
16. Synthesis of nanoparticles using microbes

Recommended Readings:

1. Biotechnology: A Textbook of Industrial Microbiology by W. Crueger, A. Crueger and T.D. Brock, Sinauer Associates Inc., USA (1991). 24
2. Industrial Microbiology: An Introduction by M.M.J. Waites, N.L. Morgan, J.S. Rockey and G. Higton, John Wiley & Sons, USA (2010).
3. Manual of Industrial Microbiology and Biotechnology by R.H. Baltz, J.E. Davies and A.L. Demain, ASM Press, USA (2010).
4. Microbial Biotechnology, Fundamentals of Applied Microbiology by A.N. Glazer and H. Nikaido, Cambridge University Press, UK (2007).
5. Microbial Biotechnology: Principles and Applications by Y.K. Lee, World Scientific Publs, Singapore (2006).
6. Microorganisms and Biotechnology by J. Taylor, N. Thornes, UK (2001). 1
7. Modern Industrial Microbiology and Biotechnology by N. Okafor, Science Publishers, USA (2007).
8. Prescott and Dunn's Industrial Microbiology by G. Reed, CBS Publishers and Distributors, India (2004).

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University of Rajasthan
Jaipur

9. Microbiology: A Laboratory Manual, J.G. Cappuccino and N. Sherman, 2002. Addison-Wesley.
10. Laboratory Manual of Experimental Microbiology, R.M. Atlas, A.E. Brown and L.C. Parks, 1995. Mosby, St. Louis.
11. Laboratory Manual in General Microbiology, N. Kannan, 2002. Panima Publishers.
12. Bergey's Manual of Determinative Bacteriology. Ninth edition J.G.Holt, N.R.Krieg, Lippincott Williams, 2000. Wilkin Publishers.
13. Pharmaceutical Microbiology SS Purohit, AK Saluja and HN Kakrani, 2012

Cluster: PPH- Plant Physiology

BOT E01: PPH: Plant Biochemistry and Metabolism

Energy: Principles of thermodynamics, free energy, Concept of energy rich compounds and intermediates, Structure and function of ATP, ATP synthesis and chemo-osmotic hypothesis of ATP generation, Redox reaction, Types and mechanisms of Phosphorylation.

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

Enzymes: Enzyme kinetics, Michalis- Menten equation and significance of Km value, negative and positive co- operativity, enzyme nomenclature and EC 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, isozymes, activators and inhibitors. **15**

Proteins: Structure, Ramchandran Plot, techniques of protein purification. Protein sequencing and proteomics, Dynamics of protein structure, Protein structure prediction tools, Protein Folding, protein stability, globular proteins and maintenance of specific confirmation, structural evolution. Molecular Chaperons, Protein Data Banks. **15**

Secondary Metabolites: Detailed account of Coumarins, Lignins, Inseticides(pyrethrins and rotenoides), Tannins, Flavonoids, Alkaloids and Steroid and their role in plant defense.

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Jaipur

Vitamins: Water and fat soluble vitamins , biochemical functions of thiamine, riboflavin nicotinic acid, pentothenic acid, pyridoxine, biotin, folic acid, vitamin B12, ascorbic acid, Vitamin A and Vitamin D. **15**

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, VoetJG : Biochemistry. 2nd edition.Wiley, New York. 1995.
4. WilliamG.Hopkins and Norman P.Huner. (2009),Introduction to Plant Physiology,Published by John Wiley &Sons,Inc,USA.
5. LincolnTaiz (2014). Plant Physiology and Development, Published by Oxford University Press.
6. Bob.B Buchanan, W. Gruissem, and RL Jones.(2015).Biochemistry and Molecular Biology of Plants, 2nd Edition,Published by Wiley-Blackwell.

Elective Practical Lab BOT E11: Plant Biochemistry and Metabolism

Suggested Laboratory Exercises:

1. Estimation of lipids
2. Separation of chlorophyll by paper chromatography.
3. Separation of amino acids by paper chromatography.
4. Separation of chlorophyll by liquid-liquid chromatography.
5. Test of phenols, steroids, alkaloids and terpenoids.
6. Isolation of VAM fungi
7. Quantification of protein in given plant sample.
8. Separation of aliphatic wax components by thin layer chromatography (TLC)
9. Quantification of carbohydrates in given sample.
10. Study of stomatal regulation.
11. Demonstration of Physiological effects of growth regulator.
12. Effect of temperature and different solvents on membrane permeability of beet root.
13. To determine proline in given plant material.
14. The effect of temperature on enzyme activity.
15. The effect of pH on enzyme action.
16. Determination of amylase activity
17. Demonstration of plasmolysis in *Rheo discolor* leaf peel.
18. Isolation of root nodule bacteria from roots of legume plant.

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Jaipur

BOT E02:PPH: STRESS BIOLOGY

Environmental stresses: Introduction, significance, types
Water deficit stress: Effects on physiological processes, Physiological responses to water deficit stress, Various strategies of drought resistance in plants, Mechanism of stomatal action, Antitranspirants, ABA as stress hormone, ABA dependent and ABA independent pathways, LEA proteins **10**

Flooding stress (anoxia): Nature of waterlogging stress, Effects of flooding stress on physiological processes in plants, Wetland and non-wetland species, Mechanism of waterlogging tolerance **05**

Salinity stress: Definition of saline soil, Causes of soil salinization, A brief outline of salt affected soils in India. Salinity stress- combination of osmotic stress and ionic stress, Physiological responses of plants to salinity stress, mechanism of salinity tolerance in higher plants, Signaling under salinity stress- Salt Overly Sensitive (SOS) Pathway, Compatible osmolytes- role in osmotic adjustment **10**

Heavy metal stress: Effect of ion toxicity (iron, zinc), heavy metals toxicity and aluminum toxicity in plants, Mechanism of aluminum tolerance, Phytoremediation **05**

Thermal stresses: Effects of high and low temperatures on plant, Physiological responses of plants to high and low temperatures, Mechanisms of high and low temperatures tolerance, Role of Heat Shock Proteins (HSPs) , calcium, calmodulin and C-repeat binding factors (CBFs) **10**

Oxidative stress: Influence of high light intensity on photosynthesis, Generation of reactive oxygen species (ROS), Effects of ROS, Photoprotection and ROS detoxification mechanisms in plants **05**

Biotic stresses: Responses of plants towards biotic stresses, plant defense system, genetic basis, understanding of R genes, Systemic acquired resistance **07**

Biotic stress signaling (plant defense): Elicitors and plant defense: Plant responses to elicitors and their role in crop improvement, Plant defense priming, Role of Jasmonic acid, salicylic acid, ethylene and nitric oxide signaling in plant defense. **08**

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Suggested Readings:

1. Plant Physiology (3rd edition), Lincoln Taiz and Eduardo Zeiger (2002), Sinauer Associates
2. Biochemistry and molecular biology of plants: Buchanan et al 2000, American Society of Plant Biologists, USA
3. Abiotic stress adaptation in plants: Pareek et al (2010), Springer
4. Plant Responses to Abiotic Stress: Hirt and Shinozaki: (Online) Springer
5. Plant Responses to environmental stress: Smallwood et al BIOS Scientific Publishers
6. Plant, Genes and Crop Biotechnology, Maarten J. Chrispeels& David E. Sadava, 2002, American Society of Plant Biologists, USA
7. Handbook of Plant and Crop Physiology: Pessarakli et al 2002, Marcel Dekker Inc. USA
8. Plant Ecophysiology: Prasad MNV 1997, John Wiley & Sons, Inc, USA
9. Introduction to Plant Physiology. Second Edition, Hopkins, William G. John Willey & Sons, Inc.
10. Oxidative stress and the molecular biology of antioxidant defenses. Scandolios, J. 1997. New York: Cold Spring Harbor Laboratory Press.

Elective Practical Lab BOT E12: Stress Biology

Suggested Laboratory Exercises:-

1. Measurement of RWC under stress.
2. Leaf disc assays under various abiotic stresses.
3. Determination of chlorophyll content under stress.
4. Determination of electrolyte leakage under stress.
5. Estimation of sodium, potassium, chlorides in different plant leaves.
6. Estimation of free amino acids content in the given sample
7. Study of effect of fungal infection on peroxidase activity.
8. Study of phenolics in scales of onion varieties differing in disease resistance.
9. Study of free radicals scavenging enzymes, catalase and super oxide dismutase.
10. Estimation of proline content in given water stressed samples
11. Study of seed germination under stress condition.
12. Estimation of betaine content in salt stressed samples.
13. Determination of ascorbic content in temperature (low and high) and salt stressed samples.

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

14. Determination of the concentration of polyamines in the given stressed samples.
15. Effect of stress on the activity of following scavenging enzymes:
(a) superoxide dismutase, (b) catalase, (c) peroxidase, (d) ascorbate peroxidase.
16. Visualization of stress proteins by SDS-gel electrophoresis.
17. Effect of stress on membrane damage in relation to lipid peroxidation.
18. Effect of water stress and Hyperthermia on the activity of nitrate reductase.

BOTE03: PPH: ADVANCED PLANT PHYSIOLOGY

Signal transduction in plants: Receptors and G-Proteins, secondary messengers, phospholipid signaling, role of cyclic nucleotides, calcium-calmodulin cascade, diversity of protein kinases and phosphate, single transduction mechanism with special reference to pathways activated by Auxins, Gibberellins,Cytokinins, ethylene and Abscisic acid **15**

Photomorphogenesis: Responding to light: Photoreceptors, Phytochrome: Responding to Red and Far-Red Light.Cryptochromes: Responding to Blue nd UV-Light. Phtochrome and Cryptochrome mediate numerous Developmental Responses-Seed germination, De-Etiolation, Shade avoidance, Control of Anthocyanin Biosynthesis, Rapid phytochrome response.Chemistry and mode of action of Phytochrome and Cryptochrome. Physiology of light induced responses- Tropic (Phototropism& Gravitropism) and Nastic movements; Stomatal movement; Molecular mechanism of actions of photomorphogenic receptors. **15**

Biological Clocks in plants: Clock-driven Rythms persists under constant conditions, Role of light and temperature,.Characteristics , mechanism and Significance.

Physiology of flowering& Fruit Development: Role of Photoperiodism and Vernalization in fiowering, Genetic and molecular analysis of flower development: ABC model; fruit development and ripening as regulated by hormones, Seed formation and deposition of stored reserves during seed development,Embryo maturation and desiccation, Germination,Physiology of Bud and seed dormancy. **15**

Programmed Cell Death (PCD), Senescence- Types of cell death observed in plants, overview of senescence, Pigment metabolism , protein metabolism & nucleic acid degradation during senescence, impact of senescence on photosynthesis & oxidative metabolism. Environmental & hormonal influence on senescence, Examples of developmental PCD in plants - formation of tracheal elements and mobilization of cereal endosperm and examples of PCD as a plant response to stress: formation of aerenchyma and hypersensitive response. **15**

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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. Lehninger AL, Nelson DL, Cox MM (2000): Principles of Biochemistry. 3rd edition. Macmillan Publishers, Worth New York.

5.WilliamG.Hopkins and Norman P.Huner. (2009),Introduction to Plant Physiology, John Wiley &Sons,Inc,USA.

6.Lincoln Taiz (2014). Plant Physiology and Development, Oxford University Press.

7.Bob.B Buchanan, W. Gruissem, and RL Jones.(2015).Biochemistry and Molecular Biology of Plants, 2nd Edition, Wiley-Blackwell.

Elective Practical Lab BOT E13: Advanced Plant Physiology

Suggested Laboratory Exercises

1. Study of effect of PEG induced water stress on seed germination.
2. Effect of various Plant growth regulators on Leaf discs (Normal &senescencing)
3. Effect of Red and Infrared light on seed germination and study of photo morphogenesis.
4. Hormonal regulation of leaves and petal senescence.
5. To study the rhythmic movements of plants.
6. Study of changes in starch and protein content during seed development.
7. Study of Tropic movements in Plants.
8. Estimation of Total Chlorophyll in Healthy leaves and senescencing leaves.
9. Estimation of Antioxidative enzyme activity in senescencing leaves.

BOT E04: PPH: PHYTOCHEMISTRY AND HERBAL MEDICINE

Historical background & Present status- Scope of Medicinal Botany, Indigenous medical system, Bioprospecting, Indigenous Knowledge system, Ayurveda, Siddha, Unani, Homeopathy, Tibetian and Folklore system of medicine. Need to Preserve Knowledge system. **10**

Phytochemical screening of crude drugs: Crude Drugs: Scope & Importance, Classification (Taxonomical, Morphological Chemical, Pharmacological); Cultivation, Collection & Processing of Crude Drugs. **8**

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Extraction and Characterization of Phytochemicals: Extraction, isolation, purification, characterization of following phytoconstituents such as Carbohydrates &Derived Products; Glycosides- Digoxin, Sennosides (Digitalis, Aloe, Dioscorea- Extraction Methods); Tannins(Hydrolysable & Condensed Types);Volatile Oils (Clove, Mentha- Extraction Methods); Alkaloids: Caffeine, Atropine, Ergometrine, Morphine; Flavonoids- Rutin, Quercetin; Terpenoids-Taxol, Pyrethrin; Saponins- Glycyrrhizinic acid, Diosgenin. **15**

Analysis of Phytochemicals: Standardization of phytopharmaceuticals by: UV, IR, HPLC, and HPTLC, GCMS techniques. Preliminary Screening, Assay of Drugs– Biological Evaluation/Assays, Microbiological Methods; Methods of Drug Evaluation (Morphological, Microscopic, Physical & Chemical); Processing, equipment and analytical profiles; Sterility, stability and preservation of extracts; Drug Adulteration – Types of Adulterants. **15**

Indian Trade in Medicinal and Aromatic plants: Export potential of Indian medicinal herbs. Indian medicinal plants used in cosmetics and aromatherapy. Spices and their exports, Classification of medicinal plant based industry, Production and utilization of medicinal plants and their products in India, List of medicinal plants cultivated in India. **Global regulatory status of herbal medicines:** Patents: Indian and international patent laws, Recent amendments as applicable to herbal/ natural products and processes. **12**

Elective Practical Lab BOT E14: Phytochemistry and Herbal Medicine

Suggested Laboratory Exercises:

1. Crude drug preparation methods.
2. Demonstration of Soxhlet extraction method.
3. Solvent Screening for various phytochemical extractions.
4. Extraction methods of Phytochemicals (alkaloids, tannins, glycosides, Flavonoids)
5. Reagent test of alkaloids determination in plants (Dragendorff's reagent, Meyer's reagent, Hager's reagent, Wagner's Test).
6. Phytochemical screening and detection of carbohydrates (Molisch's Test, Benedict's test, Fehling's Test)
7. Phytochemical screening and detection of glycosides, saponins, phytosterols, flavonoids, and tannins extracted from plant samples (at least one assay for each type of phytochemical).

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8. Demonstration of counter current extraction, microwave-assisted extraction, ultrasound extraction (sonication), supercritical fluid extraction, and distillation techniques (water distillation, steam distillation, phytonic extraction (with hydro fluorocarbon solvents).

Text /References Books:

1. Pharmacognosy, C. K. Kokate, A. P. Purohit& S. B. Gokhale (1996), NiraliPrakashan, 4th ed.
2. Natural Products In Medicine: A Biosynthetic Approach (1997), Wiley.
3. Melmon, K.L., and Morelli; Clinical Pharmacology: Basic Principle of Therapeutics, McMillan, New York
4. Craig, C.R. and Stitzel, B.E.; Modern Pharmacology, Little Brown and Co, Boston
5. Drill, V.A.; Pharmacology in Medicine, McGraw Hill, New York
6. Goodman and Gilman; Pharmacological Basis of Therapeutics, McGraw Hill
7. Trease and Evans, Pharmacognosy, Saunders Company, London.
8. Wallis T. E., Text Book of Pharmacognosy, CBS publishers & distribution, Delhi.
9. Textbook of Industrial Pharmacognosy, by A. N. Kalia, CBS Publishers and Distributors. New Delhi
10. Chaudhari R D, Herbal Drug Industry, Eastern publication.
11. Chadwick,D.J. & Marsh, J.:Bioactive compounds from plants.
12. J.C. Willis: Pharmacognosy
13. C.K. Kokate: Pharmacognosy
14. Trease, G.E and Evans, W.C.: Pharmacogonosy, Saunders, 1996.
15. Natesh, S. 2001. The changing scenario of herbal drugs: Role of Botanists. Phytomorphology. (Golden Jubilee Issue)., Pp.75-97.
16. JonneBernes – Herbal Medicines, Pharmaceutical Press, London 3rd ed.2007
17. Cutler, S.J. and Cutler, S.H.G. 2000. Biologically active natural Products – Pharmaceuticals. CRC Press, USA.
18. Herbal Cosmetics - H.Pande, Asia Pacific Business press, New Delhi.
19. Homeopathic Pharmacy An introduction & Hand book by Steven B. Kayne.
20. Indian Herbal Pharmacopoeia, Vol.1&2, RRL, 1DMA, 1998, 2000.
21. Ayurvedic system of medicine, 2nd edition, Kaviraj, NagendranathSengupata, vol. I &II.
22. Kumar, N.C. (1993). An Introduction to Medical botany and Pharmacognosy. Emkay Publications, New Delhi.
23. JonneBernes – Herbal Medicines, Pharmaceutical Press, London.
24. Siddha Pharmacopoeia by Dr.S. Chidambarathanupillai, Ist edition.
25. Unani Pharmacopoeia.

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Cluster: PE- Plant Ecology

BOTF01: PE: 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, ICAR classification of Indian grasslands, Significance of grasslands **10**

Freshwater Ecosystems –Classification of Freshwater Habitats, Lentic: Lakes & Ponds: Temperature and Oxygen stratification, Zonation based on light penetration, Flora and fauna, Trophic Interactions in Aquatic Food Chain, Productivity classes of lakes, Marshes and Swamps, Bogs Lotic: Springs, Streams and Rivers. **10**

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**

Forest Ecosystems - Forest types -Boreal, Temperate and Tropical forests, Characteristic features, Stratification of the forest, Forest animal life, Importance of Forest ecosystem, Deforestation: Causes and Effects **5**

Urban and Rural Ecosystem -Urban environmental and Climatic conditions, Physical complexes, Flora and fauna,Problems of urbanization: problems of air pollutants, drinking water supply, floods, waste disposal. Problems of RuralEcosystem: Problems of discharge of chemical fertilizers, pesticides and drinking water. Management of waste, Principle: Social Forestry. **5**

Desert Ecosystem: **Desert**: Definition, classification (hot and cold), physiography, desert features, flora, fauna and water, formation, topography, distribution and characteristics of world deserts; consequences of desertification, combat desertification **Thar desert:** Geomorphic evolution, Characteristic of 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); wind break and shelter belts, Indira Gandhi Canal and its ecological implications, dry land farming, underground water resources. **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. **20**

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Suggested Readings

1. P. L. Jaiswal, A.M. Wadhwani and N.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, N.S. and A.V.S.S. Sambamurty 2000. Ecology. Narosa Publishing House, New Delhi.

4. G. M. Masters and W. P. Ela. 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

Elective Practical Lab BOT F11: Ecosystem Ecology

Suggested Laboratory Exercises

- Find out stomatal index of Xerophytes (*Nerium, Calotropis, Zizyphus*,) growing in your locality.
- Study of trichomes of xerophytes (*Zizyphus, Lantana, Calotropis, Aerua*) 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.T.C. method
- Dormancy (seed coat & temperature) 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.

BOTF02: PE: CONSERVATION BIOLOGY

Introduction: Global as well as Indian Prospective - Biodiversity of World, India and Rajasthan.Hotspots or Important Biodiversity Area of India and Rajasthan, Biodiversity Categorization.

10

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Aims and Concept of Biodiversity Conservation: Necessity of conservation, Economic value, balance of Nature, Genetic Resources, Aesthetic Enjoyment, Education, IUCN categorization of species (Extinct, Extinct in Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Conservation Dependent and Least Concern), Earth summit 1992, Agenda 21, National and International organization for conservation of Biodiversity:IUCN, TRAFFIC, WWF, WII, BSI, NBPGR, National Biodiversity Authority India and National Medicinal Plant Board. **20**

Current issues in Biodiversity Loss: Community based conservation approach, Impact of climate change on species diversity, Human-wildlife conflict, Illegal trading (special reference to medicinal plants and timber), Habitat loss and Habitat fragmentation. **10**

Management and the conservation: Sustainable Development, *ex-situ* and *in-situ* conservation, World Heritage sites, Sacred groves, Bishnoi tradition, Chipko movement, Case studies of Tehri dam, SardarSarovar and Narmada dam. **Action to save endangered species:** Rehabilitation and reintroduction, gene banks, Captive breeding and propagation. Project Tiger and Elephant (role in protection of Indian forests), Project Rhino (role in protection of Tarai land) and Project GIB (Protection of Desert Grass land). **10**

Conservation Policies: Biodiversity conservation National policies and goals, CBD, Wildlife Protection Act-1972 and Amendment Act, 2002, 2006, Environment Protection Act-1986, Forest Conservation Act-1980; Biodiversity Act-2002 and Forest Rights Act-2006, Ramsar Convention, CITES **10**

Elective Practical Lab BOT F12: Conservation Biology

Suggested Laboratory Exercises:

1. Visit any protected area (National park/Sanctuary) and document red listed species.
2. Biodiversity assessment in your area
3. Documentation of wildlife protection act for the plants species.
4. Documentation of conservation major for Sandal wood, Red Sandal wood, Teak and Sal wood.
5. Documentation of IUCN and CITES species of Rajasthan plants.
6. Visit any Sacred groves and documentation of their species.
7. Visit any tribal community and describe their role for conservation.
8. In situ conservation of germplasm /plant species

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9. Preparation of list of endangered plant species in your area
10. Analysis and discussion of data of Project Tiger, Project Elephant, Project Rhino and GIB

Books Recommended:

1. Bookhout, T. A. (1996). *Research and management techniques for wildlife and habitats* (5th Ed.). The Wildlife Society, Allen Press, Kansas, USA.
2. Woodroffe R., Thirgood S. and Rabinowitz A. (2005). *People and Wildlife, Conflict or Co-existence?* (Conservation Biology) CambridgeUniversity.
3. Caughley G. and Sinclair A.R.E. (Eds.) (1994) *Wildlife Ecology and Management*, Blackwell Science, Cambridge.
4. Hunter M.L., Gibbs J.B. and E.J. Sterling (2008) *Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory.* Blackwell Publishing.
5. Rangarajan M. (2001) *India's Wildlife History*. Permanent Black, New Delhi, India.
6. Krebs, C. J. (1999). *Ecological Methodology* (2nd Ed.) Addison-Welsey Educational Publishers, Inc.
7. Sutherland, W. J. (2000). *The conservation handbook; research, management and policy*. Blackwell Sciences Ltd. London.

BOTF03: PE: 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; **12**

Water Pollution: Eutrophication- Process and Control; Oil Pollution, Thermal Pollution, Heavy metal Pollution, Treatment, Disposal & Recycling of Wastewaters, drinking water standards, Minimum National Standards **10**

Solid & Hazardous waste management & Resource Recovery: Solid wastes, Types, collection, Shrinking waste streams: 4Rs (Refuse,Reduction, Recycle & Reuse), composting, energy from waste, demanufacturing; Methods of disposal: **Land fill, Open dumps, Exporting waste;** Hazardous waste: Definition, disposal and management **08**

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Energy: Sources, Fossil fuels, Nuclear fuel, Solar Energy, Fuel Cells, Biomass, Hydropower, Wind Power, Geothermal, Tidal & Wave energy, Energy conservation **05**

Climate Issues: Greenhouse gases (CO_2, CH_4, N_2O, CFCs: sources, trends and role) and consequence of greenhouse effects (CO_2 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**

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. **05**

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**

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.
- BrijGopal, 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.Abrolamd V.V. DhruvaNarayana (Editors) 1990. Technologies for Wasteland Development. ICAR, New Delhi.
- J.S. Singh, K.P. Singh, Shuda Gupta: Environmental Biology
- G. M. Masters and W. P. Ela. 2008. Introduction to Environmental Engineering and Sciences. PHI Learning Private Limited, New Delhi.

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•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. Maiti. 2004. Handbook of Methods in Environmental Studies Vol. 1 &2. ABD Publisher, Jaipur.

Elective Practical Lab BOT F13: Environmental Biology

Suggested Laboratory Exercises

•To estimate pH, EC 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.

•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 and unpolluted habitat

Cluster:GE- Plant Genetic Engineering

BOT G01: GE: GENOMICS & PROTEOMICS

Genomic analysis: Introduction to gemone and genomics, Structural & functional Genomics, Structure & Organization of Prokaryotic (*E.coli*) & Eukaryotic genome (Yeast), Genome and Gene databases, Brief Outlook of Various Plant Genome Projects and their Outcome (Arabidopsis, Tomato, Potato, Rice), Human Genome Project. Genome sequencing strategies, new technologies for high throughput sequencing, Various Approaches in sequencing genome; shotgun, directed short gun & Clone Contig Approach, Primer Walking, Chromosome Walking, Chromosome Jumping, Contig Assembly, methods for sequence alignment and gene annotation.

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Approaches to analyze differential expression of genes - ESTs, SAGE, microarrays and their applications, gene tagging, gene and promoter trapping; knockout and knock-down mutants. Transcriptome, Transcriptomics, RNA interference and gene silencing, genome imprinting, small RNAs-biogenesis and functions, role of small RNAs in heterochromatin formation and gene silencing, tools to study methylome and histone modifications. **15**

Proteomics: Introduction to Proteome, Sequence & Structural Proteomics, Interaction &
Functional Proteomics
Tools andtechniques of proteome analysis: 1-D and 2-D gel electrophoresis, DIGE (Differential In Gel Electrophoresis), Image analysis of 2D and DIGE gels: spot detection & quantitation, gel matching, data analysis and presentation,Liquid Chromatography and Multidimensional Chromatography; Protein Identification by Mass Spectroscopy (MALDI/TOF), LC/MS-MS for identification of proteins, Peptide Mass Fingerprinting, Protein *de novo* sequencing. **15**

Analysis of proteins by different biochemical and biophysical procedures: CD (Circular Dichroism), NMR, Analysis of post-translational modifications and protein-protein interactions; protein chips and arrays, Proteome Databases: Protein Sequence Database, SWISS-PROT, PROSITE, PDB etc. other protein related bioinformatics tools (ExPASy, PFAM). Applications of proteomics in medicine, toxicology and Pharmaceuticals. **15**

Elective Practical Lab BOT G11: Genomics & Proteomics

Suggested Practical Exercises:

1. Demonstration and listing of sequence retrieval online tools.
2. Demonstration and listing of sequence submission online tools.
3. Listing and demonstration of Protein and DNA Sequence Databases and their utilities.
4. Demonstration of DNA and Protein Array Technology and applications.
5. Reverse transcription-PCR to examine gene expression.
6. Real-time PCR to quantify gene expression.
7. Northern and Western Blotting analysis.
8. Demonstration of Instrumentation (MALDI/TOF, LC-MS-MS, 2DGE) by visit or audio-visual medium.
9. Protein separation techniques (Chromatography-Ion-Exchange, Gel Filtration, Affinity; Ultrafiltration, Recombinant protein separation techniques).

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10. Comparison of Next-generation sequencing methods (by Chart/ poster preparation).
11. Any other exercises designed by course teacher as per the syllabus.

SUGGESTED READINGS:

1. Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Campbell AM &Heyer LJ, Benjamin Cummings 2007; CSH Press, NY. ISBN-10: 8131715590
2. Principles of Proteomics. R.M Twyman (2004). (BIOS Scientific publishers). ISBN-10: 1859962734
3. Principles of Gene Manipulation and Genomics- Primrose S &Twyman R, 7th Edition, Blackwell, 2006. ISBN-10: 1405135441
4. Principles of Genome Analysis and Genomics. Primrose SB &Twyman RM. 2007. Blackwell. ISBN-10: 1405101202.
5. Introduction to Genomics. A.M Lesk, Oxford University press, 2007. ISBN-10: 0199557489 .
6. A Primer of Genome Science. Greg Gibson and Spencer V. Muse. 2nd ed. 2004. SINAUER Associates Inc. ISBN-10: 0878932364.
7. Genome III – T.A. Brown Garland Science Publ. June 08, 2006. ISBN-10: 0815341385.
8. Introduction to Proteomics: Tools for the New Biology. Daniel C. Liebler, Humana Press Inc., 2002. ISBN-10: 0896039919.
9. Bioinformatics – Sequence and Genome Analysis – David W. Mount –Cold Spring Harbor Laboratory Press, U.S.; 2nd Revised edition, 2004. ISBN-10: 9746520709.
10. Lieber DC (2006) Introduction to Proteomics: Tools for New Biology; Humana Press, NJ.
11. Pennington SR, Dunn MJ (Eds.) (2002) Proteomics: From Protein Sequence to Function, BIOS Scientific Publishers, United Kingdom.
12. Sambrook J and Russell DW (2001). Molecular Cloning – A Laboratory Manual, Vols I – III, Cold Spring Harbor Laboratory, USA.

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BOT G02: GE: ADVANCE GENETIC ENGINEETRING AND MOLECULAR PHARMING

Enzymes used in genetic engineering: Restriction nucleases: exo&endo nucleases, DNA modifying enzymes and their mechanisms of action: DNA polymerases, DNaes, RNaes, Reverse transcriptase, Polynucleotide phosphorylase, Polynucleotide kinase, Alkaline phosphatase, Ligase,Terminaldeoxynucleotidyltransferase.

Cloning and expression hosts: Characteristics of cloning and expression host, bacterial, yeast, plant and mammalian host systems for cloning and expression of genes. **10**

Vectors for plant transformation: Basic features of vectors (Promoters, terminators & sequences influencing gene expression, selectable markers & reporter genes, origin of replication), Vectors for cloning - Plasmids, Bacteriophage λ vectors, Cosmids, BAC and YAC vectors, Shuttle vectors, Expression vectors, Co-integrative and binary vectors for plant transformation **10**

Heterologous gene expression in plants and **Genetic manipulation** of plants for Herbicide tolerance (Roundup ready Soybean), Insect resistance (Bt Cotton), stress tolerance, disease resistance, Improvement of crop yield and quality (Post-harvest loses, longer shelf-life of fruits (flavrsavr tomato), color manipulation of flowers (Blue rose), Making of Golden Rice

Genome editing (TALEN & CRISPR) and its applications in crop improvement. Applications of DNA based molecular markers (RFLP, RAPD and AFLP) in plant biotechnology. **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 and Risk manageme

Molecular Pharming in Plants

Introduction and brief history of plant molecular farming; Unique properties of host species for molecular farming (tobacco, alfalfa, white clover, lettuce, spinach, dry seed crops, oil crops, fruit and vegetable crops); Types of plant expression systems for molecular pharming (Stable nuclear transformation, plastid transformation system, virus-infected plants, transiently transformed leaves, hydroponic cultures, hairy roots, shooty teratomas, suspension cell cultures, Oleosin system); Comparison, advantage and disadvantages of production system of molecular pharming (bacteria, yeast, transgenic animal, plant cell culture and transgenic plants). **15**

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Jaipur

Plant Made Pharmaceuticals (PMPs)

(1) Plant Made Pharmaceutical and Therapeutic proteins (Human Serum Albumin, Human Insulin-like Growth Factors, Human Interferon, Anti-Microbial Peptides, Therapeutic Enzymes, Lactoferrins) (2) Industrial proteins (3) Monoclonal recombinant antibodies (4) Antigens(Edible vaccines- Rabies, Hepatitis B, Respiratory Syncytial Virus, Enterotoxic *E.coli* and *Vibrio cholerae*). Detailed account of Biopharmaceuticals already in market and close to market. **10**

Elective Practical Lab BOT G12: Advance Genetic Engineering and Molecular Pharming

Suggested Laboratory Exercises:-

1. Aseptic culture techniques for establishment and maintenance of cultures for genetic engineering.
2. Preparation of suitable media to grow transformed *E. coli* cells.
3. Activity assay of various enzymes involved in genetic engineering.
4. Analysis of different Plant DNA samples by molecular markers.
5. *Agrobacterium* culture, selection of transformants, reporter gene (GUS) assays.
6. Isolation of plant DNA using CTAB method.
7. PCR and Gel electrophoresis for gene cloning.
8. Demonstration of GLPs and Biosafety in research labs.
9. Preparation of Competent cells of *E.coli* for harvesting plant transformation vector.
10. Transformation of competent cells of *E coli* with plant transformation vector.
11. Mobilization of Ti plasmid from common laboratory host (*E. coli*) to an *Agrobacterium tumefaciens* strain
12. Development technique for production for transgenic plant (*Agrobacterium tumefaciens* mediated plant transformation).
13. Assignments on topics such as GMO, genome editing, PCR, gene cloning and molecular farming etc..

Suggested Readings:

1. Molecular Farming: Plant-Made Pharmaceuticals and Technical Proteins by Rainer Fischer and Stefan Schillberg, Wiley-Blackwell publisher, 2005.
2. Plant tissue culture by Bhojwani SS and Razdan MK. Elsevier, 2004.
3. Molecular Farming in Plants: Recent Advances and Future Prospects by Aiming Wang (Editor), Shengwu Ma (Editor), Springer, 2011.

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4. Plant Genetic Engineering: by Jaiwal P K, Vol 8-9, Metabolic Engineering and Molecular Farming (2005), Studium Press. USA.
5. J.Hammond,P. McGarvey and V. Yusibov (Eds.): Plant Biotechnology. Springer Verlag, 2000.
6. T-J.Fu,G. Singh,and W.R. Curtis(Eds):Plant Cell and Tissue Culture for the Production of Food ingredients. Kluwer Academic/Plenum Press.1999.
7. H.S.Chawla:Biotechnology in Crop improvement. International Book Distributing Company,1998.
8. P.K.Gupta:Plant Biotechnology. Rastogi and Co.Meerut,2010
9. Slater A, Scott N, Fowler M: Plant biotechnology: the genetic manipulation of plants. Oxford: Oxford University Press.2010.
10. Metabolic Engineering: *Stephanopoulos, Aristidou, A. A. and Nielsen J.*, Academic Press.
11. Basic Biotechnology-Ratledge C, Kristainsen B, Cambridge Publication.
12. Principles of Crop Improvement by Simmonds N.W. , Longman, London and New York. 1979.

Cluster:GEN- GENERAL

BOT H01: GEN: PRINCIPLES OF PLANT BREEDING

Overview & Historical perspectives: History of Plant Breeding-the pioneers, their theories and plant breeding techniques. **3**

Population and quantitative Genetic principles: Concept of Population ,gene pool, gene frequency and inbreeding and its implications in breeding, Qualitative genetics versus Quantitative genetics, the concept of Population Improvement. **6**

Reproductive systems: Importance of Mode of Reproduction , Types of Reproduction, Autogamy, Haploids and double haploids: their application in plant breeding, Allogamy, Inbreeding depression, hybrid vigour, Hybridization, wide crosses, clonal propagation and *In vitro* culture **8**

Germplasm for Breeding: Variation-Types, origin and scale, Plant Domestication-Centres & Models ,Plant Genetic resources-Importance & Sources of Germplasm, Concept of Gene pools, Crop vulnerability, Germplasm conservation: *In situ&Ex situ,* Types of Germplasm collection, Germplasm storage technologies, Plant explorations & Introductions & their impact on agriculture. **10**

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Jaipur

Breeding Objectives: Yield and morphological trait- Yield potential, Harvest Index, breeding for lodging resistance, shattering resistance, plant stature & early maturity; Quality traits- breeding for improved protein content, improved fatty acid content, seedlessness in fruits, delayed ripening & novel traits, Breeding for resistance to disease & insect pests – Resistance Breeding strategies; Abiotic Stresses –Breeding for drought resistance, cold tolerance, salt tolerance, heat stress, aluminium toxicity, oxidative stress, resistance to water logging **13**

Selection Methods: Breeding -self-pollinated species- Mass selection, pure line selection, Pedigree selection & Bulk population; cross pollinated species -hybrid cultivars and clonally propagated species. **7**

Molecular Breeding: Molecular markers- classification, Mapping of Genes- gene maps & QTL mapping, Marker assisted selection, Mutagenesis and Polyploidy in Plant Breeding **7**

Marketing and Societal issues in Breeding: Performance and Evaluation for crop cultivar release, Seed certification and commercial seed release, Regulatory and Legal issues, Value driven concepts and social concerns, International Plant breeding Efforts.Plant cultivar protection, legislation, patenting and transgenics. **6**

Elective Practical Lab BOT H11: Principles of Plant Breeding

Suggested Laboratory Exercises:

1. Vegetative propagation methods of important crops of the locality.
2. Emasculation, selfing and crossing techniques.
3. Floral biology in self pollinated species
4. Floral biology in cross pollinated species
5. Floral biology in self pollinated species
6. Selection methods in segregating populations and evaluation of breeding material
7. Germplasm conservation methods- In situ & Ex.situ methods
8. Haploid production.
9. In situ & ex situ conservation methods
10. Analysis of variance (ANOVA).
11. Maintenance of experimental records
12. Field inspection at different growth stages to study various breeding objectives.

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Suggested Readings:

1. George Acquaah.2012 Principles of Plant Genetics and Breeding.Wiley-Blackwell.
2. B.D.singh and A.K.Singh.2015.Marker Assisted Plant Breeding .Springer.
3. B.D.singh .2015.Plant Breeding principles & Methods .Kalyani Publishers.
4. Jack Brown ,Peter Caligari and Hugo campos.2014.An Introduction to Plant Breeding.Wiley.
5. Brown and Caligari. 2008.An Introduction to Plant Breeding.Blackwell Publishing.
6. Chopra VL. 2001. Breeding Field Crops. Oxford & IBH.
7. Chopra VL. 2004. Plant Breeding. Oxford & IBH.
8. Gupta SK. 2005. Practical Plant Breeding. Agribios. Jodhpur
9. Roy D. 2003. Plant Breeding, Analysis and Exploitation of Variation. Narosa Publ. House.
10. Sharma JR. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill.
11. Simmonds NW. 1990. Principles of Crop Improvement. English Language Book Society.
12. Dana, Sukumar. 2001. Plant Breeding. Naya Udyog, Colcutta. 700 006
13. Kucku, Kobabe and Wenzel (1995). Fundamentals of Plant Breeding. Narosa Publishing House.
14. Singh BD. 2006. Plant Breeding. Kalyani.
15. Singh P. 2002. Objective Genetics and Plant Breeding. Kalyani.
16. Singh P. 2006. Essentials of Plant Breeding. Kalyani.
17. Singh S & Pawar IS. 2006. Genetic Bases and Methods of Plant Breeding. CBS.
18. Stoskopf, N C, Tomes, D T and Christie. 1993. Plant breeding: theory and Practice. Scientific Publishers (India) Jodhpur.

BOT H02: GEN: BIOINFORMATICS AND BIOSTATISTICS

Concepts of Bioinformatics: Introduction and future prospects; Applications in genomics and proteomics; Public databases; Gene bank; Database searches: sequence retrieval systems; Similarity searching: BLAST, FASTA; Multiple sequence alignment: CLUSTALW; Detecting functional sites in DNA; Motif and domain prediction and analysis; Identification of open reading frames (ORF); Gene annotation technology. **11**

Databases and online tools: Biological Databases:- Types and applications; Sequence databases:- GenBank, EMBL, DDBJ, PIR-PSD, SWISS-PROT; Structure

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Jaipur

Databases:- PDB, SCOP, NDB; Derived Databases:- PROSITE, PRINTS, TIGR, Online tools:- Genetool; STRING; I-TASSER; Bioedit; BioGRID; MEGA; Sequin, Bankit **09**

Applications of Bioinformatics: Computational methods for sequence analysis: Dot blot and dynamic programming methods; Phylogenetic analysis; Virtual and electronic cell; Internet tools for DNA sequence translation; Restriction enzyme mapping; Prediction of secondary structure of proteins; Application tools- primer designing, molecular mapping and concept and tools of computer aided drug designing **10**

Fundamentals of statistics: Arithmetic mean, median, mode: theory and simple numerical problem; Measures of variation: standard deviation, variance, coefficient of variation; Correlation, types and methods: simple, multiple, linear and nonlinear correlation, spearman's correlation, rank correlation; Regression: linear and curvilinear regression (for two variable X and Y only), Regression lines by least square method; regression equations of X on Y and Y on X only; Sample size; Power of study. **13**

Tests of significance: Null hypothesis; Standard error; Level of significance; Degrees of freedom; Significance of mean for large samples; Significance in means for small samples (students t-test); Significance in ratio of two samples; F test (for difference between variance of two samples); Chi square test; Analysis of variance test (ANOVA) for one and two way classification; Calculation of an unknown variable using regression equation. **13**

Laws of probability, theorem of total probability **4**

Elective Practical Lab BOT H12: Bioinformatics and Biostatistics

Suggested Laboratory Exercises

1. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB etc.
2. Sequence retrieval using BLAST
3. Sequence alignment
4. Phylogenetic analysis using clustalW
5. Protein structure prediction
6. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction).
7. Prediction of different features of a functional gene

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Jaipur

8. Determination of Statistical averages/ central tendencies
a) Arithmetic mean b) Median c) Mode

9. Determination of measures of Dispersion a) Mean deviation b) Standard deviation and coefficient of variation c) Quartile deviation

10. Tests of Significance-Application of following a) Chi- Square test b) t- test c) Standard error

11. To learn graphical representations of statistical data with the help of computers (e.g. MS Excel).

Suggested Readings

1. Introduction to Bioinformatics, Arthur M. Lesk, Oxford University Press.
2. Introduction to Bioinformatics, Attwood, Pearson Education.
3. A Textbook of Systems Biology, E. Klipp, W. Liebermeister, C. Wierling, Axel Kowald, H. Lehrach, R. Herwig (2009), Wiley-VCH Verlag GmbH & Co.
4. Bioinformatics: Sequence and Genome Analysis, David W. Mount (2001), Cold Spring Harbor (CSH) Laboratory Press.
5. Plant System Biology, Coruzzi, G.M. (2009), Wiley Publishing House.
6. Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins. 2nd Edition by Baxevanis.
7. Bioinformatics: Sequence, structure and Data Bank: A Practical Approach by Higgis.
8. Bioinformatics - from Genomes to drug. 2 volumes by Lenganer.
9. Bioinformatic Methods and Protocols - Misener.
10. Bioinformatics: Sequence and Genome analysis.
11. . Introduction to Bioinformatics by Altwood.
12. Proteome Research: New Frontiers in Functional Genomics: Principles and Practices.
13. Genomics: The Science and Technology behind the human project.
14. Protein Biotechnology. Edited by Felix Franks. Humana Press, Totowa, New Jarsey.
15. Practical Statistics for experimental biologist by Wardlaw, A.C. (1985).
16. Statistical Methods in Biology - 2000 by Bailey, N.T. J. English Univ. Press.
17. Biostatistics - 7th Edition by Daniel 8. Fundamental of Biostatistics by Khan
18. Statisticsfor Biologist by CampbellR.C. (1974) Cambridge University Press
19. Introduction to Biostatistics, Le and Chap (2009), Wilay and Sons.
20. Fundamentals of Biostatistics, B. Rosner (2005), Duxbury Press.
21. Medical Statistics from Scratch, Bowers (2008), Wiley and Sons.

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BOT H03: GEN: PLANT RESOURCE UTILIZATION

Economic importance of microbes, with special reference to Bacteria and algae of your locality and found in extreme habitats **3**

Role of fungi in industries with reference to the production of alcohol, organic acids, antibiotics and enzymes **3**

Plant Biodiversity: Concept, status in India, utilization and concerns, Sustainable development: Basic Concepts. Origin of agriculture **6**

World centers of primary diversity of domesticated plants: The Indo-Burmese centre, plant introductions and secondary centers. **3**

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, spices condiments & oil-yielding crops. **10**

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**

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**

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**

Basic Horticultural techniques (soil preparation, bed preparation transplantation and pruning). Vegetative cultivation of cut flowers (Roses, Gerberas and Carnations), Bonsai- Types, forms structure and styles, Green House technique: Importance, types and operation techniques. Soil less culture (hydroponics concept) **5**

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Suggested Reading:-

1. Introduction to Agricultural Botany in India Chalam, 1965: G.V.I. Venkateshwarlu J.,: Asia Publishing House, New Delhi.
2. Ankur : (Magazine) and Plant Propagation, 2005 : M.K. Sadhu, New Age International, New Delhi
3. A Hand book of Field and Herbarium Methods,1977: S.K. Jain &R.R. Rao, Today &Tomorrow's Printers and Publication, New Delhi.
4. Contributions of IndianEthnobotany : S.K.Jain
5. A Manual of Ethnobotany,2016 : S.K. Jain, Saujanya Books , Jodhpur
6. Plant Propagation,2013 : H. Hartmann and D. Kester, Pearson New International
7. Anonymous 1997. National Gene Bank : Indian Heritage on Plant Genetic Resources (Booklet). National Bureau of Plant Genetic Resources, New Delhi.
8. Arora, R.K. and Nayar, E.R. 1984. Wild Relatives of Crop Plants in India.NBPGR Science Monograph No.-7.
9. Baker, H.G. 1978. Plants and Civilization (3rd edn.) C.A. Wadsworth, Belmont. 41
10. Bole, P.V. and Vaghani, Y. 1986. Field Guide to Common Indian Trees. Oxford, University Press, Mumbai.
11. Chandel, K.P.S., Shukla, G. and Sharma, N. 1996. Biodiversity in Medicinal and Aromatic Plans in India : Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.
12. Chrispeels, M.J. and Sadava, D. 1977. Plants, Food and People, W.H. Freeman and Co., San Francisco.
13. Cristi, B.R. (ed.) 1999. CRC Handbook of Plant Sciences and Agriculture.Vol. I. Insituconservation.CRC Press, Boca Raton, Florida, USA.
14. Conway, G. 1999. The Doubly Green Revolution : Food for All in the 21st Century.Penguin Books.
15. Conway, G. and Barbier, E. 1990. After the Green Revolution.Earthscan Press, London.
16. Conway, G. and Barbief, E. 1994. Plant.Genes and Agriculture. Jones and Bartlett Publishers, Boston.
17. Council of Scienfific and Industrial Research 1986. The Useful Plants of India.Publications and Information Directorate, CSIR, New Delhi.
18. Council of Scientific and Industrial Research (1948 - 1976). The Wealth of India.ADictionary of Indian Raw Materials and Industrial Products. New Delhi. Raw Materials I-XII, Revised Vol. I-III (1985-1992) Supplement (200).
19. Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants.Columbia University Press, New York, USA.
20. Directory of Indian Wetlands, 1993. WWF INDIA, New Delhi and AWB, Kuala Lumpur.

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

21. Falk, D.A., Olwel, M. and Millan C. 1996. Restoring Diversity. Island Press.Columbia, USA.
22. FAO/IBPGR 1989. Technical Guidelines for the Safe Movement of Germp1asm.FAO/IBPGR, Rome.
23. Frankel, O.H., Brown, A.H.D. and Burdon, J.J. 1995. The Conservation of Plan Diversity.Cambridge University Press, Cambridge, U.K.
24. Gadgil, M. and Guha, R. 1996. Ecology and Equity : Use and Abuse of Nature in Contemporary India.Penguin, New Delhi.
25. Gaston, K.J. (Ed.) Biodiversity : a Biology of Numbers and Differences. Blackwell Science Ltd., Oxford, U.K.
26. Heywood, V. (Ed). 1995 Global Biodiversity Assessment.United Nations Environment Programme. Cambridge University Press, Cambridge, U.K. 42
27. Heywood, V.H, and Wyse lackn, P.S. (Eds) 1991. Tropical Botanical Gardens.TheirRole in Conservation and Development. Academic Press, San Diego.
28. Kocchar, S.L. 1998. Economic Botany of the Tropics, 2nd edition.Macmillian India Ltd., Delhi.
29. Kothari, A. 2009-10. Understanding Biodiversity: Life Sustainability and Equity.OrientLongman.
30. Kohli, R., Arya, K.S., Singh, P.H. and Dhillon, H.S. 1994. Tree Directory ofChandigarh.Lovdale Educational, New Delhi.
31. Nair, M.N.B. et. al. (Eds.) 1988.Sustainable Management of Nonwood Forest Products.Faculty of Forestry, University Putra Malaysia.43004 PM SerdongSelangor, Malaysia.
32. Paroda, R.S. and Arora, R.K. 1991. Plant Genetic Resources Conservation and Management.IPGRI (Pubiication) South Asia Office, C/o NBPGR.Pusa Campus, New Delhi.
33. Pimentel, D. and Hall, C.W. (Eds.) 1989. Food and Natural Resources, Academic Press, London, New York.
34. Pinstrup-Anderson, P. et. al. 1999. World Food Prospects :Critical Issues for the Early 21st Century. International Food Policy Research Institute. Washington, D.C., USA.
35. Plant Wealth of India 1997. Special Issue of Proceedings Indian National Science Academy B-63.
36. Plucknett, D.L., Smith, N.J.H., William, J.T. andMurtiAnnishetty, N. 1987. Gene Banks and Worlds Food.PrincetonUnivrersity Press, Princeton, New Jersey, USA.
37. Rodgrs, N.A. and Panwar, H.S. 1988. Planning a Wildlife Protected Area Network in India. Vol. I.TheReport.Wildlife Institute of India, Dehradun.
38. Sahni, K.C. The Book of Indian Trees.2nd edition. Oxford University Press, Mumbai.

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

39. 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.
40. Swaminathan, M.S. and Kocchar, S.L. (Eds.) 1989. Plants and Society. Macmillan Publication Ltd., London.
41. Thakur, R.S., Puri, H.S.and Husain, A. 1989. Major Medicinal Plants of India.CentralInstitute of Medicinal and Aromatic Plants, CSIR, Lucknow.
42. Thomas, P. 2000. Trees: Their National History. Cambridge University Press,Cambridge.
43. Wanger, H., Hikino, H. and Farnswarth, N. 1989. Economic and Medicinal Plant Research. Vols. 1-3. Academic Press, London.
44. 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.

Elective Practical Lab BOT H13: Plant Resource Utilization

Suggested Laboratory Exercises

The Practical course is divided into three units: (I)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 :

(a) Textile fibres : cotton, jute, linen, sunn hemp, *Cannabis*.

(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).

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Jaipur

Papaversomniferu,,Catharanthusroseus, Adhatodazylanica(syn A. vasica) Allium sativum, Rauwolffiaserpentina, Withaniasomnifera, Phyllanthusamarus (P. fratermus), Andrographispaniculata, Aloe barbadens, Menthaarvensis, Rosa sp., Pogostemoncablin, Origanumvulgare, Vetiveriazizanioides. Jasminumgrandiflorum, Cymbopogon sp.,

Pandanusodoratissimus.

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

5. Vegetaible oils : Mustard, groundnut, soybean, coconut, sunflower, castor, Morphology, microscopic 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, *Buteamonosperma, Lawsoniainermis*) 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 aprropriate 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

iii. A mangrove

Dy. Registrar (Academic-I)
University of Rajasthan
Jaipur

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 H04: GEN: METHODS IN PLANT SCIENCES

Centrifugation: Plant Extraction and isolation of cell organelles, Basic principle, RCM, classification, Ultracentrifuge, Precautions and applications. **05**

Spectroscopy: Ultraviolet and visible: principle, Instrumentation, Sampling, application in Biology- DNA,RNA quantification and purity check. Fluorescence & Phosphorescence spectrophotometry: instrumentation &application.Quantification of Biomolecules.Calorimetry and Visible Spectrophotometry **08**

ImmunotechniquesAntibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow cytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH. **07**

Biophysical Method: Molecular analysis using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy Molecular structure determination using X-ray diffraction and NMR, Molecular analysis using light scattering, different types of mass spectrometry . **08**

Radiolabeling techniques: Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, Autoradiography-Principle, method, use in gene probe molecules, safety guidelines. **06**

Dy. Registrar (Academic-I)
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Jaipur

Microscopic techniques: Visualization of cells and sub cellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze- fracture methods for EM, image processing methods in microscopy. **08**

Statisitcal Methods: Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; Levels of significance; Regression and Correlation; t-test; F-test Analysis of variance; X2 test. **10**

Bioinformatics (Definition, history, applications &scope): Biological databases and Sequence analysis, BLAST and FASTA, Multiple sequence alignment, phylogenetic analysis and Bioinformatics in Drug Discovery. **08**

Elective Practical Lab BOT H14: Methods in Plant Sciences

Suggested Laboratory Exercises:

1. Instrumentation in Lab.
2. Microscopy- SEM, TEM, Florescence, Staining & fixation procedures
3. Centrifugation technique for isolation of cell organelles
4. Separation of biomolecules by Column/TLC/partition chromatography.
5. Measurement of cell size using stage micrometer and ocular micrometer.
6. Quantification of DNA by UV-Visible spectrophotometer.
7. Quantification of RNA by UV-Visible spectrophotometer
8. NMR spectroscopy technique.
9. IR spectroscopy technique.
10. Numericals related to biostatistics
11. ELISA, RIA, Flow cytometry
12. BLAST and FASTA
13. Phylogenetic analysis
14. Any other Exercise within scope of the syllabus

Suggested Readings:

1. Keith Wilson and John Walker,(2005).Principles and Techniques of Biochemistry and Molecular Biology, 6th edition ,Cambridge University Press.
2. K.L.Ghatak,2011.Techniques and Methods in Biology,PHL learning Private Limited, New Delhi.

Dy. Registrar (Academic-I)
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3. Upadhyay, Upadhyay and Nath,(2014).Biophysical Chemistry-Principles and Techniques,4th Edition,Himalaya Publishing House Pvt.Ltd.
4. Hammes GD (2005) Spectroscopy for the Biological Sciences; Wiley Interscience, USA.
5. Vinay Sharma. (2008).Text Book of Bioinformatics. Rastogi Publications.
6. Pranav Kumar (2016).Fundamentals and Techniques of Biophysics and Molecular Biology Paperback.Pathfinder Publication.
7. Rosener.(2010).Fundamentals of Biostatistics . Cengage Learning, Inc.

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