RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY
NAGPUR

M. Sc. Botany Syllabus

Semester pattern with Choice Base Credits System

2017 -18 and Onwards

APPENDIX – 1
Scheme of teaching under choice based credit system for M. Sc. Program in Botany.

S. No.	Semester	Course Code / Paper	Title of the Paper	Course / Paper	Teaching Scheme		
					Theory (Hours)	Practical (Hours)	Number of Credits
1	One	1T1	Microbiology, Algae and Fungi	I	04	04	04
2	One	1T2	Bryophytes & Pteridophytes	II	04	04	04
3	One	1T3	Paleobotany and Gymnosperms	III	04	04	04
4	One	1T4	Cytology and Genetics	IV	04	04	04
5	One	1P1	Algae, fungi, Bryophytes	Pract. I	-	-	04
6	One	1P2	Pteridophytes, Gymnosperms, Paleobotany, Cytology & Genetics	Pract. II	-	-	04
7	One	1S1 Seminar					01
8	Two	2T1	Plant Physiology and Biochemistry	I	04	04	04
9	Two	2T2	Plant Development and Reproduction	II	04	04	04
10	Two	2T3	Cell and Molecular Biology-I	III	04	04	04
11	Two	2T4	Angiosperms-I and Ethnobotany	IV	04	04	04
12	Two	2P1	Plant Physiology, Plant Biochem., Plant Development & Reproduction	Pract. I	-	-	04
13	Two	2P2	Cell and Molecular Biology I, Angiosperms I	Pract. II	-	-	04
14	Two	2S1 Seminar					01
15	Three	3T1	Plant Ecology and Conservation Biology	I	04	04	04
16	Three	3T2	Angiosperms-II	II	04	04	04
17	Three	3T3	Elective -I	III	04	08	04
18	Two	3T4	Foundation I	IV	04	-	04

19	Three	3P1	Plant Ecology and Conservation Biology and Angiosperms II	Pract. I	-	-	04
20	Three	3P2	Elective	Pract. II	-	-	04
21	Three	3S1 Seminar					01
22	Four	4T1	Cell and Molecular Biology-II	I	04	04	04
23	Four	4T2	Plant Biotechnology and Plant Breeding	II	04	04	04
24	Four	4T3	Elective II	III	04	-	04
25	Four	4T4	Foundation II	IV	04	-	04
26	Four	4P1	Cell and Molecular Biology-II, Plant Biotechnology and Plant Breeding	Pract. I	-	-	04
27	Four	4P2	Project	Pract. II	-	08	04
28	Four	4S1 Seminar					01

1. In each semester student will have to give seminar on any topic relevant to the syllabus encompassing the recent trends and development in that field. The topic of the seminar will be decided at the beginning of each semester in consultation with supervising teachers. The students have to deliver the seminar, which will be followed by discussion. The seminar will be open to all the teachers of the department invitees and students.

2. The students will have to carry out the research based project work in lieu of practical in the fourth semester in the department or depending on the availability of placement; he/she will be attached to any of the national/ regional/ private research institute / organization for the duration of the fourth semester. The student will be randomly allotted the priority number for the selection of the supervisor in the third semester. The student in consultation with supervisor will finalize the topic of the project work at the third semester.

3. These course can be taught by person having post graduate qualification in relevant / equivalent subjects/ or having teaching / research experience in that particular area.

APPENDIX – 2

Scheme of the examination under choice based credit system for M. Sc. Program in Botany

S. No.	Semester	Course Code / Paper	Title of the Paper	Duration of Paper / hrs		Maximum Marks	Total Credits
				Theory	Practical		
1	One	1T1	Microbiology, Algae and Fungi	03		80 + 20	04
2	One	1T2	Bryophytes & Pteridophytes	03		80 + 20	04
3	One	1T3	Paleobotany and Gymnosperms	03		80 + 20	04
4	One	1T4	Cytology and Genetics	03		80 + 20	04
5	One	1P1	Algae, fungi, Bryophytes		06	100	04
6	One	1P2	Pteridophytes, Gymnosperms, Paleobotany, Cytology & Genetics		06	100	04
7	One	1S1	Seminar		01	25	01
8	Two	2T1	Plant Physiology and Biochemistry	03		80 + 20	04
9	Two	2T2	Plant Development and Reproduction	03		80 + 20	04
10	Two	2T3	Cell and Molecular Biology-I	03		80 + 20	04
11	Two	2T4	Angiosperms-I and Ethnobotany	03		80 + 20	04
12	Two	2P1	Plant Physiology, Plant Biochem., Plant Development & Reproduction		06	100	04
13	Two	2P2	Cell and Molecular Biology I, Angiosperms I		06	100	04
14	Two	2S1	Seminar		01	25	01
15	Three	3T1	Plant Ecology and Conservation Biology	03		80 + 20	04
16	Three	3T2	Angiosperms-II	03		80 + 20	04
17	Three	3T3	Elective -I	03		80 + 20	04
18	Two	3T4	Foundation I	03		80 + 20	04
19	Three	3P1	Plant Ecology and		06	100	04

			Conservation Biology and Angiosperms II				
20	Three	3P2	Elective		06	100	04
21	Three	3S1	Seminar		01	25	01
22	Four	4T1	Cell and Molecular Biology-II	I	03	80 + 20	04
23	Four	4T2	Plant Biotechnology and Plant Breeding	II	03	80 + 20	04
24	Four	4T3	Elective II	III	03	80 + 20	04
25	Four	4T4	Foundation II	IV	03	80 + 20	04
26	Four	4P1	Cell and Molecular Biology-II, Plant Biotechnology and Plant Breeding	Pract. I		100	04
27	Four	4P2	Project			100	04
28	Four	4S1	Seminar		01	25	01

1. In each semester student will have to give seminar on any topic relevant to the syllabus encompassing the recent trends and development in that field. The topic of the seminar will be decided at the beginning of each semester in consultation with supervising teachers. The students have to deliver the seminar which will be followed by discussion. The seminar will be open to all the teachers of the department, invitees and students.

2. The students will have to carry out the research based project work in lieu of practical in the fourth semester in the department or depending on the availability of placement; he/she will be attached to any of the national/ regional/ private research institute / organization for the duration of the fourth semester. The student will be randomly allotted the priority number for the selection of the supervisor in the third semester. The student in consultation with supervisor will finalize the topic of the project work at the third semester.

3. The regular full time teacher of the department / contributory teacher approved by university / scientist of government / private research laboratory appointed by university as a contributory teacher and having M. Phil. or Ph. D. degree can supervise the project work of the student.

Subject Wise Core Elective Papers:

M. Sc. Subject	Core elective paper to be opted in Semester III	Core elective paper to be opted in Semester IV
Botany	Molecular Biology and Plant Biotechnology - I	Molecular Biology and Plant Biotechnology - II
	Reproductive Biology of Angiosperms - I	Reproductive Biology of Angiosperms - II
	Advanced Phycology and Hydrobiology - I	Advanced Phycology and Hydrobiology - II
	Mycology and Plant Pathology - I	Mycology and Plant Pathology - II
	Plant Physiology - I	Plant Physiology - II
	Paleobotany - I	Paleobotany - II
	Palynology - I	Palynology - II

Foundation Course: (Candidate can opt for any one foundation course paper in the Semester III and IV; however, student shall opt for this paper from any other subject other than his /her main subject for post-graduation.

List of foundation courses is available in the Appendix - A of Direction No. 13 of 2017

SEMESTER I

PRACTICAL (1P1)

Time : 6 Hours Full marks : 100

Q. 1	To identify the given Cyanobacterial material A.	10
Q.2	To identify two algal forms B, C, from the given mixture.	10
Q.3	To identify the given fungal culture D	10
Q. 4	To identify the given plant pathogen in the given material E.	10
Q. 5	To prepare a temporary microprepration of the given Bryophytic Material F and identify it	10
Q. 6	Comment on the given spot G (Cyanobacteria/Bacteria), H (Algae), I (Fungi), J (Bryophyte)	10
Q.7	Viva-voce	20
Q. 8	Practical Recordand tour report	20

SEMESTER I

PRACTICAL (1P2)

Time : 6 Hours Full marks : 100

Q. 1	To prepare a double stained microprepration of the given Pteridophytic materialA and identify it.	10
Q.2	To prepare a double stained microprepration of the given gymnospermic material B and identify it.	10
Q.3	Comment on the given fossil specimen C	10
Q. 4	One experiment from Cytology and Genetics D	10
Q. 5	Comment on the given spot E (Pteridophyte), F (Gymnosperm), G (Fossils), H (Cytology/Genetics)	20
Q.6	Viva-voce	20
Q. 7	Practical Recordand tour report	20

SEMESTER II

PRACTICAL (2P1)

Time : 6 Hours Full marks : 100

Q. 1	To perform the given physiological experiment A and report the findings	10
Q.2	To quantify the given metabolite in the given sample B	5
Q.3	To study the cytohistological zonation in SAM of given material C	10
Q. 4	Toperform the given exercise based on plant development D	10
Q. 5	Write a note on given stage of micro-or megasporogenesis E	10
Q. 6	Spotting: F (Physiology), G (Plant development), H (Reproduction)	15
Q. 7	Viva-voce	20
Q. 8	Practical Record	20

SEMESTER II

PRACTICAL (2P2)

Time : 6 Hours Full marks : 100

Q. 1	One experiment from paper VII A	15
Q.2	One experiment from paper VII B	10
Q.3	One experiment from paper VIII C	15
Q. 4	One experiment from paper VIII D	10
Q. 5	Spotting	10
Q. 6	Viva-voce	20
Q. 7	Practical Record and field diary	20

SEMESTER III

PRACTICAL (3P1)

Time : 6 Hours Full marks : 100

Q. 1	To perform the given ecological exercise A	15
Q.2	To solve the given statistical problem B	15
Q.3	To describe the given plant in technical language with floral formula and floral diagram C	10
Q. 4	To prepare the generic/family key D	5
Q. 5	To identify species of the given plant using Flora	5
Q. 7	Spotting	10
Q. 8	Viva-voce	20
Q. 9	Practical Record	20

SEMESTER III

PRACTICAL 3P2 (ELECTIVE)

ADVANCED PHYCOLOGY & HYDROBIOLOGY

Time: 6 Hours Full Marks: 100

1. Isolation and identification of Two Procaryotes (Bacteria & Cyanobacteria) (A) 10
2. Isolation and identification of Two Eucaryotes (B) 10
3. To demonstrate Any One of the following Experiments: (C) 10

a. Separation of algal pigments.

b. Extraction and separation of amino acids of fats or carbohydrates

c. Count the density of phytoplanktons.

4. Analysis of water samples for Any One of the following : (D) 10

a. Dissolved Oxygen, pH & Temperature
b. Free Carbon dioxide pH and Temperature
c. Total alkalinity
d. Total Hardness
e. Calcium Hardness
f. BOD & COD
g. Chloride
h. Ammonical Nitrogen

5. Analysis of soil for Any One of the following : (E) 10

a. Chloride, d. Calcium

b. Phosphate, e. Magnesium

c. Nitrogen

6. Identify the spots giving reasons F,G 10

7. Viva-Voce 20

8. Practical Record and Field Report 20

PRACTICAL 3P2 (ELECTIVE)

REPRODUCTIVE BIOLOGY OF ANGIOSPERMS

Time: 6 Hours Full Marks: 100

1. Dissect and mount the endothecium/endosperm from the given materials. 10

2. Dissect and mount given stage of embryo from the material. 10

3. In vitro pollen germination percentage and pollen tube growth. Record the data under given conditions. 10

4. Study the Morphology of pollen grain. 10

5. A) Localize the Biochemical compounds in a given plant material. 5

B) Draw the camera lucida figure of a embryological stage focused under the microscope. 5

6. Identification and comment on the given spots.(2 Spots) 10

7. Practical record & field Report. 20

8. Viva-voce 20

PRACTICAL 3P2 (ELECTIVE)

APPLIED MYCOLOGY AND PLANT PATHOLOGY

Time: 6 Hours Full Marks: 100

1. Identify giving salient characters of fungi from the given culture. (A) 10

2. Identification of given diseased material, their symptoms and characters.(B) 10

3. Effects of different concentrations of sugar solutions on the conidial germination and

presentation of data on graph paper.	10
4. Drawing of camera lucida diagram of the given fungus/microorganism.	10
5. Demonstration of pure culture techniques /transfer techniques.	10
6. Spotting (two spots)	10
7. Practical record, Herbarium and field report	20
8. Viva-voce	20

PRACTICAL 3P2 (ELECTIVE)

MOLECULAR BIOLOGY AND PLANT BIOTECHNOLOGY

Time: 6 Hours Full Marks: 100

1. One Major Experiment from Group A	15
2. One Minor Experiment from Group A	10
3. One Major Experiment from Group B	15
4. One Minor Experiment from Group B	10
5. Identification and comments on given two spots	10
6. Practical record	20
7. Viva-voce	20

PRACTICAL 3P2 (ELECTIVE)

PLANT PHYSIOLOGY

Time: 6 Hours Full Marks: 100

1. One Major Experiment from Special paper- I A	15
2. One Minor Experiment from Special paper- IB	10
3. One Major Experiment from Special paper- II C	15
4. One Minor Experiment from Special paper- IID	10
5. Identification and comments on given two spots (E, F)	10
6. Practical record and Project/field report.	20
7. Viva-voce	20

PRACTICAL 3P2 (ELECTIVE)

PALYNOLOGY

Time: 6 Hours Full Marks: 100

1. Pollen preparation by standard method/s - Section 'A'.	15
2. Any ONE experiment from Section B.	15
3. Any ONE experiment from Section C.	15
4. Any ONE experiment from Section A/B/C (Minor) (Other than asked in Question 1 - 3)	5
5. Spotting	10
6. Practical Record, Permanent slides & field record	20
7. Viva-voce	20

PRACTICAL 3P2 (ELECTIVE)

PALAEOBOTANY

Time: 6 Hours Full Marks: 100

1. Preparation of ground section slide of a given fossil specimen	10
2. Preparation of slide by maceration technique	10
3. Preparation of a peel section of given fossil specimen. Draw a well Labelled Diagram and comment	10
4. Write monograph on the given specimen	10
5. Comment on Given Fossil wood	10
6. Comment on the spots	10
7. Practical record and Field Report	20
8. Viva-Voce	20

SEMESTER IV

PRACTICAL (4P1)

Time : 6 Hours | Full marks : 100

Q. 1	One experiment from Paper XIII A	15
Q.2	One experiment from Paper XIII B	10
Q.3	One experiment from Paper XIV C	15
Q. 4	One experiment from Paper XIV D	10
Q. 5	Spotting from Elective Paper II	10
Q. 6	Viva-voce	20
Q. 7	Practical record	20

M. Sc. Botany Syllabus

Semester I

1T1- Core : Microbiology, Algae and Fungi

Botany 1T1- Core : Microbiology, Algae and Fungi

Objectives:

Understanding & Application the structure, reproduction eco. imp. of bacteria, viruses and archaebacteria

Understanding & Application classification, life cycles, eco. imp. Of various groups of algae and fungi

Understanding & Application symptoms, histopathology, etiology and identification of plant diseases and measurements

Outcomes: After completion of the course, the student will be able to

Identify the structure, life cycles, economic importances etc of bacteria, virus, arhaebacteria, algae, fungi and apply this knowledge

Based on symptoms, identify plant diseases and apply knowledge for control of diseases

Perform various microbial culture techniques and apply for development of various cultures.

Module I: Prokaryotes and viruses

General Microbiology: History- Contributions made by Leeuwenhoek, Pasteur, Robert Hook, Jenner, Waksman, Iwanowsky. Koch's Postulates.

Bacteria: Structure, morphology, reproduction.

Viruses: General account; Morphology and ultrastructure of TMV, Bacteriophage; Introduction to viroids, prions and interferon.

Archaebacteria and bacteria: General account; ultrastructure, nutrition and reproduction, biology and economic importance; Cyanobacteria:*Microcystis, Lyngbya*, *Nostoc*, *Scytonema*, *Gloeotrichia* and *Stigonema*.

Module II: Phycology

Criteria for classification of algae: Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Pheophyta and Rhodophyta; pigments, reserved food, flagella.

Algae in diversified habitats (terrestrial, freshwater, marine), thallus organization; cell ultrastructure; reproduction (vegetative, asexual, sexual); algal blooms, algalbiofertilizers; algae as a food, feed and uses in industry.

Module III: Mycology

General account: Classification of Fungi (recent trends and criteria used in classification); Physiology of Fungi (with reference to biotrophs, hemibiotrophs, symbionts); Fungal Cytology; Heterothallism, heterokaryosis, parasexual cycle.

Comparative study, classification and evolutionary trends in the following: Myxomycota: Protist characters and general account with special reference to *Physarium* and *Plasmodiophora*

Eumycota: i. Oomycetes: *Saprolegnia, Synchytrium, Phytophthora, Peronospora,*

ii. Zygomycetes: *Mucor, Rhizophus, Syncephalastrum, Cunninghamella*

Module IV: Mycology and plant pathology

Mycology contd….: Comparative study, classification and evolutionary trends in the following: iii. Ascomycetes: *Saccharomyces, Phyllactinia, Chaetomium, Xylaria*

iv. Basidiomycetes: *Melampsora, Puccinia, Ravenelia, Ustilago, Polyporus*.

v. Deuteromycetes: *Helminthosporium, Fusarium, Colletotrichum.*

Plant Pathology: Symptomology, histopathology, etiology and identification of diseases with reference to following fungal, bacterial and viral diseases (Paddy blast, wheat rust, bunt of wheat, smut of jowar, black arm of cotton, red rot of sugarcane, citrus canker, gummosis, leaf curl of papaya, potato blight.)

Practicals

Classification and type study of the following classes:

Prochlorophyta: *Prochloron,* Chlorophyta:*Pandorina, Eudorina, Stigeoclonium, Ulva, Chlorella,* Scenedesmus, Caulerpa, Valonia, Acetabularia; Phaeophyta:*Spacelaria, Padina,Turbinaria*; Rhodophyta: *Nemalion, Gelidium, Gracilaria, Corallina, Polysiphonia*; Euglenophyta:*Euglena, Phacus*; Bacillariophyta:*Cyclotella, Synedra, Cymbella, Navicula, Gomphonema.*

Morphological Studies of Fungi (any 15 of the following)

Stemonities, Perenospora, Phytopthora, Albugo, Mucor, Rhizopus, Yeast, Aspergillus, Penicillium, Chaetomium, Taphrina, Peziza, Erisyphe, Phyllactenia, Uncinula, Melamosora, Uromyces, Drechslera,Ravenallia, Ustilago, Polyporus, Morchella, Cyathus, Alternaria, Helminthosporium, Curvularia, Colletotrichum, Phoma, Plasmodiophora, Cercospora, Fusarium, Claviceps.

Symptomology of some diseased plants (any 7 of the following).

White rust of Crucifers, Downy mildew, powdery mildew, Rusts, Smuts, Ergot, Groundnut leaf spot (Tikka disease), False smut of paddy, red rot of Sugarcane, Wilt disease, Citrus canker, Angular leaf spot of cotton, Potato blight, Leaf mosaic of bhindi/ papaya, Leaf curl of tomato/Potato/Papaya, Little leaf of brinjal.

Identification of Fungal cultures (Any 5)

Rhizopus, Mucor, Aspergillus, Penicillum, Drechslera, Curvularia. Phoma, Colletotrichum, Alternaria, Helminthosporium.

Field study: For collection and studying fungal flora

Suggested Readings:

1. Kumar HD (1988) Introductory Phycology. Affiliated East-West Press Ltd. New Delhi
2. Morris I (1986) Introduction to the Algae. Cambridge University Press, UK
3. Round FE 1986 The Biology of Algae. Cambridge University Press, UK
4. Mandahar CL 1978 Introduction to Plant Viruses. Chand & Co. Ltd., New Delhi
5. Agrios, G.N. (1980) Plant Pathology, academic Press, INC, New York.
6. Ainsworth, G.C. and A.S.Sussman (eds). The Fungi, An advance Treatise Vol.I, II, III & IV Academic Press, New York.
7. Alexopoulos, C.J. (1962). Introductory Mycology John Wiley Eastern Pvt.Ltd.
8. Alexopoulos, C.J. and Mims C.W. (1979). Introductory Mycology 3rd Edition, John Wiley and Sons, Inc. Wiley, New York.
9. Alexopoulos, C.J., Mims and Black well (1996) 4th ed. John Wiley and Sons, Inc. Wiley, New York
10. Aneja, K.R. (1993) Experimental in Microbiology, Plant Pathology & Tissue Culture, Wiswa Prakashan, New Delhi.
11. Bessey, E.A. (1950) Morphology and Taxonomy of Fungi. The Blakiston co. Philadelphia.
12. Bilgrami, K.S. and H.C.Dube (1985) A text Book of Modern Plant Pathology, Vikas Publication House, New Delhi.
13. Barnett, J.H. (1968) Fundamentals of Mycology. The English Language Book Society and Edward Arnold Publication, Limited.
14. Dube, R.C. and D.K.Maheshwari (1999) A.Text Book of microbiology, S.Chand & Co. Ltd.
15. Dube, R.C. and D.K.Maheshwari (2000) Practical Microbiology -S.Chand & Co. Ltd.
16.Gupta, V.K. and M.K.Behl (1994) Indian Plant Viruses and Mycoplasma Kalyani Publishers, 1/1, Rejinder Nagar, Ludhiana.
17. Jha, D.K. (1993) A Text Book of Seed Pathology, Vikas Publication House.
18. Mehrotra, R.S. (1989) Plant Pathology, Tata McGraw Hill.
19. Mehrotra, R.S. and K.R.Aneja (1998) An Introduction to Mycology, New Age Intermidiate Press.
20. Pelzer, M.J. , Jr.Cahn, E.C.S. and N.R.Krieg (1993) Microbiology, Tata McGraw Hill.
21. Preece and Dickeson. Ecology of leaf surface microorganism Academic Press, New York.

22. Rangaswamy, G. and A.Mahadevan (1999) Diseases of Crop Plant in India, Prentice Hall of India.
23. Raychoudhari, S.P. and Nariani, T.K. (1977) Virus and Mycoplasma Diseases of Plant in India, Oxford and IBH Publication Co.
24. Schlegel, H.G. (1996) General Microbiology, 7th Edition, Cambridge University Press.
25.Snowdon, A.L. (1991) A colour Atlas of Post harvest diseases & disorders of fruits & vegetables Vol.I & II Wolfe Scientific, London.
26. On line Journals available on UGC -VSAT

Semester I

1T2- Core: Bryophytes & Pteridophytes

Objectives:

- **Understanding general characters, ecology, fossil history, classification, various types of bryophytes, pteridophytes.**
- **Learn evolutionary trends of various orders of Bryophytes, Pteridophytes and their different organs**

Outcomes:
After successful completion of the course the students will be able to

- **Learn various types of bryophytes, Pteridophytes characters for identification in lab and nature.**
- **Understand various types of fossils in bryophytes and Pteridophytes**
- **Understand evolutionary trends in bryophytes and pteridophytes**

Module I: Bryophytes

General characters, distribution, classification, ecology of Bryophytes, fossil history of bryophytes, cytology of bryophytes, regeneration in bryophytes, evolution of sporophyte-Retrogressive and Progressive theory.

Module II: Bryophytes contd…..

General account of-Hepaticopsida: Sphaerocarpels, Takakiales; Anthocerotopsida: Anthocerotales; Bryopsida: Sphagnales, Polytrichales.

Module III: Pteridophytes

General characters, distribution, classification, evolution of stele, heterospory and seed habit, apospory and apogamy; Important contributions of Indian Pteridologists, General account of Ryniopsida, Psilopsida, Lycopsida [protolepidodendrales, Lycopodiales, Selaginales, Isoetales].

Module IV: Pteridophytes contd…

General account and evolutionary trends of Sphenopsida [Hyeniales, Equisetales], Filicopsida [Ophioglossales, Filicales, Salvinales, Marsileales], Tracheophyta [Progymnospermosida].

Practicals

Bryophytes:

Study of morphological and reproductive characters of representative members mentioned in the syllabus using cleared whole mount preparations, dissections and sections. Preparation of permanent slides is necessary.

Study of bryophytes in their natural habitats.

Botanical excursion outside the state is compulsory to study the bryophytes in their natural conditions.

Pteridophytes:

Study of fossil forms (specimens and permanent micropreparations).

Study of living forms: Morphological, anatomical and reproductive characters of the forms mentioned in the syllabus. Anatomical characters to be studied either by taking free hand sections (t.s./l.s.) and by observing the permanent micropreparations. Preparations of permanent slides are essential.

Study of pteridophytes in their natural habitats.

Botanical excursion outside the state is compulsory to study the pteridophytes in their natural conditions.

Suggested Readings

1. Andrews H.N. Jr. (1961) Studies in Paleobotany (Jonh Wiley & Sons, New York)

2. Arnold C.A. (1947) An introduction to Paleobotany (McGraw Hill, New York)

3. Banks H.P. (1968) The early history of Land plants. In evolution and environment, ed. E.T. Drake. New Haven: Yale Univ. Press, pp, 73-107.

4. Banks H.P. (1970) Evolution and plants of past. (Belmont, California, Wadsworth).

5. Banks, H. P. (1975). Reclassification of Psilophyta, Taxon.24, 401-13.

6. Berrie, G. K. (1963). Cytology and Phylogeny of liverwoets. Evolution 17, 347-357.

7. Bierhorst D.W (1971) Morphology of vascular plants, New York (Mac Millan)

8. Campbell, D. H. (1961). The evolution of the Land Plants (central Book Depot, Allahabad)

9. Cavers, F. (1910). The interrelationship of Bryophyta I-IV.New Phytologist.

10. Cavers, F. (1911). The interrelationship of Bryophyta VII-IX.New Phytologist.

11. Chrysler M.A. (1910) The fertile spike in Ophioglossaceae. Ann. Bot. 24:1-18.

12. Delevoryas T. (1962) Morphology and Evolution of fossil plants (Holt, Rinehart and Winston, New York).

13. Eames A.J (1936) Morphology of vascular plants, lower groups (McGraw Hill, New York).

14. Foster A.S.and E.M Gifford Jr. (1959) Comparative morphology of vascular plants Freeman, San Fransisco.

15. Grolle, R. (1963). Takakia in Himalayas, Ost. Bot. Zeitscher, 110:444-447.

16. Gupta K.M. (1962) Marsilea, Botanical monograph no. 2 (CSIR, New Delhi).

17. Ingold, C. T. (1939). Spores discharge in land plants (Oxford London)

18. Kashyap S.R. (1929). Liverworts of the western Himalayas and The Punjab Plain 1 (Chronica Botanica)

19. Kashyap S.R. (1933). Liverworts of the western Himalayas and The Punjab Plain 2(Chronica Botanica)

20. Lacey, W. A. (1969). Fossil Bryophytes.Biological Reviews, 44,189-205.

21. Mehra, P.N. and O. N. Handoo (1953). Morphology of Anthoceros erectus and A. himalayensis and the phylogeny of the anthocerotales. Bot. Gaz.114:371-382.

22. Parihar N. S. (1976). An introduction to Embryophyta, Bryophyta (Centaral Book House, Allahabad)

23.Parihar N.S. (1977) The biology and morphology of the Pteridophytes (Central Book Depot, Allahabad).

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Semester I

1T3- Core: Paleobotany and Gymnosperms

Objectives:

- **Understand fossils formation, history, preservation, geological time scale, reconstruction and nomenclature of various types of fossils**
- **Learn the origin of gymnosperms, classification, evolution, eco. imp. of gymnosperms**

Outcomes:

After successful completion of the course the students will be able to

- **Identification, nomenclature, reconstruction of fossils and their significance in time scale**
- **Identification of various gymnosperms, evolution of gymnosperms and their relationships**

Module I: Paleobotany

Introduction; Plant fossils- Preservation, preparation, age determination, geological time scale; Fossil record- systematics, reconstruction and nomenclature; Applied aspects of paleobotany.

Module II: Gymnosperms

General account; distribution (living, Fossil); origin; systems of classification; economic importance.

Comparative morphology and evolutionary tendencies of:

1.Pteridospermales- Lyginoptridaceae (*Calymotheca hoeninghausii, Hetarngium, Spherostoma*); Medullosaceae (*Medullosa, Trignocarpus*).

2. Cycadales- Cycadaceae; Fossil history (*Baenia, Nilssonia, Androstrobus*)

3. Cycadeoidales- Williamsoniaceae, Cycadoeoidaceae

Module III:Gymnosperms contd…

General account and relationships of- Cordaitales, Caytoniales, Glossopteridales, Pentoxylales, Gnetales

Module IV: Gymnosperms contd…

Ginkgoales (*Ginkgo, Baiera, Trichopitys*); Coniferales (General characters, Embryogeny and phylogeny, evolution of ovuliferous scales, phylogeny); Taxales (*Taxus*, taxonomic position of taxales with respect to coniferales)

Laboratory exercise

Comparative Study of vegetative and reproductive parts of: *Cycas, Zamia, Cedrus,Abies, Pinus, Cupressus, Cryptomeria, Taxodium, Podocarpus, Agathis, Thuja, Gnetum,Ephedra, Juniperus,Cephalotaxus, Taxus*. Permanent micropreparatious to be submitted by the students.

Ginkgo: Morphology to be studied from Museum specimens & anatomy from permanent slides only.

Study of important fossil gymnosperms from material and permanent slides.

Visit to palaeobotanical Institutes, localities and collection of specimens.

Field visits to ecologically different localities to study living gymnosperms.

Suggested Reading

1. Stewart, W.N. and Rothwell G.W. (1993), Palaeobotany and the Evolution of Plants, Cambridge University Press.

2. Foster A.S. & Gifford F.M. (1967): Comparative morphology of vascular plants, FreemanPublishers, San Fransisco.

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8. Coulter J.M. & Chamberlain C.J.(1978): Morphology of Gymnosperms, Central Book Depot, Allahabad.

9. Kakkar, R.K.and Kakkar, B.R. (1995), The Gymnosperms (Fossils & Living), Central Publishing House, Allahabad.

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

13. Singh, H. (1978), Embryology of Gymnosperms, Encyclopedia of Plant Anatomy X, Gebryder, Bortragear, Berlin.

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19. On line Journals available on UGC -VSAT

Semester I

1T4- Core: Cytology and Genetics

Objectives:

- **Understand the laws of inheritance, various modifications, types of chromosomal inheritance patterns**
- **Understand multiple alleles and multiple gene inheritance, cytopplasmic inheritance**
- **Learn structural and numerical changes in chromosomes, mutations and inheritance patterns in various biological organisms and in their populations**

Outcomes:
After successful completion of the course the students will be able to

- **Know various types of inheritances in biological organisms and analyse inheritance patterns**
- **Understanding population genetics and equilibrium affecting various factors**
- **Understand the molecular mechanism of mutations and its role in crops improvement**

Module I

Mendel's laws of inheritance; Deviations from Mendel's findings: incomplete dominance, co-dominance,penetrance, expressivity, multiple alleles and isoalleles (example Corn, Drosophila and *Nicotiana*), gene interactions (non-epistatic and epistatic), Linkage; Chromosome theory of inheritance; Modifiers, suppressors and pleiotrpic genes; multigene families (globin and immunoglobin genes); sex determination in plants, *Drosophila, C. elegans*.

Module II

Cytoplasmic inheritance and maternal effect

Chromatin organization: Chromosome structure and packaging of DNA, molecular organization of centromere and telomere, rRNA genes, euchromatin and heterochromatin; Karyotype analysis and evolution, banding patterns; C-value paradox, Cot curve and its significance; specialized types of chromosomes: polytene, lampbrush, B-chromosome, sex chromosome; molecular basis of chromosome pairing.

Module III

Structural and numerical (heteroploidy) changes in chromosomes; origin, breeding behaviour of duplications, deficiency, inversion and translocation heterozygotes; effect of aneuploidy on plants; transmission of trisomics and monosomics and their use in chromosome mapping; complex translocation heterozygotes, translocation tester sets; Robertsonian translocation.

Population genetics: Hardy-Weinberg equilibrium; Factors affecting Hardy-Weinberg equilibrium; Quantitative trait loci (Kernel colour in wheat, corolla length in *Nicotiana longifera*).

Module IV

Mutations: Spontaneous and induced; physical and chemical mutagens- classification, mode of action; molecular basis of gene mutations; transposable genetic elements; site directed mutagenesis- definition, applications and PCR based oligonucleotide mutagenesis; role of mutations in crop improvement; induction of polyploidy

Epigenetics: Introduction; histone code; base modification; paramutations in maize; Callipygh sheep; Epigenetics and Lamarckism; Epigenome and epigenomics (Introduction).

Practicals

1. To study cell division (mitosis and meiosis) in the given material.
2. To study the effect of mutagen treatment on germination and seedling height.
3. To study effect of mutagen on the rate of cell division.
4. To study effect of mutagen on genetic material by scoring the chromosomal aberrations.
5. To study the translocation heterozygote in *Rheo discolor* or any other suitable material.
6. To study polytene chromosomes in *Chironomas* larvae.
7. To solve the given problems on interaction of genes (atleast five).
8. To study the karyotype of given organism.
9. To study the chiasma frequency in the given material.
10. To solve the given problem on population genetics (atleast three).

Suggested Reading

Gupta P K 2007 Genetics: Classical to Modern. Rastogi Publications, Meerut.

Hexter W and Yost Jr. H T 1977 The Science of Genetics. Prentice Hall of India Pvt. Ltd.,

New Delhi.

Hartl D L and Jones E W 1998 Genetics: Principles and Analysis (4thed.). Jones and Barflett Publishers, USA.

Khush G S 1973 Cytogentics of Aneuploids.Academic press, New York.

Snustad D P and Simmons M J 2000 Principles of Genetics (2nded.) John Wiley and Son Inc., USA.

Semester II

2T1- Core: Plant Physiology and Biochemistry

Objectives:

- **Understanding photosynthesis and respiration in plants.**
- **Understanding mechanistic underpinnings of the plant hormones and sensory photobiology.**
- **Understanding Enzymology.**
- **Understanding the solute transport system and metabolism.**

Outcomes:

After successful completion of the course the students will be able to

- **Understand the aspects of plant respiration and photosynthesis.**
- **Understand the aspects of metabolism of different components**
- **Perform and check the enzymatic activities of different components.**

Module-I

The Scope of plant physiology

Photosynthesis: Evolution of photosynthetic apparatus, pigments, Light, light harvesting complex, Mechanism of electron transport, Photo protective mechanism, CO2 fixation, C3, C4 and CAM pathway, Photorespiration, the chemiosmatic-coupling hypothesis and ATP Synthesis, , ATP Synthesis in chloroplast

Respiration:- introduction, ,Glycolysis, Citric acid cycle, oxidative pentose phosphate pathway, Plant mitochondrial electron transport and ATP synthesis (oxidative phosphorylation) alternate oxidase.

Module-II

Plant hormones:- biosynthesis, storage , breakdown and transport of hormones, physiological effect and mechanism of action of hormones auxins, gibberellins and cytokinine

Sensory photobiology:- structure, function and mechanism of phytochromes, cryptochromes and phototropins, stomatal movement. Photoperiodism and biological clock

Module-III

Enzymes: Nomenclature and classification of Enzymes enzyme kinetics, Michaelis –Menten equation, mode and mechanism of Enzyme action (Regulation of Enzyme activity), Activators & Inhibitors of enzymes, properties of Enzymes, factors affecting Enzyme activity, isozymes.

Solute transport and photo-assimilate translocation:-uptake transport and translocation of water, ion, solutes and macromolecules from soil through cell, across membranes, through xylem and phloem , transpiration, mechanism of loading and unloading of photo -assimilates

Module –IV

Carbohydrate Metabolism: Composition, structure and function of carbohydrates, synthesis of starch and

Sucrose, catabolism (degradation) of starch and sucrose

Lipid Metabolism: Composition, structure and function of lipids, fatty acid biosynthesis, membrane Storage lipids.

Protein metabolism: Composition, structure (Ramchandra plot. secondary, tertiary and quaternary structure)and function of Proteins

Metabolism of amino acids: Composition, structure and function of amino acids, amino acid biosynthesis in Plants.

Nitrogen metabolism: Nitrate and ammonium assimilation

Secondary metabolites: Biosynthesis of terpenes, phenols. Nitrogenous compounds and their roles

Suggested laboratory exercises

1. To study the effect of time and enzyme concentration on the rate of reaction of enzyme (e.g. phosphatase, nitrate reductase).

2. To study the effect of substrate concentration on activity of enzyme and determination of its Km value.

3. Demonstration of the substrate inducibility of the enzyme nitrate reductase.

4. Determination of succinate dehydrogenase activity, its kinetics and sensitivity to inhibitors.

5. To determine the total carbohydrate content in the given sample

6. Estimation of Pectic Substances-gravitic method .

7. To prove Berr-Lambert.s law using a suitable solution.

8. Extraction of chloroplast pigments from leaves and preparation of the absorption spectrum ofchlorophyll and carotenoids.

9. To determine the chlorophyll a/ cholorophyll b ratio in C3 and C4 plants.

10. Isolation of intact chloroplasts and estimation of choloroplast proteins by spot protein assay.

11. Preparation of standard curve of protein (BSA) and estimation of protein content in extractsof plant material by Lowry's or Bradford's method.

12. Preparation of Leaf Protein Concentrates from green vegetables.

13. Determination of reducing sugars by Nelson – Somogyi Method.

Suggested reading (for laboratory exercises)

1 Bajracharya, D. 1999. Experiments in Plant Physiology: A Laboratory Manual. Narosa Publishing House, New Delhi.

2 Cooper, T.G. 1977. Tools in Biochemistry.John Wiley, New York, USA.

3Copeland, R.A. 1996. Enzymes: A Practical Introduction to Structure, Mechanism andData Analysis. VCH Publishers, New York.

4Dennison C. 1999.A guide to Protein Isolation. Kluwer Academic Publishers, Dordrecht,The Netherland.

5Devi, P. 2000. Principles and Methods of Plant Molecular Biology, Biochemistry and Genetics. Agrobios, Jodhpur, India.

6 Dryer, R. L. and Lata, G. F. 1989.Experimental Biochemistry. Oxford UniversityPress, New York.

7Hames, B.D.(Ed.).1998. Gel Electrophoresis of Proteins: A Practical Approach, 8th edition. PAS, Oxford University Press, Oxford, UK.

8Harborne, T.C. 1981. Phytochemical Methods: A Guide to Modern Techniques of Plants Analysis. Chapman& Hall, London.

9Moore, T.C. 1974. Research Experiences in Plant Physiology: A Laboratory Manual.Springer-Verlag, Berlin.

10Ninfa, A. J. and Ballou, D. P. 1998. Fundamental Laboratory Approaches forBiochemistry and Biotechnology. Fitzgerald Science Press, Inc., Maryland, USA.

11 Plummer, D.F. 1988. An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

12Scott, R.P.W. 1995. Techniques and Practice of Chromatography.Marcel Dekker, Inc., New York.

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14Wilson, K. and Walker, J. 1994. Practical Biochemistry: Principles and Techniques, 4th edition. Cambridge University Press, Cambridge, UK.

15 Sadasivam and Manikum: Biochemical Methos , New Age International (p) Limited Publishers 4835/24, Ansari Road, Daryaganj, New Delhi-110002

Suggested readings (for theory)

1 Buchanan, B. B., Gruissem, W. and Jones, R.L. 1989.Biochemistry and Molecular Biology of plants.American Society of Plant Physiologists, Maryland, USA.

2Dennis, D.T., Turpin, D. H., Lefebvrc, D.D. and Layzell, D.B. (eds).1997. Plant Metabolism (2nd Ed.)Longman, Essex, England.

3 Gaiston, A.W.1989. Life Processes in Plants. Scientific American Library, Springer-Verlag, New York, USA.

4 Hooykass P.J.J., Hall, M. A. and Libbenga, K.R.(eds).1999. Biochemistry and Molecular Biology of plant Horm. Elsevier, Amsterdam, The Netherlands.

5 Hopkins, W.G. 1995. Introduction to Plant Physiology.John Wiley & Sons, Inc., New York, USA.

6 Jones R, Ougham H, Thomas H and Waaland S 2013 The Molecular life of plants. Wiley-Blackwell Publ., USA

6 Lodish, H., Berk, A., Zipursky S.L., Matsudaira, P., Baltimore, D and Darnell, J. 2000.Molecular Cell Biology (4thed). W. H. Freeman and Company. New York ,USA.

7 Moore, T.C. 1989. Biochemistry and Physiology of Plant Hormones (2nded). Springer-Verlag, New York, USA.

8 Nobel, P.S.1999. Physicochemical and Environmental Plant Physiology (2nd ed). Academic Press, Diego, USA.

9 Salisbury, F.B. and Ross, C.W.1992: Plant Physiology (4thed). Wadsworth Publishing Co., California, USA.

10 Singhal G.S., Renger, G., Sopory, S.K., Irrgang, K.D. and Govindjee.1999: Concepts in Photobiol Photosynthesis and Photomorphogenesis. Narosa Publishing House, New Delhi.

11 Taiz, L. and Zeiger, E. 1998: Plant Physiology. Sinaucr Associates, Inc., Publishers, Massachus, USA.

12 Thomas,B. and Vince-Prue,D.1997: Photoperiodism in Plants (2nd ed). Academic Press, San Diego, USA.

13 Westhoff, P.1998: Molecular Plant Development: From gene to plant. Oxford University Press, Oxford, UK.

14 Dey, P. M. And Harborne, J. B. 2000: Plant Biochemistry ,Harcourt Asia PTE Ltd. A Harcourt Publishers International Company, 583 Orchard Road 09-01 Forum Singapore

15 Ranjan, purohit, Prasad 2003: Plant Hormones Action and Application, Agrobios(India), agro house, behind Nasrani cinema Chopasani Road, Jodhpur -34

Semester -II

2T2- Core: Plant Development and Reproduction

Objectives:

- **Understanding the basic growth kinetics and growth patterns in plants**
- **Understanding the plant growth regulators with respect to plant growth and metabolism**
- **Understanding dormancy, senescence and their influences on plant growth and reproduction.**

Outcomes:
After successful completion of the course the students will be able to

- **Know the basic growth kinetics and role of phytohormones in plant development**
- **Know the molecular mechanism of growth and differentiation of root, leaf flowers and seeds**
- **Learn to use biomolecules for flower formation, seed setting, senescence effects.**

Module I: Plant development

Plant growth kinetics and patterns of growth.

Seedling growth: Tropisms; Photomorphogenesis of seedling; hormonal control of seedling growth.

Shoot Development: Organization of shoot apical meristem (SAM); cytological and molecular analysis of SAM; regulation of cell fate in meristem; tissue differentiation in the shoot.

Phytohormones: Classification, chemical nature and their role in plant development.

Module II:Plant development contd…..

Leaf growth and differentiation: Determination; phyllotaxy; control of leaf form; differentiation of epidermis (with special reference to stomata & trichomes) and mesophyll.

Root Development: Organization of root apical meristem (RAM); vascular tissue differentiation; lateral root hairs; root microbe interactions.

Flower Development: Physiology of flowering, florigen concept and photoperiodism, Genetics of floral organ differentiation; homeotic mutants in *Arabidopsis* and *Antirrhinum*.

Pollination mechanisms and vectors.

Module III: Reproduction

Male Gametophyte: Structure of anther, microsporogenesis, tapetum; pollen development and gene expression; male sterility; sperm dimorphism; pollen germination; pollen tube growth and guidance.

Female Gametophyte: Ovule types; megasporogenesis; organization of embryo sac; structure of embryo sac cells.

Pollen-pistil interaction, self-incompatibility and fertilization; Structure of the pistil; pollen-stigma interactions, double fertilization; *in vitro* fertilization.

Module IV:Reproduction contd…..

Seed Development and fruit growth: Endosperm development; embryogenesis; ultrastructure and nuclear cytology; storage proteins of endosperm and embryo; polyembryony; apomixes; embryo.

Fruit development and growth

Latent life: Dormancy; Importance and types of dormancy; seed dormancy; overcoming seed dormancy; bud dormancy.

Senescence and Programmed Cell Death (PCD): Basic concepts; types of cell death, PCD in life cycle of plants; metabolic changes associated with senescence and its regulations; influence of hormones and environmental factors on senescence.

Suggested readings

1) Bhojwani, S.S. and Bhatnagar, S.P. 2000. The Embryology of Angiosperms (4th revised and enlarged edition). Vikas Publishing House, New Delhi.

2) Fageri, K. and Van der Pol, L. 1979. The Principles of Pollination Ecology. Pergamon Press, Oxford.

3) Fahn, A. 1982. Plant Anatomy, (3rd edition). Pergamon Press, Oxford.

4) Fosket, D.E. 1994. Plant Growth and Development.A molecular Approach. Academic Press, San Diego.

5) Howell, S.H. 1998, Molecular Genetics of Plant Development. Cambridge University Press, Cambridge.

6) Leins, P., Tucker, S.C. and Endress, P.K. 1988. Aspects of Floral Development. J. Cramer, Germany.

7) Lyndon, R.F., 1990. Plant Development.The Cellular Basis. Unnin Hyman, London.

8) Murphy, T.M. and Thompson, W.F. 1988. Molecular PlantDevelopment. Prentice Hall, New Jersey.

9) Proctor, M. and Yeo, P. 1973. The Pollination of Flowers.William Collins Sons, London.

10) Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, Cambridge.

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

12) Raven, P.H., Evert, R.F. and Eichhorn, S.E. 1992. Biology of Plants (5th Edition).worth, New York.

13) Steeves, T.A. and Sussex, I.M. 1989. Patterns in Plant Development (2nd edition). Cambridge University Press, Cambridge.

14) Sedgely, M. and Griffin, A.R. 1989. Sexual Reproduction of Tree Crops, Academic Press, London.

15) Waisel, Y., Eshel, A. and Kafkaki, U. (eds) 1996. Plant Roots: The Hidden Hall (2nd edition.) Marcel Dekker, New York.

16) Shivanna, K.R. and Sawhney, V.K. (eds) 1997. Pollen Biotechnology for Crop Production and Improvement, Cambridge University Press, Cambridge.

17) Shivana, K.R. and Rangaswamy, N.S. 1992. Pollen Biology: A Laboratory Manual. Springer-Verlag, Berlin.

18) Shivana, K.R. and Johri, B.M. 1985. The Angiosperm Pollen: Structure and Function. Wiley Eastern Ltd., New York.

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

20) On line Journals available on UGC -VSAT

Suggested Laboratory / Field Exercises (Any 12)

1. Tissue systems, meristem, vascular and cork cambium.

2. Internal structure of root, stem and leaf (dicot and monocot), advanced secondary growth in dicot stem and root.

3. Anomalies in primary and secondary structure of stem.

4. Study of living shoot apices by dissections using aquatic plants such as *Ceratophyllum* and *Hydrilla*.

5. Study of cytohistological zonation in the shoot apical meristem (SAM) in sectioned and double-stained permanent slides of a suitable plant such as *Coleus, Kalanchoe*, Tobacco.

6. Examination of shoot apices in a monocotyledon in both T.S. and L.S. to show the origin and arrangement of leaf primordia.

7. Study of alternate and distichous, alternate and superposed, opposite and superposed; opposite and decussate leaf arrangement.

8. Examination of rosette plants (*Launaea, Mollugo, Raphanus, Hyoscyamus* etc.) and induction of bolting under natural conditions as well as by GA treatment.

9. Microscopic examination of vertical sections of leaves such as *Cleome, Nerium*, Maize and Wheat to understand the internal structure of leaf tissues and trichomes, glands etc. Also study the C3 and C4 leaf anatomy of plant.

10. Study of epidermal peels of leaves such as *Coccinia, Gaillardia, Tradescantia, Thunbergia*, etc. to study the development and finalstructure of stomata and prepare stomatal index. Demonstration ofthe effect of ABA on stomatal closure.

11. Study of whole roots in monocots and dicots. Examination of L.S. of root from permanent preparation to understand the organization of root apical meriste m and its derivatives. (use maize, aerial roots of banyan, *Pistia, Jussieua* etc.).

12. Origin of lateral roots.

13. Study of leguminous roots with different types of nodules.

14. Study of microsporogenesis and gametogenesis in sections of anthers.

15. Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (Maize, Grasses, *Crotolaria, Tradescantia, Brassica, Petunia, Solanum melongena*, etc.)

13. Tests for pollen viability using stains and in vitro germination. Pollen germination using hanging drop and sitting drop cultures, suspension culture and surface culture.

14. Estimating percentage and average pollen tube length *in vitro*.

15. Role of transcription and translation inhibitors on pollen germination and pollen tube growth.

16. Pollen-pistil interaction, self-incompatibility, *in vitro* pollination.

17. Study of ovules in cleared preparations; study of monosporic, bisporic and tetrasporic types of embryo sac development through examination of permanent stained serial sections.

18. Field study of several types of flower with different pollination mechanisms (wind pollination, thrips pollination, bee/butterfly pollination, bird pollination).

19. Emasculation, bagging and hand pollination to study pollen germination, seed set and fruit development using self compatible and obligate outcrossing systems.

20. Study of cleistogamous flowers and their adaptations.

21. Study of nuclear and cellular endosperm through dissections and staining.

22. Isolation of zygotic globular, heart-shaped, torpedo stage and mature embryos from suitable seeds and polyembryony in citrus, jamun (*Syzygium cumini*) etc. by dissections.

23. Study of seed dormancy and methods to break dormancy.

Semester II

2T3 - Core: Cell and Molecular Biology-I

Objectives:

- **Understanding the structures and functions of the cell wall, plasma membrane and plasmodesmata**
- **Understanding the structures and functions of cell organelles, cytoskeleton, nuclear envelope, and structure of DNA**
- **Understanding various types of stresses and defense mechanisms in plants and apply this knowledge.**

Outcomes:

After successful completion of the course the students will be able to

- **Know the cell wall & cellular organization of the eukaryotic and prokaryotic cells**
- **Learn the cell cytoskeleton and its role**
- **Learn and apply techniques of stress related problems in plants**

Module I:

Cell wall: Structure; function; biogenesis and growth.

Plasma membrane: Membrane architecture (fluid mosaic model); sites for ATPases; membrane transport-ion carriers, channels, pumps and aquaporins; receptors.

Plasmodesmata: Structure, role in movement of molecules and macromolecules; comparison with gap junction.

Module II:

Cellular organelles: Ultra-structure and function of golgi complex, lysosomes, peroxisomes, endoplasmic reticulum, mitochondria, chloroplast and plant vacuoles.

Cell shape and motility: The cytoskeleton; organization and role of microfilaments, intermediate filaments and microtubules; motor movements, implications in cell division, flagellar & other movements.

Module III:

Nucleus: Ultrastructure, nuclear pores, nucleolus, DNA structure A, B and Z forms, replication in prokaryotic and eukaryotic cells, DNA replication proteins, damage and repair.

Module IV:

Stress biology: Definition and classification of stress.

Biotic stress: Plant defence mechanism (passive and active); HR and SAR; modulation of plant metabolism in response to biotic stress: early and late response; production of ROS, induction of enzymes; PR proteins; R-genes.

Abiotic stress: Effect of water, temperature, salt and light stress on plants; developmental and physiological mechanisms protecting plants against environmental extremes.

Suggested readings

Atherly, A.G., Griton, J.R. and Mc Donald, J. F. 1999.The Science of Genetics.Saunders College Pub. Fort Worth, USA

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Bush, H. Rothblum, L. 1982. Vol. X. The Cell Nucleus RDNA part A. Academic Press.

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De Robertis, E.D.P. and De Robertis, E.M.F. Cell and Molecular Biology 8Ed. B. I. Waverly Pvt. Ltd., New Delhi.

Jones R, Ougham H, Thomas H and Waaland S 2013 The Molecular life of plants. Wiley-Blackwell Publ., USA

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Kleinsmith, L.J. and Kish, V.M. 1995 Principles of Cell and Molecular Biology (2nd Edi.)Harper Collins Coll. Publisher, New York, USA.

Krishnamurthy, K.V. 2000 Methods in Cell wall Cyto-chemistry. CRC Press, Boca Raton, Florida

Lodish, H., Berk, A. Zipursky, S. L. Matsudaira, P., Baltimore, D. and Dar nell, J. 2000 Molecular Cell Biology Edi. W.H. Freeman and Co., New York, USA

Russel, P. J. 1998 Genetics (5th Edi.) The Banjamin/ Cummings Publishing Com. Inc., USA

Wolf, S.L. 1993. Molecular and Cellular Biology, Wadsworth Publishing Co., California, USA

Taiz, L. and Zeiger, E. 1998: Plant Physiology. Sinaucr Associates, Inc., Publishers, Massachus, USA

Practicals

1. To study salivary gland chromosomes of Chironomas and Drosophila.
2. To isolate mitochondria and determine the activity of its marker enzyme SDH.
3. To isolate bacterial and plant DNA and quantify them by spectrophotometric method.
4. To demonstrate the semi-permeability of the plasma membrane.
5. To study the activity of Na/K ATPase.
6. To demonstrate different components of cytoskeleton in the suitable material.

7. To perform flagellar staining.

8. Isolation of DNA and preparation of Cot-curve.

9. Demonstration of vital structure and functions of cell

10. To study the activity of PAL in the seedlings challenged with elicitors.

11. To study the induction of antioxidant enzymes in the seedlings challenged with elicitors.

12. To study the effect of water stress on the seedling growth and its chlorophyll content.

13. To study the effect of temperature stress on the seedling growth and its chlorophyll content.

14. To study the effect of salt stress on the seedling growth and its chlorophyll content.

Suggested readings (for laboratory exercises)

Fukui, K. and Nakayama, S. 1996. Plant Chromosomes: Laboratory Methods. CRS Press, Boca Raton, Florida.

Glick, B. R. and Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology.CRC Press, Boca Raton, Florida USA.

Goswami, H. K. 1986. Practical cytology – Applied Genetics and Biostatistics Himalaya Pub. House, Bombay.

Gunning, B.E.S. and Steer, M.W. 1996. Plant Cell Biology: Structure and Function. Jones and Barlett Publishers, Boston, Massachusetts.

Hall, J.L. and Moore, A.L. 1983.Isolation of Membranes and Organelles from Plant Cells Academic Press, London, U.K.

Harris,N. and Oparka, K.J. 1994. Plant Cell Biology: A Practical Approach. IRL Press, at Oxford University Press, Oxford, U.K.

Sharma, A.K. and Sharma, A. 1999. Plant Chromosomes: Analysis, Manipulation and Engineering. Har Academic Publishers, Australia.

Shaw, C.H. (Ed.), 1988. Plant Molecular Biology: A Practical Approach. IRL Press, Oxford.Techniques, 2nd edition. PAS, IRL Press at Oxford University Press, Oxford.

References: Online journals available on UGC V-SAT programme.

Review Journals:

Annual Review of Plant Physiology and Molecular Biology

Biochemistry and Cell Biology

Cell Death and Differentiation

Cell Motility and the Cytoskeleton

Cellular Physiology and Biochemistry

Current Advances in Plant Sciences

European Journal of Cell Biology Journal of Cell Science

Nature Reviews: Molecular and Cell Biology

Protoplasma-An International Journal of Cell Biology

Trends in Cell Biology

Trends in Plant Sciences

Semester II

2T4 –Core :Angiosperms-I and Ethnobotany

Objectives:

- **Understanding the morphology of flowers of dicot and monocots for proper identification of angiosperm plants**
- **Understanding plant taxonomy and modern trends in taxonomy and conservation methods of ethnobotanical plants**

Outcomes:

After successful completion of the course the students will be able to

- **Learn basic structure of flowers for identification and distinguish them**
- **Apply taxonomic tools in taxonomic classification, modern and numerical taxonomy and phylogeny**

Module I:

Angiosperm Morphology, structural units and floral symmetry, dicot and monocot flower; structure, diversity origin and evolution of stamen, carpels; placentation types and evolution.

Floral adaptation to different pollinators

Module II:

Angiosperm Taxonomy: Scope, aims, principles of taxonomy, historical development of plant taxonomy, relative merits and demerits of major systems of classifications. Taxonomic structure: taxonomic hierarchy, concept of taxa, concept of species, concept of genus and family; Taxonomic character: HETEROBATHMY, ANALYTIC versus synthetic character, qualitative versus quantitative characters.

Module III:

Taxonomic evidence: Morphology, anatomy, embryology, palynology, cytology, phytochemistry, genome analysis.

Taxonomic tools: herbarium, floras, monographs, botanical gardens, biochemical and molecular techniques, computers and GIS.

Module IV:

Biosystematics: The population concept phenotypic plasticity, biosystematic categories, methods of biosystematics studies. Numerical taxonomy: principles, aims and objectives, cladistics in taxonomy, polarity of characters, homology, homoplasy, monophyly, polyphily.

Plant nomenclature: Salient features of ICBN

Ethnobotany:Definition; scope and significance; Sacred groves and their role in conservation.

Practicals

1. To study the floral symmetry in various taxa.

2. To study and work out the differences in dicot and monocot flower.

3. To study the variation in stamens and carpels.

4. To study placentation types in various taxa.

5. To study the floral adaptations for pollination.

6. To study anatomical features of various taxa.

7. To study embryological features of various taxa.

8. To study palynological features of various taxa.

9. To study cytological features of various taxa.

10. To prepare a cladogram on the basis of various morphological features of the species belonging to a genus.

Suggested Readings

Devis, P.H. and Heywood, V. H. 1973.Principles of angiosperms taxonomy. Robert E. Kreiger Pub. Co. Newyork.

Grant, V. 1971.Plant Speciation, Columbia University press, London.

Grant W. F. 1984. Plant Biosystematics.Academic press, London.

Harisson, H.J. 1971. New concept in flowering plant Taxonomy. Hickman educational books Ltd. London.

Hislop-Harisson, J. 1967.Plant Taxonomy.English Language Book Sco.And Edward Arnold Pub.Ltd, UK.

Heywood, V. H. and Moore, D. M. 1984. Current concepts in Plant Taxonomy. Academic Press, London.

Joncs, A. D. and Wibins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co. New York.

Jones, S. B., Jr.and Luchsinger, A. E. 1986. Plant Systematics (gd edition). McGraw -Hill Book Co., New York.

Nordentam, B., El Gazaly, G. and kassas, M. 2000.Plant systematic for 21st century.Portland press.Ltd, London.

Radford, A. E. 1986. Fundamentals of plant systematic.Harper and Raw publication, USA.

Solbrig, O.T. 1970. Principles and methods of plant Sytematics. The Macmillan Co. Publication Co. Inc., USA.

Woodland, D. W. 1991. Contemporary Plant Syatematics, Pentice Hall, New Jersery.

Takhtajan, A. L. 1997. Diversity and classification of Flowering Plants. Columbia University Press, New York.

Stebbins, G. L. 1974. Flowering Plants-evolution Above species Level. Edvard Arnold Ltd, London.

Joncs, A. D.; Wibins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co.

Jones, S. B., Jr.and Luchsinger, A. E. 1986. Plant Systematics (gd edition). McGraw Hill Book Co., New

Semester III

3T1 - Core : Plant Ecology and Conservation Biology

Objectives:

- **Understanding the concept of community, ecological succession trends and climax.**
- **Understanding the structures and functions of ecosystem**
- **Understanding and applying various methods of plant conservation; importace and maintenance of National parks, sanctuaries, Biospheres, botanical gardens etc.**

Outcomes:

After successful completion of the course the students will be able to

- **Learn structure and function of ecosystems and their succession and climax formation**
- **Learn and apply the knowledge of conservation methods.**

Learn and apply techniques of Botanical gardens etc.

Module I:

Vegetation organization: Concepts of community and continuum, analysis of communities (analytical ad synthetic characters): interspecific associations, concept of ecological niche.

Vegetation development: Temporal changes (cyclic and non-cyclic); mechanism of ecological succession (relay floristics and initial floristic composition; facilitation, tolerance and inhibition models).

Community function- Dynamics and succession, laboratory model, trends in succession, climax concept, General introduction to autecology.

Module II:

Ecosystem organization: Structure and functions; primary production (methods of measurement, global pattern, controlling factors); energy dynamics (trophic organization, energy flow pathways, ecological efficiencies); litter fall and decomposition (mechanism, substrate quality and climatic factors); global biogeochemical cycles of C, N, P and S. Nutrient budget in forest and aquatic ecosystem.

Module III:

Ecosystem stability: Concept (resistance and resilence); Ecological perturbations (natural and anthropogenic) and their impact on plants and ecosystems; ecology of plant invasion; environmental impact assessment; ecosystem restoration.

Ecological management: Concepts; sustainable development; sustainability indicators.

Module IV:

IUCN- General account, categories, Commissions, role in conservation; Red Data Book

Protected areas- Sanctuaries, National parks, Biosphere reserves.

Wetlands and Mangroves

Coral Reefs- Types, importance, artificial reefs, conservation measures

Botanical gardens, Seed Banks; *In-vitro* repositories; Cryobanks,

Practicals

Based on Biostatistics

1. Calculate mean, variance, standard deviation and coefficient of variation for comparing two means related to given ecological data.
2. Calculate mean, variance, and to use t-test for comparing two means related to given ecological data.
3. To find out association between important grassland species from the given data using chi-square test.
4. To find out relationship between two ecological variables using correlation analysis.
5. To perform the one-way ANOVA from the given data.

Based on Ecology

1. A trip to the grass land/ forest/ water body to get acquainted with their plant species.
2. Distribution pattern of different plant species determined by Quadrate/Transect/ Point centered Quarter methods.
3. To determine minimum size and number of quadrats required to study grassland.
4. Qualitative parameters of distribution of plant species, Frequency, Density, Basal cover, dominance, Abundance and IVI.
5. To determine diversity indices (Shanon-Weiner, species richness, B-diversity) from given data.
6. To estimate DO content in the eutrophic and oligotrophic water samples by azide modification of Winklers method.
7. To determine gross and net phytoplankton productivity by light and dark bottle method.
8. To estimate chlorophyll content in SO_2 fumigated and unfumigated leaves.
9. Analysis of soils of two different areas i.e. Cropland and forest/ grassland for certain nutrients, CO3, NO3, Base deffiency.
10. To study ecological adaptations of the given plants

Suggested readings

1. Ambasht R.S. 1968. Freshwater ecosystem-Manual of Ecology 123-137 (See Misra KC et al 1968)

2. Ambasht R.S. 1966 Conservation Ecology, Abs Proc School on Plant Ecol (Full paper in press Oxford and IBH Calcutta).

3. Ambasht R.S. 1995 A text book of plant ecology Student and co. Varanasi-5

4. Anderson JM Ecology for environmental sciences: biosphere ecosystems and man

5. Billings WB 1964 Plants and the ecosystem Macmillan & co, London.

6. Clements FE 1916 Plant succession, An analysis of the development of vegetation. Carnegie Institute of Washington.

7. Cragg JB 1968 The theory and practice of conservation, IUCN Publ, New Series No. 12, 25-35.

8. Dash MC 1993 Fundamentals of Ecology WB Saunders and co. Philadelphia USA.

9. Deangelis DL Energy flow, nutrient cycling and ecosystem resilience. Ecology 56, 23843.

10. Dwivedi Rama Shankar 1968. The decomposer system manual of ecology See Misra KC et al 1970)

11. Frankel OH, Soule ME, 1981, Conservation and Evolution, Cambridge Univ Press.

12. Grace J 1983, Plant atmosphere relationships. Champman & Hall.

13. Greig Smith P 1983, Quantitative plant ecology, Univ California Press, California.

14. Hutchings MJ (ed) 1988, Plant population biology, Blackwell.

15. Hutchinson GE 1978, An introduction to population ecology. Yale Univ. Press.

16. Kochhar PL 1986 Plant Ecology Ratan prakashan, Mandi, Agra.

17. Krebs GJ 1972 Ecology Harper and Row Publ, New York.

18. Kumar HD 1994 Modern concepts of ecology. Vikas publishing house pvt ltd, New Delhi.

19. May RM (ed) 1981 Theoretical Ecology, Blackwell.

20. Odum EP 1963 Ecology Holt Reinhart and Winston Inc.

21. Odum EP 1983 Basic Ecology, Saunders Publ Philadelphia.

22. Reynolds CS 1984 The ecology of phytoplankton, Cambridge Univ Press

23. Silverton JW 1982 Introduction to plant population ecology, Longman.

24. Southwick CH 1983 (ed) Global Ecology Sinauer.

25. Whittaker RH 1975 Communities and Ecosystems (2nded) MacMillan, New York.

Semester III

3T2 - Core : Angiosperms-II

Objectives:

- **Understanding the morphology and descriptions of various dicot and monocots groups for proper identification of angiosperm plants**
- **Understanding plant biodiversity concept, role**

Outcomes:

After successful completion of the course the students will be able to

- **Learn and apply knowledge basic structure of flowers for identification and distinguish them family-wise.**
- **Training in usage of floras for identification of species, field trips for preparation of field notes and compilation of plant data.**

Module I

General account, distinguished characters, floral variation and evolution, affinities of:- Magnolidae, Hamamelidae, Dilleniidae, Rosidae, Asteridae, circumscription as per Cronquist,1968

Module II

Alismatidae, commelinidae, Aracidae, Lilidae; Interesting features and systematic position of Cucurbitaceae, Cactaceae, Asteraceae, Amentiferae, Lemnaceae, Palmae, Orchidaceae.

Module III

Probable ancestors of angiosperms, primitive living angiosperms, speciation and extinction, IUCN categories of threat, distribution and global pattern of biodiversity.

Module IV

Biological diversity concept and levels, role of biodiversity in ecosystem functions and stability, Endemism, hotspots and hottest hotspots, invasions and introductions, local plant diversities and its socioeconomic importance.

Practicals

1. Description of specimens from representative, locally available families.

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

3. Description of various species of a genus, location of key characters and preparation 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 herbarium sheets of such plants, wild or cultivated as are abundant.

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

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

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

Suggested readings

Devis, P.H. and Heywood, V. H. 1973.Principles of angiosperms taxonomy. Robert E. Kreiger Pub. Co. Newyork.

Grant, V. 1971.Plant Speciation, Columbia University press, London.

Grant W. F. 1984. Plant Biosystematics.Academic press, London.

Harisson, H.J. 1971. New concept in flowering plant Taxonomy. Hickman educational books Ltd. London.

Hislop-Harisson, J. 1967.Plant Taxonomy.English Language Book Sco.And Edward Arnold Pub.Ltd, UK.

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Joncs, A. D. and Wibins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co. New York.

Jones, S. B., Jr.and Luchsinger, A. E. 1986. Plant Systematics (gd edition). McGraw -Hill Book Co., New York.

Nordentam, B., El Gazaly, G. and kassas, M. 2000.Plant systematic for 2ft century.Portlant press.Ltd, London.

Radford, A. E. 1986. Fundamentals of plant systematic.Harper and Raw publication, USA.

Solbrig, O.T. 1970. Principles and methods of plant Sytematics. The Macmillan Co. Publication Co. Inc., USA.

Woodland, D. W. 1991. Contemporary Plant Syatematics, Pentice Hall, New Jersery.

Takhtajan, A. L. 1997. Diversity and classification of Flowering Plants. Columbia University Press, New York.

Stebbins, G. L. 1974. Flowering Plants-evolution Above species Level. Edvard Arnold Ltd, London.

Joncs, A. D. and Wibins, A. D. 1971. Variation and adaptation in Plant species Hickman and Co.

Jones, S. B., Jr.and Luchsinger, A. E. 1986. Plant Systematics (gd edition). McGraw Hill Book Co., New Delhi.

Semester III

3T3- Core Elective I:(Molecular Biology and Plant Biotechnology- I)

Objectives:

- **Understanding the structures, replication and damage and repair mechanisms of the DNA, transcription, translation.**
- **Knowledge on recombinant DNA technology & its tools**
- **Practical knowledge and analysis skills in usage of various bioinformatic tools.**

Outcomes:

After successful completion of the course the students will be able to

- **Learn the structure, replication of DNA etc.**
- **Learn the transcription, translation etc.**
- **Learn and apply bioinformatic tools for analysis of bioinformation data.**

Module I

a. DNA replication: DNA replication in prokaryotic organism– Initiation, elongation, and termination, DNA replication in eukaryotes – origin, replication form, replication proteins, Comparative account of DNA replication in prokaryotes and eukaryotes, DNA replication proteins

b. DNA damage and repair:Types of DNA damage, factors for DNA damage, Repair system: Single base change, direct repair, mismatch repair, SOS response.

Gene expression and regulation: Transcriptional, translational and post-translational regulation

Module II

a. Tools of rDNA technology: DNA manipulation enzymes- Nucleases, polymerases, ligases, kinases and phosphatases; methods of gene isolation.

b. Molecular probing: Recombinant DNA libraries (gDNA and cDNA, oligonucleotide probes); nucleic acid hybridization (southern, northern, dot-blot and slot-blot); antibodies as probe for proteins (immunoblotting or western blotting, immunoprecipitation, southwestern screening).

Module III

a. Splicing of foreign DNA into cloning vector: Vectors for prokaryotes; ligation.

b. Introduction of foreign DNA into host cell: Transformation; transfection; transgenesis

c. Isolation of genes or protein products from clones: Expression vectors-Characteristics; vectors producing fusion proteins

d. Polymerase chain reaction: The basic techniques and its modifications; applications of PCR in molecular biology

Module IV

a. Sequence alignment and phylogenetic trees: Pairwise (dot-matrix method, dynamic programming method, Word or k-tuple method) and multiple alignment, Local and global alignment, significance of alignment, phylogeny and phylogenetic trees.

b. Genomics: Definition; Structural, functional and comparative genomics.

c. Proteomics: Description of protein structure; classification of proteins on the basis of structure and sequence similarity; prediction of a protein structure.

Suggested readings

Alberts, Bruce; Johnson Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Peter, C. 2002 Molecular Biology of the Cell, Garland Science, New York and London.

Baxevanis, A. D. and Ouellate, B. F. F. 2009 Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.

Baxevanis, A. D., Davison, D. B.; Page, R. D. M.; Petsko, G. A.; Stein, L. D. and Stormo, G. D. 2008 Current Protocols in Bioinformatics

Bergman, N.H 2007 Comparative Genomics. Humana Press Inc., Part of Springer Science+ Business Media

Brown, T. A. 1999. Genomes, John Wiley &Sons(Asia) Pvt. Ltd., Singapore

De Robertis, E.D.P. and De Robertis, E.M.F. Cell and Molecular Biology 8th Ed. B. I. Waverly Pvt. Ltd., New Delhi.

Glover, D.M. and. Hames, D.B 1995 DNA Cloning : A practical approach, R.L. Press, Oxford.

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.

Jolles, O. and Jornvall, H. (eds) 2000. Proteomics in Functional Genomics.Birkhauser Verlag, Basel, Switzerland.

Karp, G. 1999 Cells and Molecular Biology; Concepts and Experiments. John Wiley & Sons, Inc., USA.

Lehninger. Principles of biochemistry-Nelson, Cox, 4th Edn., W.H.Freeman and Co.,2005.

Lewin, B. 2000 Gene VII Oxford Univ. press, New York.

Lewin, B. 2010 Gene X Oxford Univ. press, New York.

Lodish, H., Berk, A. Zipursky, S. L. Matsudaira, P., Baltimore, D. and Darnell, J. 2000 Molecular Cell Biology Edi. W.H. Freeman and Co., New York, USA

Mount W. 2004 Bioinformatics and sequence genome analysis 2nd Edi. CBS Pub. New Delhi

Old and Primrose , 1994, Principles of gene manipulation. Blackwell Scientific Publ.

Raymond Schuler and Zielinski, E. 2005, Methods in plants Molecular biology.Acad. Press.

Russel, P. J. 1998 Genetics (5th Edi.) The Banjamin/ Cummings Publishing Com. Inc., USA

Sambrook and Russel. 2001. Molecular cloning Vol. 1-3 CSH press.

Shaw, C.H. 2006, Plant Molecular Biology: A practical approach. Panima Pub. Corp.

Stryer, Berg, Biochemistry-6th Edition, W. H. Freeman and Co.,2007.

Voet, D.; Voet, J.; Biochemistry – 3rd Edn. John Wiley and sonsInc., 2004.

Wilson Keith and Walker John 2005 Principles and techniques of biochemistry and molecular biology, 6th Ed. Cambridge University Press, New York.

Wolf, S.L. 1993. Molecular and Cellular Biology, Wadsworth Publishing Co., California, USA

Practicals

Group A

1. To detect the damage caused by mutagens to the DNA.
2. To detect molecular polymorphism in different species using a suitable technique.
3. To demonstrate the presence of a particular polypeptide by Western blotting.
4. To design PCR primers to isolate the given gene for cloning it in the given vector.
5. To amplify and sequence the nrDNA by PCR
6. To find the sequences of a given protein in the protein database
7. To work out the sequence from given autoradiogram and to identify it from GeneBank by BLAST method.
8. Todownload the DNA sequences from databases and generate pairwise and multiple sequence alignment.
9. Todownload the protein sequences from databases and generate pairwise and multiple sequence alignment.
10. To generate phylogenetic tree using given sequences.
11. To predict a protein from given sequence by using online tools from NCBI.

Group B

12. To demonstrate *Agrobacterium tumefaciens* mediated gene transfer in a suitable plant.
13. To perform ELISA testing of Bt gene in cotton.
14. To raise the suspension culture using a callus and plot the growth curve.
15. To induce the secondary metabolite synthesis in suspension culture.
16. To isolate the secondary metabolites from suitable plant material by gel filtration method.
17. To purifythe plant metabolite/ protein by column chromatography.

18. To demonstrate the use of molecular markers to detect polymorphism in different varieties of plants/strains of microbes.
19. To isolate and develop the protein profile of different plant species by SDS-PAGE.
20. To demonstrate bacterial transformation and selection of transformed cells.
21. To perform DNA ligation and analysis of ligated DNA on agarose gel.
22. To study of expression of inducible genes at biochemical level.
23. To demonstrate Organogenesis using appropriate explants.
24. To demonstrate somatic embryogenesis using appropriate explants and prepare artificial seeds.
25. To demonstrate preparation of artificial seeds.
26. To demonstrate the anther culture.
27. To study the effect of heavy metals on the growth of plants.
28. To screen the hyperaccumulator plants for a given heavy metal.

Suggested readings (for laboratory exercises)

Baxevanis, A. D. and Ouellate, B. F. F. 2009 Bioinfor matics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.

Baxevanis, A. D., Davison, D. B.; Page, R. D. M.; Petsko, G. A.; Stein, L. D. and Stormo, G. D. 2008 Current Protocols in Bioinformatics. McEntyre, J.; Ostell, J., editors Bethesda (MD) The NCBI Handbook: National Library of Medicine (US), NCBI; 2002-2005

Sambrook and Russel. 2001. Molecular cloning Vol. 1-3 CSH press.

Tools & updated literature available atwww.ncbi.com

References: Online journals available on UGC V-SAT programme.

Semester III

3T3- Core Elective I: (Reproductive Biology of Angiosperms - I)

Objectives:

- **Understanding of need of reproductive system as experimental material.**
- **Understanding of structure of male and female reproductive parts and thei developmentin Angiosperms.**
- **Understanding & Application of knowledge of male sterility .**
- **Understanding of pollen mechanism, pollen-pistil interaction and incompatability.**

Outcomes: After completion of the course, the student will be able to

- **Learning the structure, and developmental variation in the sexual organs in Angiosperms.**
- **Analysis of causes for male sterility.**
- **Understanding and application of knowledge of reproduction for human welfare**

Module I

General: Need for reproductive system as experimental material, Interdisciplinary approaches: genetic and molecular perspective,

Anther: Structure, anther wall; endothecium, middle layer, tapetum-Structure, typesstructure-function relationship, role of tapetum, microsporogenesis-sporogenous cells cytoplasmic reorganization during sporogenesis (Ultrastructural changes), molecular biology of meiosis, DNA and RNA synthesis, Protein synthesis, meiosis specific genes. Pollen tetrad development, pollen wall proteins, adaptive significance of pollen wall.

Module II

Male gametophyte development: formation of vegetative and generative cells, differential behaviour of sperms, gene expression during pollen development.

Pollen: Physiological and biochemical aspects, pollen storage, viability, causes for loss of viability. Pollen abortion and male sterility: structural, developmental and functional aspects of male sterility environmental factors, role of mitochondrial genome in male sterility, gametocides.

Module III

Pistil: Carpel determination, ovule and its structural details.

Megasporogenesis: Meiosis, functional megaspores, organization of female gametophyte structure of the embryo sac, egg, synergid-ultrastructure, role central cell, antipodal cell, haustoria, cytoskeleton of the embryo sac, enzymatic isolation of embryo sac, types of embryo sac, nutrition of embryo sac.

Module IV

Pollination: pollination mechanism, biotic and abiotic pollination, floral attractants and rewards,

Pollen-pistil interaction: The stigma-Types and structure, stigmatic exudates, style-transmitting tissue, canal cell, post pollination events (stigma receptivity, pollen adhesion, pollen hydration, pollen germination and pollen tube growth, biochemistry of pollen germination, RNA and protein metabolism during pollen tube, calcium gradient in the pollen tube (Chemotropism) pollen allelopathy.

Incompatibility: General concept, self incompatibility (Intraspecific type) heteromorphic, homomorphic types, mechanism of self compatibility, importance of self compatibility, methods of overcoming self incompatibility, Parasexual hybridization,

Suggested readings

1. Asker S. 1979, Progress in apomixis research. Hereditas 91, 231-240.

2. Barnier, G. 1986, The flowering process as an example of plastic development. Soc. Expt.. Biol. 40: 257-286.

3. Barth, F.G. 1991, insects and flowers, Princeton Univ. Press. Princeton.

4. Battaglia, E. 1963. Apomixis In recent advances in the embryology of angiosperms (ed P. Maheshwari), pp-264, Intt. Soc. Plant Morphologists, Univ. Delhi.

5. Bhandari N. N. 1984, The microsporangium in embryology of angiosperms (ed B.M. Johri) Springer-Verlag, Berlin, pp. 53-121.

6. Bhandari N.N., M. Bhargava and P. Chitralekha 1986, Cellularization of free nuclear endosperm of Pappaver somniferum L. Phytomorphology, 36, 357-366.

7. Bhojwani S.S. and M.K. Rajdan 1983, Plant tissue culture Theory and Practice Elsevier, Amsterdam.

8. Boesewinkel F.D. and Boman F. 1984, The seed structure in embryology of angiosperms (ed B.M.Johri), Springer-Verlag, Berlin, pp. 567-610.

9. Bouman F. 1984 The ovule in embryology of angiosperms (ed B.M.Johri), Springer-Verlag, Berlin, pp. 123-157.

10. Cartson P.S., Smith N.H., Dearing R.D. (1972) Parasexual interspecific plant hybridization. Proc. Nat. Acad. Sci. USA, 69, 2292-2294.

11. Cartson P.S. (1973) The use of protoplasts of genetic research. Proc. Nat. Acad. Sci. USA, 70, 598-602.

12. Chitralekha P. and N.N. Bhandari 1991, Post fertilization development of antipodal cells in Ranunculus scferatus. Phytomorphology 41, 200-212.

13. Ciampolini F.M., Nepi and E. Pacini 1993, tapetum development in Cucurbita pepo (Cucurbitaceae) Pt. Syst. Evol. (Suppl) 7-13-22.

14. Cocking E.C. 1960, A method for the isolation of plant protoplasts and vacuoles. Nature (London) 187-927-929.

15. Cocking E.C. 1970, Virus uptake, cell wall regeneration and virus multiplication in isolated plant protoplasts. Int. Rev. Cytol 28-89-124.

Practicals

1) Study from the permanent preparations.

a) Development and structures of anther pollen.

b) Structure of ovule, types, megasporogenesis, embryo sac types.

c) Development of endosperm, types.

d) Structure and development of embryo-types

e) Pericarp and seed coat structure from sections and macerations.

f) Sketching of ovular structure, embryo sac, anther wall, embryo with the help of camera lucida.

2) Techniques, Familiarity with phase contrast, polarizing, fluroscence and electron microscopy, wholemounts, fissection and macerations, permanent double stained microtome sections, photo microscopy.

3) Preparation of dissected wholemounts of endothecium, tapetum, endosperm and embryo, squash preparations of tapetum, microspore mother cells, dyads, tetrads pollinia and massulae. Study of mitosis and meiosis and identification of various stages.

4) Study of different pollen using acetolysed and non acetolysed pollen, preparation of permanent slides for morphological study. (polarity, symmetry, shape, size, aperture, sporoderm stratification: minimum 15 slides to prepare).

5) Interpretation of electron micrographs (SEM, TEM) of pollen.

6) Short term exercises on pollen production, viability and their percentage of germination. Rate of growth of germ tube to be studied in a given period.

7) Viability of seed through germination, biochemical and excised embryo methods.

8) Cytology of pollen inhibition in self and interspecific incompatibility, application of some technique to overcome incompatibility.

9) Experiments on intra-ovarian pollination.

10) Experiments on plant tissue culture. Technique-washing.Sterilization, preparation of media, storage of media, inoculation, callus initiation, proliferation.

11) Responses of calli to stress condition viz. temp, (low, high), moisture, salinity.

12) Induction of androgenesis through anther culture.

13) Physiology of embryo development, using electropheratic and histochemical methods embryo culture.

14) Somatic embryogenesis

15) Protoplast culture.

Semester III

3T3 - Core Elective I :(Mycology and Plant Pathology - I)

Objectives:

- **Understanding structure, reproduction of bacteria, viruses, fungi and mycorrhiza.**
- **Understanding & Application of knowledge human diseases caused by various fungi**
- **Understanding fungal metabolite production and its uses.**

Outcomes: After completion of the course, the student will be able to

- **Learning the structure, life cycles, economic importances etc of bacteria, virus, fungi and apply this knowledge in identification of organisms.**
- **Analysis of diseases based on symptoms, and apply knowledge for identification of disease**
- **Understanding and application of knowledge of fungal metabolites, their uses for human welfare**

Module I:General Microbiology

Bacteria- Morphology, size, shape, structure, Characters of Eubacteria, Actinomycetes, Archaebacteria, Bacterial nutrition, reproduction.

Viruses- General Characteristics, structure, classification (LHI System), replication (lytic cycle & lysogeny)

Rikettsia- General Characters.

Fungal diversity in different ecosystems, effect of environment on fungal growth and behaviour.

Module II: Mycorrhiza

1. Kinds of mycorrhizae. Ectotrophic and endotrophic mycocrhizae, their morphology and anatomy.V A-mycorrhiza.Mycorrhiza in plant growth promotion, mycorrhiza in plant disease control.

2. Rhizoshere and phyllosphere -General concept and importance.

3. Medical Mycology-Dermatophytic fungi -Knowledge of common dermatophytes and human diseases caused by them viz. *Tinea pedis, Tinea capitis, Tinea barbae. Tinea, corporis* and *Tinea manuum*; Aspergillosis, fungi allergic to human beings.

Module III: Production of Metabolites by Fungi

A) Industrial Fungal Metabolites:

i) Antibiotics -Penicillin, Cephalosporin, Griseofulvin, Industrial production of Penicillin

ii) Enzymes -. Amylase, proteases, Lipases, Pectinases, Cellular and xylanases.

iii) Organic acids -Critic acid, Gluconic acid, lactic acid, kojic acid, Itaconic acid.

B) Non Industrial Fungal Metaboilites:

i) Phytoalexins, ii) Mycotoxins

Module IV: Fungi as welfare to human beings

i) Fungi in food processing: soybean products, cheese, fermented milk, other fermented foods.

ii) Fungal metabolites – General account of production and application: Primary metabolites (vitamins, proteins), Secondary metabolites (antibiotics, pigments, alkaloids)

iv) Fungi as food -edible mushrooms, methods oftheir cultivation

v) Concept of biodeterioration and Biodegradation

a) Biodeterioration of non-cellulosic materials (leather, plastics, hydrocarbons, pesticides)

b) Biodeterioration of cellulosic materials.

c) Role of microorganisms in Biodegradation of organic wastes. Factors affecting the process of Biodegradation.

Suggested readings

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25. Walker, J.G. (1952) Diseases of Vegetables Crops. McGraw Hill, New York.

26. Walker, J.C. (1968) Plant Pathology, McGraw Hill, New York.

27. Eggins, H.O.W. and Allsop (1975) The Filamentous Fungi Vol. I Industrial Mycology (Biodetoriation and Biodegradation by Fungi) Eds. J.E. Smith and D.R. Berry Edward Arnold, London.

28. Emmons, C. W., C. H. Bin ford, J.P. Utz and Know Chung (1977) Medical Mycology, Lea and Febigo, Philadelphia.

29. Holliday, P. Fungus disease of tropical plants (1980), Cambridge University Press, Cambridge.

On line Journals available on UGC -VSAT

Practicals

1. Principles & working of tools, equipments and other requirements in the Mycology & Plant Pathology laboratory.

2. Micrometry and measurement of organisms.

3. Sterilization Processes viz. moist heat, dry heat, chemical and radiation.

4. Drawing of Camera Lucida diagrams and knowledge of computer based photomicrography and image processing

5. Preparation of different cultural media for cultivation of Fungi and Bacteria.

6. Monitoring and analysis of Aeromycoflora.

7. Isolation & identification of Phyllosphere mycoflora.

8. Demonstrate antifungal activities of different antibiotics and leaf, flower and root extract.

9. Study of toxicity of fungi in relation to seed germination, and seedling abnormality.

10. Cultivation of Mushrooms.

11. Demonstration on biodegradation of organic waste.

12. Isolation of Soil fungi by soil plate (War cup) and serial dilution (Walksman) method.

13. Isolation and identification of Rizosphere mycoflora.

14. Isolation of external and internal seed borne mycoflora by blotter and Agar Plate method. Cereals, pulses, oil seeds, fruit seeds.

15. Demonstration of Koch's Postulate.

16. Calculation of spore count using haemocytometer.

17. Qualitative estimation of enzymes – cellulases, amylases.

18. Estimation of sugars, proteins and aminoacids in fungal mycelium and culture filtrate.

19. Study of mycorrhiza (VAM)

20. Monographic study of locally available plant diseases caused by fungi (atleast 10).

21. Study of locally available crop plant diseases caused by Bacteria (Five)

22. Study of locally available plant diseases caused by viruses & Phytoplasma (Five)

23. Demonstration of morphological & physiological changes in disease plants.

24. Preparation and presentation of herbarium of pathological specimens available in the region (Atleast 15)

25. Field visit to different localities Visit to Agriculture University, Plant Pathological research centers

Semester III

3T3 - Core Elective I:(Palynology - I)

Objectives:

- **Know the history, palynological centres in India**
- **Understanding the structure of pollen & pistil and their importance.**
- **Understanding pollination, floral adaptations to diff. Pollinators, applications of pollen biology.**
- **Knowledge on different types of honeys, uses of honey in medicine, cosmetics etc.**

Outcomes:

After successful completion of the course the students will be able to

- **Understand the diff. aspects of pollen, pistil and pollination**

Applying knowledge with reference to agriculture, horticulture, medicine

Module I

General aspects of Palynology: -Historical background, Definition, basic concepts, scope,inter-relationship with other branches of Botany, Applications, Indian work on Palynology,Palynological centres in India.

Microsporogenesis : Stamen initiation, anther differentiation- anther initiation, anther wall,Tapetum, structure and functions, its role in pollen development, Functions of callose wall,pollen/microspore and wall development, production and deposition of sporopollenin.

Pistil : Structure and function of stigma and style, stigma receptivity and its importance.

Module II

Pollination Biology -Origin of pollination biology/anthecology, Spore and pollen dispersal inlower plants and gymnosperms, Pollination in angiosperms- types of pollination, floral adaptation to different pollinators(mode, style) flowers pollinated biotically (Hymenoptera, Diptera, Coleoptera, Lepidoptera,birds, bats) and abiotically (wind, water), pollination-plant interactions, special devices associated with pollinator attraction - pollen, nectar,Elaiophores, resin glands, osmophores, floral scent and perfume flowers.

Palaeopalynology: - Palynomorphs, their preservation in diverse lithic types, techniquesinvolved in the recovery and concentration of spores and pollen from clays, shales, coals andlignites. Maceration techniques, Application of Palynology in relation to oil and coal exploration. Role of spores and pollen in stratigraphy, index spores.

Module III

Phylogeny of Pollen and spores, Systematic palynology-monocotyledoneae anddicotyledoneae, evolutionary trends among pollen grains based on palynotaxonomical works, Palynology of spores / pollen- Algae, Fungi, Bryophytes, Pteridophytes and pollen types ofGymnosperms.

Pollen morphology of Angiosperms.: Introduction- Pollen units, polarity, symmetry, Shape, size, Apertures size, shape of thepollen grain, sporoderm stratification, Apertures-NPC System of classification, Apertural types, Exine ornamentation, LO analysis, evolutionary trends in exine structure, trends of evolution in apertural pattern, Techniques for the preparation of pollen slides, Light and scanning election microscopic studies of pollen, significance of SEM and TEM studies.

Module IV

Melittopalynology- Pollen analysis of honey-methods, qualitative and quantitative, social organization of honey bees, foraging behavior, geographical and floral origin of honey, its chemical analysis, adulteration of honeys, physical characteristics of honey, deterioration of honey, heavy metal contamination in honey, honey as environmental monitors, unifloral and multifloral honey, Applied Palynology with special reference to Agriculture and Horticulture - Bees as pollinators, role of apiaries in crop production. Use of honey in medicine, cosmetics, confectionary and other applications, Pollen loads, analysis, Bee pollen, chemical composition, utility, and its role in curing various human ailments.

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List of practicals:

Section A. Basic aspects / Pollen Morphology

1. To study structure of stamen
2. Study of permanent slides of microsporogenesis
3. Field study on different pollination mechanism
4. To study structure of pistil
5. Preparation of glycerin jelly
6. Preparation of pollen- Acetolysis technique
7. Preparation of pollen – Wodehouse technique.
8. Study of pollen types using acetolysed and non-acetolysed pollen. Pollen
9. morphology polarity, symmetry, shape, size, sporoderm stratification aperture NPC(To study the pollen types from at least 30 different species, Angiosperms preparation of permanent slides.)
10. Preparation and palynological description in technical language (at least 10 speciesof Angiosperms).

11. Interpretation of selected electron micrographs (SEM, TEM) of pollen.

12. Preparation, description and identification of spores of Algae, Fungi, Bryophytes,Pteridophytes and pollen types of Gymnosperms.

Section B. Aeropalynology/Melittopalynology/Palaeopalynology (Atleast two expts.)

13. Use of pollen traps to study local air-spora.

14. Analysis of aerospora slides.

15. Preparation of reference slides by different techniques, culture method (culture of fungi/Algae)

16. Preparation of slides honey samples

17. Analysis of honey samples for qualitative and quantitative study of pollen contents.

18. Estimation of pollen load from bee hive or bees/ pollinator

19. Analysis of coal samples for microfossils with special reference to pollen and spores.

20. Preparation of allergenic extract of pollen.

Section C Pollen Physiology/ecology/biochemistry/ecology. (Atleast three expts)

21. To study pollen production of the given flowers.

22. To study pollen viability of the given flowers.

23. To study percentage of pollen germination & rate of pollen tube growth.

24. To study different techniques of pollen storage

25. Effect of temperature and relative humidity on viability of stored pollen

26. Effect on Boron and Calcium on pollen germination and tube growth.

27. Semi-vivo technique to study pollen germination and pollen tube growth.

28. Multiple staining for localizing pollen tubes in the pistil

29. To study pollen germination and pollen tube growth in the pistil by employing aniline-blue fluorescence method

30. Cytochemical localization of esterase on stigma surfaces

31. Cytochemical analysis of pollen and pollen tube for various metabolites like proteins, amino acids, carbohydrates, starch, ascorbic acid, DNA, RNA, lipids,lignin, pectin, cellulose, etc (at least five metabolites)

32. Study of pollen contents by paper chromatography/TLC.

33. Colorimetric estimation of proteins/carbohydrates of pollen grains

34. To separate pollen proteins by SDS-PAGE electrophoresis

35. Enzyme bioassay in pollen grains.

Semester III

3T3 - Core Elective I:(Plant Physiology - I)

Objectives:

- **Understanding Plant growth and Development.**
- **Understanding the function of different growth regulators.**
- **Understanding seed physiology**
- **Understanding stress physiology**

Outcomes:

After successful completion of the course the students will be able to

- **Understand the aspects of plant growth and development**

Understand the aspects of seed physiology and stress physiology

Module:-I

Plant Growth and Development: - Growth, Differentiation and development. Control of growth and development, genetic control of development, hormonalControl of development. Pattern of growth and development, Plant growth Kinetics- Growth through time, Plant organs- How they grow? Morphogenesis.

Nitrogen: Importance of nitrogen for growth and development,nitrogen cycle, biological nitrogen fixation, symbiotic nitrogen fixation in legumes

Module-II

Growth Regulators (Plant Hormones): -Biosynthesis, Storage, breakdown and transport, physiological effects and movement of action., ABA, ethylene And nontraditional growth hormones, Jasmonate, Brassinosteriods, oligosachharins, polyamines, salisalate, nitric oxide, commercial application of plant growth regulators,

A brief idea about role of plant growth retardants: - a) CCC b) maleic hydrazide c) Trizoles d) TIBA

Module-III

Seed physiology:-

Structure of monocot and dicot seed

Latent life -Seed dormancy: Importance and types of dormancy, overcoming seeddormancy, bud dormancy. Factors responsible for dormancy, mechanism of dormancy, methods of breaking the seed dormancy.

Germination of seed: types of germination, chemical Changes duringgermination, mobilization of reserve Food during germination, hormonalControl seed Germination

Post Harvest Physiology: Ripening of fruit and its regulation, metabolismof leafy vegetables during storage.

Seed development: Biochemical changes during development of seeds.

Module-IV

Stress physiology: Response of plants to biotic(pathogen and insect) and abioticStress (water, temperature and salt)

a) Biotic Stress: - mechanism of resistance to biotic stress (HR, SAR) and tolerance to abiotic stress

b) Abiotic Stress:-

Water stress: - causes of water stress, drought effect On physiological processesin plants,various mechanism of drought resistance in plants.

Flooding stress: - nature of water logging stress. Effect of flooding onphysiological processes in plants. Mechanism of water logging tolerance

Salt stress :- definition of saline soil, physiological responses ofplants to salinitystress, halophytes and glycophytes mechanism of salinity tolerance in higherplants, genetic engineering for salt tolerance.

Thermal stresses: - Effect of high and low temperatures on plant metabolism,mechanism of high and low temperatures tolerance, cold hardening, role of HSP.

Oxidative stress: - Generation of reactive oxygen species, effect ofROS onmetabolism, ROX detoxification mechanisms in plants.

Suggested Readings (For theory):

Asana, R.D. and Sarin M.N. (1968): Crop Physiology in India IARI Publ.

Abdelhamid Elaissari, (2008). Colloidal Nanoparticles in Biotechnology, John Wiley

Apps *et al*., (1992).Biochemistry, ELBS.

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Bewley. J.D. and Black, M. 1994. Seeds: Physiology of Development andGermination, Plenum Press. New York.

Charles PP and Frank JO, (2006).Introduction to Nanotechnology, Wiley India Ed.

Cherry , J. H. 1989. Environmental stresses in plants .biochemical and physiological

mechanisms.

Conn E.E, Stumpf , Bruening G, Doi RH.(2005) . Outlines of Biochmistry 5/Ed, Wiley&Sons Pvt .ltd.

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Dennis, D.T., Turpin, D. H., Lefebvrc, D.D. and Layzell, D.B. (eds).1997. Plant Metabolism (2nd Ed.)Longman, Essex, England.

Evans, L.T. 1972. Crop physiology

Fageria, N. K. 1992. Maximizing crop yield.

Fertilizer association of India (1974): Fertilizer handbook of Usage.

Fitter, A. H. and Hay, R. K. M. S. (1987): Environmental Plant Physiology.

Gupta, U. S. (1972): Crop Physiology.

Gupta, I. S. (1986): Physiological aspects of dryland farming.

Gupta, U. S. (1975): Physiological aspects of dryland farming.

Gaiston, A.W.1989. Life Processes in Plants. Scientific American Library, Springer-Verlag, New York, USA.

Hans-Walter Heldt (2004) Plant Biochemistry . Elsevier Academic Press, 200 Wheeler Road, Burlington, MA 01803, USA, 525 B Street, Suite 1900, San Diego, California 92101-4495,USA

Hooykass P.J.J., Hall, M. A. and Libbenga, K.R.(eds).1999. Biochemistry and molecular Biology of plant Horm. Elsevier, Amsterdam, The Netherlands.

Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York,USA.

Hale, M.C. and Orcutt, D.M. (1987): The Physiology of Plants Under Stress. ICARhandbook of Fertilizers.

Jain J.L. *et al.*,(2008). Fundamentals of Biochemistry, Chand ,New Delhi

Kozlowski, T. T. (1984): Flooding and Plant Growth. 11. Levitt, J. (1969, 1980): Responses of Plants to Environmental Stress.

Lodish, H., Berk, A., Zipursky S.L., Matsudaira, P., Baltimore, D and Darnell, J. 2000. Molecular Cell Biology (4thed). W. H. Freeman and Company. New York ,USA.

Moore, T.C. 1989. Biochemistry and Physiology of Plant Hormones (2nded). Springer- Verlag, New York, USA.

Mansfield, C.A. (1976): Effect of air pollutant on plants.

Marschner, H. W. (1986): Mineral nutrition of Higher Plants.

McLaren, J.S. (1985): Chemical manipulation of crop growth and Development.

Mehrotra, R.S. (1980): Plant Pathology.

Mahadevan ,A and Sridhar R.(1986) Methods in Physiological plant Pathology, Sivakami Publications, Madras

Nobel, P.S.1999. Physicochemical and Environmental Plant Physiology (2nd ed). Academic Press, Diego, USA.

Nelson D.L, Cox M.M.(2005). Lehninger Principle of Biochemistry, W.H. freeman and Company, New York

Nickell, L.G. (1986): Plant growth regulators in Agriculture.

Pessarkli, M. (2004): Handbook of Plant and Crop Physiology, Marcel Dekkar Inc. NY.

Pessarkli, M. (2005): Handbook of Photosynthesis.

Pradeep T. (2007). NANO : The Essentials – Understanding Nanoscience andNanotechnology, TATA McGraw – Hill Education.

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Rastogi , S.C (2003). Outlines of Biochemistry , CBS Publishers &Distributors , NewDelhi

Salisbury, P.B. and Ross, C.W. 1992. Plant Physiology (4th edition).WadsworthPublishing, Belmont, California.

Steeves, T.A. and Sussex, I.M., 1989.Patterns in Plant Development (2nd edition).

Cambridge University Press, Cambridge.

Stryer, L., (1988). Biochemistry, WH Freeman & Co., NY.

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

Sinha S.K., Sane P.V., Bhargava S.C. and Agarwal P.K. (1990): Proceeding ofInternational Congress of Plant Physiology Vol. I & II.

Salisbury, F.B. and Ross, C.W.1992: Plant Physiology (4thed). Wadsworth Publishing Co.,California, USA.

Singhal G.S., Renger, G., Sopory, S.K., Irrgang, K.D. and Govindjee.1999: Cocepts in PhotobiolPhotosynthesis and Photomorphogenesis. Narosa Publishing House, NewDelhi.

Turner, N. C. and Cramer, P.J.(1980): Adaptation of plants to water and high temperature stress.

Taiz, L. and Zeiger, E. 1998: Plant Physiology. Sinaucr Associates, Inc., Publishers,Massachus, USA.

Thomas,B. and Vince-Prue,D.1997: Photoperiodism in Plants (2nd ed).Academic Press, San Diego, USA.

Upeke, L. K. (1982): Tropical tree crops.

Westhoff, P.1998: Molecular Plant Development: From gene to plant. Oxford University Press, Oxford, UK.

Zuley G.L., (1998). Biochemistry, Wm.C .Brown Publishers USA.

Journals

- Annual reviews of Plant Physiology and Molecular Biology.
- Indian Journal of Plant Physiology.
- Journal of Experimental Botany.

Suggested Laboratory Exercises

1. Estimation of phenols from given plant material.
2. Estimation of proline from plant tissues under different environmental and physiologicalconditions.
3. Study the effects of red and infrared radiation on seed germination as affected.
4. Determination of gibberellic acid by half seed (cereal) method.
5. Demonstration of effects of auxin on abscission.
6. Demonstration of effects of cytokinin on senescence.
7. Demonstration of effects of abscission acid on stomatal regulation.
8. Preparation of cytoplasmic and chloroplastic LPC.
9. Estimation of Vitamin 'C' from suitable plant material.
10. Estimation of alkaloids from medicinal plants.
11. Study of changes in starch / protein content during seed development.
12. Study of lipid accumulation during development of oil seeds.
13. Study of effect of PEG induced water stress on seed germination.
14. Study the effect of ZnSO4 (800ppm) solution on (paddy) seed germination
15. study the physical and chemical methods for breaking the seed dormancy .

Suggested Readings (for laboratory exercises):

Bajracharya, D. 1999. Experiments in Plant Physiology: A Laboratory Manual. Narosa Publishing House, New Delhi.

Cooper, T.G. 1977. Tools in Biochemistry.John Wiley, New York, USA.

Copeland, R.A. 1996. Enzymes: A Practical Introduction to Structure, Mechanism and Data Analysis. VCH Publishers, New York.

Dennison C. 1999. A guide to Protein Isolation. Kluwer Academic Publishers, Dordrecht, The Netherland.

Devi, P. 2000. Principles and Methods of Plant Molecular Biology, Biochemistry and Genetics.Agrobios, Jodhpur, India.

Dryer, R. L. and Lata, G. F. 1989.Experimental Biochemistry. Oxford University Press, New York.

Hames, B.D.(Ed.).1998. Gel Electrophoresis of Proteins: A Practical Approach, 8th edition. PAS, Oxford University Press, Oxford, UK.

Harborne, T.C. 1981. Phytochemical Methods: A Guide to Modern Techniques of Plants Analysis. Chapman& Hall, London.

Moore, T.C. 1974. Research Experiences in Plant Physiology: A Laboratory Manual. Springer-Verlag, Berlin.

Ninfa, A. J. and Ballou, D. P. 1998. Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Fitzgerald Science Press, Inc., Maryland, USA.

Plummer, D.F. 1988.An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

Scott, R.P.W. 1995. Techniques and Practice of Chromatography.Marcel Dekker, Inc., New York.

Wilson, K. and Goulding, K.H.(Eds), 1986. A Biologists Guide to Principles and Techniques of Practical Biochemistry. Edward Arnold, London,UK.

Wilson, K. and Walker, J. 1994. Practical Biochemistry: Principles and Techniques, 4th edition. Cambridge University Press, Cambridge, UK.

Sadasivam and Manikum: Biochemical Methos , New Age International (p) Limited Publishers 4835/24, Ansari Road, Daryaganj, New Delhi- 110002

Semester III

3T4 - Foundation Course I: General Botany

(Student shall opt for this paper from any other subject other than his/her main subject for post graduation)

Objectives:

- **Understanding the morphology and histology of plant, taxonomy of plants**
- **Understanding concept of biodiversity and ecotourism, vision on ecotourism.**
- **Knowledge on local plant resources etc.**
- **Understanding on ecosystems, food chain and biodegradation of waste, pollution**

Outcomes:

After successful completion of the course the students will be able to

- **Learn different aspects of morphology, history, taxonomy biodiversity, biodegradation, pollution and ecotourism.**
- **Learn to apply knowledge of ecotourism development.**

Module I: Morphology and Taxonomy

Morphology of- Root, stem, leaf, flower and fruit.

Histology- Cell types and tissue systems in plant, specialized cells

Taxonomy- Classification system of Bentham & Hooker; General characters of- Fabaceae, Solanaceae, Verbanaceae, Liliaceae, Poaceae, Plant identification techniques.

Module II: Biodiversity & Ecotourism

Concept of biodiversity; Types (Species, genetic, ecosystem diversity); present status in India; Values of biodiversity; Mega-biodiversity centres; CBD- General account.

Aesthetic beauty of wild beautiful plants and their value in nature for Ecotourism point of view in various forests.

Module III: Plant resource utilization

Botany and uses of plants as a source of- fire wood, timber, Non-Wood forest products, cereals, pulses, oilseeds, spices, condiments, narcotics, beverages, fodder, forage, medicine and essential oil (any three of each type).

Module IV: Ecology & Biodegradation of waste

Introduction, concept of ecosystem, types of ecosystems, food chain and food web.

Pollution: Sources, consequences control of soil, air and water pollution. Carbon credit.

Various methods of bio-degradation of waste materials.

Suggested readings

Dash MC 1993.Fundamentals of Ecology. WB Saunders can Co., Philadelphia.

Devis, P.H. and Heywood, V. H. 1973.Principles of angiosperms taxonomy. Robert E. Kreiger Pub. Co. Newyork.

Heywood, V. H. and Moore, D. M. 1984. Current concepts in Plant Taxonomy. Academic Press, London.

Heywood, V. H. and Moore, D. M. 1984. Current concepts in Plant Taxonomy. Academic Press, London.

Jones, S. B., Jr.and Luchsinger, A. E. 1986. Plant Systematics (gd edition). McGraw -Hill Book Co., New York.

Khalid H and Nawaz K 2014.Introductory plant taxonomy. Kalyani Publ., New Delhi.

Kochhar PL 1986. Plant Ecology. Ratan Prakashan, Agra.

Kochhar SL 1998. Economic Botany in tropics 2e. Macmillan India Ltd., New Delhi.

Kumar HD 1994. Modern concepts of ecology. Vikas Publi. House Pvt. Ltd., New Delhi.

Sharma OP 1996 Hill's Economic Botany. TMH Publ. Co. Ltd., New Delhi.

Woodland, D. W. 1991. Contemporary Plant Syatematics, Pentice Hall, New Jersery.

Semester III

3T4 – Core : Aesthetic Botany

Objectives:

- **Knowledge on floristic regions of the world and India, endemism, hotspots etc.**
- **Understanding the scope, components of the garden and features of the garden**
- **Knowledge on scope of floriculture, methods of propagation and its importance in designs**
- **Understanding the scope of landscape, elements of landscape, importance of polyhouses, designing of lawns and cactus garden.**

Outcomes:

After successful completion of the course the students will be able to

- **Learn phytogeographical regions of India, world, scope of gardening, landscaping.**
- **Learn designing of lawns and cactus, ornamental gardens.**

Module I – Phytogeography

Climate and Vegetation of the world

Floristic regions of the world. Phytogeographical regions of India; Endemism; Concept of hotspots, hot spots of the world. Forest types of India

Module II – Gardening

Garden Design: Scope and objectives of gardening; Style of gardens (Formal, Informal); Types of gardens (English, Mughal and Japanese)

Components of garden; Planning of outdoor gardens- Small, Residential, Larger Home Garden, Roof Garden, Terrace Garden, Industrial garden, Housing complex, Indoor gardening

Garden Features and Ornamentation: Water, Garden pool, Stream, Waterfall, Fountain, Rocks, Roads, Walks, Pavements and Steps, Walls fences and Gates, Hedges, Edges, Arches, Statues, Towers.

Module III– Floriculture

Nursery production and management: Scope, Site, Soil, Environment, Layout, Manure, Fertilizers, Maintenance, Garden tools, Culture and Garden calendar, Types, Nursery beds, Pest & Disease management.

Propagation of ornamental plants by seeds, bulbs, layering, cuttings, grafting, budding & tissue culture.

Plant disorders including nutrition, pests and diseases, and chimaeras

Ornamental ferns and their propagation; herbaceous perennials, Annuals & Biennials: Important Genera and Species, their importance in garden designs.

Module IV – Landscaping

Landscape Design: Definition, objectives and scope, Landscape elements of construction and designing of Residential, Commercial, Bungalow, Public area, Hotel, Educational Institute and religious places Palms and Cycas: Characteristics, propagation, culture, pest and disease, importance and uses, genera and species of palms and Cycads. Bamboo and conifers: Genera, species and varieties

Lawns & Grasses: Planting methods, maintenance, pest management

Ornamental succulents, Cacti

Polyhouse technology: Scope and objectives of floriculture.

References

Randhawa GS and Mukhopadhyay A. 2004.Floriculture in India.Allied Publishers Pvt. Limited.

Swarup Vishnu. 2003. Garden Flowers. National Book Trust

Hartmann HT, Kester DE, Davies FT and Geneve RL. 2002. Plant Propagation – Principles and Practices. Prentice Hall India Ltd.

Royal Horticultural Society's Encyclopedia of Gardening.

Semester IV

4T1 - Core : Cell and Molecular Biology-II

Objectives:

- **Knowledge on structure and functions of ribosomes, mechanism of transcription and translation in pro- and eukaryotes.**
- **Understanding the gene structure and regulation of gene expression**
- **Knowledge on genome organization and recombination mechanisms**
- **Understanding the mechanism of cell cycle, apoptosis, techniques in cell biology**

Outcomes:

After successful completion of the course the students will be able to

- **Learn structure and functions of ribosomes, mechanism of transcription and translation.**
- **Learn gene structure and regulation of gene expression**
- **Learn mechanism of cell cycle, apoptosis, application of cell biology techniques.**

Module I:

Ribosomes: Structure and function

Transcription: Transcription in prokaryotic and eukaryotic cells, plant promoters, transcription factors, types of RNA and their function, RNA splicing, mRNA transport

Translation:In prokaryotic and eukaryotic cells, structural levels of proteins, post-translational modification; structure and role of rRNA and tRNA.

Module II:

Protein sorting: Protein glycosylation; vesicles involved in protein transport; protein targeting to plastids, mitochondria, peroxisomes, nucleus, vacuoles; modification during transport.

Gene structure: Chemical nature of gene; Fine structure of gene: Classical and modern concept of gene, Cis-trans test; fine structure analysis in eukaryotes; introns and their significance, RNA splicing

Regulation of gene expression:Prokaryotes- Positive and negative control, inducible and repressible operons, lac operon, trp operon, attenutation, riboswitch; Eukaryotes- Regulation at DNA, transcription, translation and post translational level, Epigenetic regulation

Module III:

Genome organization in prokaryotes and eukaryotic organelles: Phage genome, genetic recombination in phage and mapping phage genes; mapping of bacterial genes through transformation, conjugation and transduction; genome of mitochondria and chloroplast.

Genetic recombination and genetic mapping: Recombination; independent assortment and crossing over; molecular mechanism of recombination; role of RecA and RecBCD enzymes; homologous, non-homologous and site-specific recombination; chromosome mapping- linkage

group, genetic markers, types of maps, construction of molecular maps, correlation of genetic and physical maps; Somatic cell genetics -an alternative approach to gene mapping.

Module IV:

Cell cycle and apoptosis: Control mechanismsof bacterial and eukaryotic cell cycle, check point control, presence of regulators of cell cycle, G1 – S progression, G2 – M progression, role of cyclins and cyclin dependent kinases; retinoblastoma and E2F proteins; cytokinesis and cell plate formation; Apoptosis and its pathway.

Signal transduction:Overview, receptors and G-proteins, phospholipid signaling, role of cyclic nucleotides, calcium-calmodulin cascades, diversity in protein kinases and phosphatases, specific signaling mechanisms e.g. two-component sensor-regulator system in bacteria and plants, sucrose sensing mechanism

Techniques in cell biology: Electrophoresis, immunotechniques(Western blotting and ELISA), FISH, GISH, confocal microscopy

Suggested readings

Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. 1999.

Molecular Biology of Cell, Garland Publishing, Inc., New York.

Buchanan, B.B., Gruissem, W. and Jones, R. L. 2000 Biochemistry and Molecular Biology of Plants. American Soc. Of Plant Physiologists, Maryland, USA.

De Robertis, E.D.P. and De Robertis, E.M.F. Cell and Molecular Biology 8th Ed. B. I. Waverly Pvt. Ltd., New Delhi.

Jones R, Ougham H, Thomas H, Waaland S 2013 The Molecular life of plants. Wiley-Blackwell, USA

Karp, G. 1999 Cells and Molecular Biology; Concepts and Experiments. John Wiley & Sons, Inc., USA.

Khush, G.s. 1973 Cytogenetics of Aneuploids, Academic Press, New York, London Kleinsmith, L.J. and Kish, V.M. 1995 Principles of Cell and Molecular Biology (2 nd Edi.) Harper Collins Coll. Publisher, New York, USA.

Lewin, B. 2000 Gene VII Oxford Univ. press, New York.

Lodish, H., Berk, A. Zipursky, S. L. Matsudaira, P., Baltimore, D. and Darnell, J. 2000 Molecular Cell Biology Edi.W.H. Freeman and Co., New York, USA.

Malacinski, G. M. and Freifelder, D. 1998 Essentials of Molecular Biology (3rd Edi.)Jones and Bartiet Pub. Inc., London.

Russel, P. J. 1998 Genetics (5th Edi.) The Banjamin/ Cummings Publishing Com. Inc., USA

Sunstad, D. P. and Simmons, M. J. 2000 Principles of Genetics (2nd Edi.) John Wiley & Sons Inc., USA.

Tamarin, R. H. 2001 Principles of Genetics 7th Edi.The McGraw-Hill Companies.

Wolf, S.L. 1993. Molecular and Cellular Biology, Wadsworth Publishing Co., California, USA.

References: Online journals available on UGC V-SAT programme

Practicals

1. Isolation of nuclei and identification of histones by SDS-PAGE.
2. Isolation of chloroplast and demonstration of two subunits of RUBISCO by SDS-PAGE
3. To perform the restriction digestion of the DNA and analyse the digest over agarose gel.
4. To study *in vitro* transcription.
5. To study *in vitro* translation.
6. To study conjugation in bacterial cells.
7. To detect the presence of specific antigen by ELISA
8. Isolation of RNA and quantification by spectrophotometric method.
9. To map the genes on the basis of given cross-over data.
10. Separation of amino acids by paper electrophoresis, TLC method.
11. Separation of carbohydrates by paper electrophoresis, TLC method.

Semester IV

4T2 - Core: Plant Biotechnology and Plant Breeding

Objectives:

- **Understanding the principles and techniques of gene cloning, types of vectors**
- **Knowledge on recombinant DNA technology & its tools, microbial genetic manipulations.**
- **Understanding the basic concepts of tissue culture and knowledge on transgenics.**
- **Practical knowledge and analysis skills in usage of various bioinformatic tools.**

Outcomes:

After successful completion of the course the students will be able to

- **Learn gene cloning, recombinant DNA technology etc.**
- **Learn ttissue culture methods.**
- **Learn and apply bioinformatic tools for analysis of bioinformation data.**

Module I

a. Recombinant DNA technology: Gene cloning- Principles and technique; vectors- types (cloning & expression; plasmid & viral) and their properties; construction of DNA libraries (gDNA and cDNA); splicing of insert into the vector; screening of DNA libraries and introduction of the recombinant DNA into the host cells.

b. Genetic engineering of plants: Aims, strategies for development of transgenics (with suitable examples); Agrobacterium-the natural genetic engineer; T-DNA and transposon mediated gene tagging.

Module II

a. Microbial genetic manipulation: Bacterial transformation, selection of recombinants and transformants, genetic improvement of industrial microbes and nitrogen fixers, fermentation technology.

b. Genomics and proteomics: Molecular markers for introgression of useful traits; high throughput sequencing; functional genomics; Protein profiling and its significance.

c. DNA synthesis; DNA sequencing; basic polymerase chain reaction and applications of PCR; DNA fingerprinting

Module III

Plant tissue culture: Basic concepts; Principles and scope; tissue culture media; callus induction and cell suspension; aspects of morphogenesis; haploid and triploid production; production of somatic embryos; applications of plant tissue culture; protoplast isolation and culture; production of cybrids

Transgenic production: Methods to introduce gene in plants; selection of transformed plants/explants; salient achievements in crop biotechnology.

Module IV

Bioinformatics: Introduction, History, Definition and applications of bioinformatics; Database: Sequences (nucleotide and amino acid); nomenclature- IUPAC symbols, nomenclature of DNA & protein sequences, directionality of sequences, types of sequences used in bioinformatics; Definitions, types and classification of databases- Primary Databases, Secondary databases, Literature database and Taxonomy database.

Plant breeding: Methods of breeding sexually (self and cross pollinated) and vegetatively propagated crops; heterosis and inbreeding depression and their genetic basis; use of male sterility in hybrid production.

Suggested readings

Baxevanis, A. D., Davison, D. B.; Page, R. D. M.; Petsko, G. A.; Stein, L. D. and Stormo, G. D. 2008 Current Protocols in Bioinformatics, John-Wiley and Sons Publications, New York.

Baxevanis, A. D. and Ouellate, B. F. F. 2009 Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.

Brown, T. A. 1999. Genomes, John Wiley &Sons(Asia) Pvt. Ltd., Singapore.

Callow, J. A., Ford-Lloyed, B. V. and Newbury, H. J. 1997. Biotechnology and Plant Genetic Resources: Conservation and Use, CAB International, Oxon UK.

Chrispeeels, M. J. and Sadava, D. E. 1994, Plants, Genes and Agriculture.Jones & Barlett Publishers, Boston, USA.

Dubey, R. C. 2014 Advanced Biotechnology. S. Chand & Co. Pvt. Ltd., New Delhi.

Glazer, A. N. and Nikaido, H. 1995.Microbial Biotechnology. W. H. Freeman & Company, New York, USA.

Gustafson, R. J. 2000. Genomes.Kluwer Academic Plenum Publishers, New York, USA.

Henry, R. J. 1997. Practical Applications of Plant Molecular Biology.Chapman & Hall, London, UK.

Jain, S. M., Sopory, S. K. and Veilleux, R.E. 1996. In vitro Haploid Production in Higher Plants, Vols. 1-5, Fundamental Aspects and Methods. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Jolles, O. and Jornvall, H. (eds) 2000. Proteomics in Functional Genomics.Birkhauser Verlag, Basel, Switzerland.

Kartha, K. K. 1985. Cryopreservation of Plant Cells and Organs.CRC Press, Boca Raton, Florida USA.

Kingsman, S. M. Genetic Engineering : An Introduction to Gene Analysis and Exploitation in Eukaryotes, Blackwell Scientific Publications, Oxford, 1998

Mount W. 2004 Bioinformatics and sequence genome analysis 2nd Edi. CBS Pub. New Delhi

Old, R. W. and Primrose, S. B. 1989.Principles of Genome Analysis.Blackwell Scientific Publications. Oxford, UK.

Primrose, S. B.1995. Principles of Genome Analysis.Blackwell Scientific Ltd., Oxford, UK.

Raghavan, V. 1997.Molecular Biology of Flowering Plants. Cambridge University Press, New York, USA.

Practicals

1. To study the growth characteristics of *E. coli* using plating and turbidimetric methods.

2. To isolate the plasmid from *E. coli* and quantify it with suitable method.

3. To perform restriction digestion of the given plasmid DNA and to estimate of the size of various DNA fragments.

4. To Clone the given DNA fragment in a plasmid vector.

5. To prepare competent cells from the given bacterial culture.

6. To transform the competent bacterial cells with the given vector and perform blue-whit selection.

7. To prepare the media for plant tissue culture.

8. To surface sterilize the given seeds/explant for tissue cultural manipulation.

9. To isolate protoplast and determine its viability.

10. To fuse the protoplast for production somatic hybrid.

11. To workout the DNA sequence from the given autoradiogram and identify the gene using online tools.

12. To search literature database of different organisms.

13. To search the genes in the Genebank.

14. To use the various tools to retrieve information available from NCBI

15. To locate gene(s) on chromosomes for a given disease/disorder.

Suggested Readings(for laboratory exrcises)

Baxevanis, A. D. and Ouellate, B. F. F. 2009 Bioinformatics: A Practical Guide to the analysis of genes and proteins. John-Wiley and Sons Publications, New York.

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.

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.

Maniatis et al. Molecular cloning Vol.I, II and III.Cold-Spring Harbor Lab Press.

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

References: Online journals available on UGC V-SAT programme.

Semester IV

4T3 -Core Elective II:(Molecular Biology and Plant Biotechnology - II)

Objectives:

- **Understanding the methods of gene transfer.**
- **Know the applications of transformation, transgenics, molecular farming.**
- **Knowledge on some methods of tissue culture.**
- **Practical knowledge and analysis skills in usage of various DNA fingerprinting techniques.**
- **Knowledge on pollution cleaner Biotechnology.**

After successful completion of the course the students will be able to

- **Learn gene transfer methods, transgenics, molecular farming etc.**
- **Learn tissue culture methods.**
- **Learn and apply DNA finger printing techniques for analysis of molecular markers.**

Module I:

Transgenic plants: Cloning vectors for higher plants; Methods for gene transfer, *Agrobacterium tumefaciens*mediated gene transfer-Basis of tumour formation, features of Ti and Ri plasmids, mechanisms of DNA transfer, role of virulence genes;Direct DNA transfer- particle bombardment, electroporation, microinjection, macroinjection, liposomes, electrophoretic; pollen tube method; pollen transformation; PEG method; transformation of monocots; transgene stability and gene silencing; chloroplast transformation.

Module II:

a. Applications of transformation: Herbicide resistance; insect resistance; Bt genes, disease resistance; Nutritional quality; biopesticides and biofertilizers; hazards and safety regulations for transgenic plants.

b. Transgenics and molecular farming: Production of secondary metabolites; industrial enzymes; biodegradable plastics (PHB and any other); edible vaccines; antibody production and other important drugs.

Module III:

Plant tissue culture: History, Culture types- Callus culture, organ culture, suspension culture for production of secondary metabolites, protoplast culture, fusion and somatic hybrids, Somatic embryogenesis, production of haploid plants, somaclonal variations, organogenesis (direct and indirect).

Module IV:

a. DNA fingerprinting and marker assisted breeding:RFLP maps; linkage analysis; RAPD markers; STS; SSR (microsatellites); ISSR; SCAR (sequence characterized amplified regions); SSCP (single strand conformational polymorphism); AFLP; QTL: map based cloning; molecular marker assisted selection

b. Cleaner Biotechnology: Pollution control through genetically modified organisms; types of pollutants, bioremediation and phytoremediation; Production of bioethanol, biodiesel and biohydrogen.

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Semester IV

4T3 - Core Elective II:(Reproductive Biology of Angiosperms - II)

Objectives:

- **Understanding of mechanism of fertilization. Formation of endosperm, nutritive part of the seeds.**
- **Understanding of development of embryo, variation in types of embryo formation,**
- **Understanding of use of biotechnology in solving plants reproductive problems and metabolite production and its uses.**

Outcomes: After completion of the course, the student will be able to

- **Learning of problems in fertilization and fruit froduction.**
- **Analysis of type of reproduction, production of seedless fruits and role of insects in the fruit formation/pollination**
- **Understanding and application of knowledge of role of biotechnology in the reproduction and their uses for human welfare.**

Module I:

Fertilization: Cellular nature of sperm, the sperm cytoskeleton, the male germ unit, isolation and characterization of sperm, growth of the pollen tube through the style, passage of sperm into the embryo sac, fussion of nuclei, double fertilization, triple fussion, unusual features. In-vitro approaches to the study of fertilization-Intra-ovarian pollination, test tube fertilization, in-vitro fertilization, placental pollination, Gynogenesis.

Endosperm: types of endosperms, ruminate endosperm, cytological status. endosperm haustoria, chemical composition of endosperm, food reserve in endosperm, role of endosperm in embryo development, endosperm mutants.

Module II:

Embryogenesis: Zygote and its ultra-structure, Johanssen's system of embryo development, symmetry and polarity, rest period in zygote embryonic formulae, embryonomic law. Suspensor-Ultra structure of suspensor cells, cytology of suspensor cell, physiology and biochemistry of suspensor; Nutrition of embryo-nutrient supply of the zygote, embryo-endosperm relation.

Polyembryony: Defination, causes, classification, induction of polyembryony, practical importance of polyembryony.

Module III:

Apomixis: Defination, causes, classification, -Diplospory, Apospory, pseudogamy, autogamous development of endosperm, causes of apomixes, significance.

Parthenocarpy:Defination, causes, practical importance

Mellitopalynology: Pollen analysis of honey, Role of apiary in crop production.

Biotechnology: Concept and scope of biotechnology; Cell structure, cellular totipotency

a) Anther and pollen culture,

b) Ovule and nucellus culture

c) Endosperm culture and its practical applications

Module IV:

d) Embryo culture: Techniques, nutritional aspects of embryo culture morphological and physiological considerations, culture of mature embryo and proembryo.

e) Somatic embryogenesis: historical background, embryogenesis from callus, direct embryogenesis-recurrent embryogenesis; cytology of somatic embryogenesis, nutritional factors, hormonal factors.

f) Protoplast culture and somatic hybridization-isolation of protoplast, culture methods, fussion of protoplast, selection of fussion products, consequences of fussion, production of Cybrids and hybrids.

g) Biotransformation and production of useful compounds through cell culture, factor affecting yield, biotransformation, bioreactors, perspective.

Semester IV

4T3 - Core Elective II:(Mycology and Plant Pathology -II)

Objectives:

- **Know the history, milestones in phytopathology of India**
- **Knowledge on host-parasite relationship, defence mechanism in host.**
- **Practical knowledge on disease control measures in various crops**
- **Knowledge on bacterial, viral, mycorhizal and nematode diseases, symptoms and their importance.**

After successful completion of the course the students will be able to

- **Knowledge on the history, milestones in phytopathology of India**
- **Learn host-parasite relationships, various diseases and control methods.**

Module I:

History:Milestones in phytopathology with particular reference to India. Major epidemics and their social impacts. Historical developments of chemicals, cultural and biological protectionmeasures.

Altered metabolism of plants under biotic and abiotic stresses.

Koch's Postulates

Epidemiology and forcasting of plant diseases

Indian Institutes and their research activities in Mycology and Plant Pathology

Module II: Principles of Plant pathology

i. Principles of plant pathology-Importance, nature, classification and general symptoms of plant diseases.

ii. Pathogenecity of microorganisms and pathogenesis.

iii. Host parasite relationship and Interaction; Signal transduction.

iv. Defence mechanism in host plants against pathogens -morphological or structural defence mechanism;Biochemical defence mechanisms - role of phenolic compounds, enzymes and toxins,

v. Principles and methods of plant disease control -cultural methods, chemical methods, Biological control,transgenic approach for plant disease control, integrated pest management (IPM), Biopesticides.

Module III:

A Detailed study of the Diseases of the following crops caused by fungal pathogens with effective control measures.

Diseases of Cereals: Seedling blight of cereals, Smut of wheat, Foot rot of wheat, Covered smut of Barley, False smut of rice, Downey mildew of jowar, Green ear disease of Bajra, Ergot of Bajra, Downey mildew of maize.

Diseases of Vegetable crops with special reference to the important diseases of thefollowing: Chilli, Brinjal, Tomato, Onion, Bhindi.

General knowledge of post harvest diseases of fruits and vegetables and their control.

Diseases of Oil Seed Crops viz. *Linum*, *Seasamum*, Groundnut, Mustard and Sunflower

Diseases of Fruit Trees-With special reference to important diseases of the following Citrus, Apple, Mango, Banana and Grapes.

Module-IV:

Bacterial diseases of plants - Bacterial blight of rice, Tundu disease of wheat, Angular leaf spot of cotton, stalk rot of maize, Fire blight of Apple, Bacterial soft rot of fruits and Vegetables.

Viral Diseases of Plant: Bunchy top of Banana, Leaf curl of Papaya, Yellow vein mosaic of Bhindi. Mosaic of Cucurbits, Viral diseases of Tobacco, Potato and Tomato.

Mycoplasma/Phytoplama (PPLO) Diseases of Plants: Citrus greening, Rice yellow dwarf: Little leaf of Brinjal, Sandal Spike.

Nematode Diseases of Plants: General knowledge of plant parasitic nematodes and important nematode diseases viz.Root knot of Vegetables, Ear cockle of wheat. .

Suggested readings

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On line Journals available on UGC -VSAT

Semester IV

4T3 - Core Elective II:(Palynology - II)

Objectives:

- **Knowledge on pollen physiology and biochemistry**
- **Understanding the pollen biotechnology, genetics and forensic palynology.**
- **Knowledge on aerobiology history and various methods applied for collection and data analysis.**
- **Knowledge on pollen allergy, causes, symptoms, prevention and cure.**

Outcomes:

After successful completion of the course the students will be able to

- **Understand the diff. aspects of pollen physiology, biochemistry, genetics, biotechnology and forensic palynology.**
- **Applying knowledge on pollen allergies, identification of allergents, cure etc.**

Module I: Pollen physiology and biochemistry-

Pollen production, Pollenviability, tests for pollen viability, Pollen germination of pollen in *vivo* and in *vitro*, germination requirements, Role of boron and calcium in pollen germination, Factors affecting pollen germination. Chemical composition of pollen wall and pollen contents (amino acids, proteins, carbohydrates, lipids, vitamins, pectin, DNA, RNA, ascorbic acid, flavones, pigments etc.). Fine structure inside the tube, pollen culture movements of nuclei-and formation of calloseplug, promotion and inhibition of pollen tube, elongation, pollen enzymes and isozymes.

Module II: Pollen biotechnology and genetics, forensic palynology

Pollen storage-Factors affecting viability in storage, freeze-drying of pollen, storage of pollen in organic solvents, causes of decreased viability in storage and pollen germination.

Pollen-pistil interaction- significance, self incompatibility (regulation of fertilization) Pollen biotechnology & crop production- Anther / pollen culture, production of haploids

Genetics of pollen: Genetic segregation of pollen, pollen sterility- genic and cytoplasmic male sterility, factors involved in male sterility. Male sterility through recombinant DNAtechnology.

Forensic palynology- Introduction, methodology, role in criminology, examples

Module III:

Aerobiology-Introduction, Historical background, applications of Aeropalynology, Aeromycology,Aerophycology. Importance in medical field, importance of aero mycological

studies in various types of crop infection by spores, disease forecasting, aerobiological work in India and abroad.

Intramural and extramural studies, different devices to collect spores, pollen grains such askite, balloons, trap air strips and slides, volumetric samplers, culturing techniques, analysis ofdata and their processing, seasonal changes of air-spora, Indoor environments, Outdoor airspora, characteristics, identification

Module IV:

Airborne allergens- Introduction, allergens and their types, Impact of airborne materials onhuman system, Lung as particulate sampler, Source, causes, symptoms of Pollen allergy, fungal spore allergy, dust mite allergy, algal allergy other allergies, pollinosis, nasobroncheal allergy, Prevention and cure, Human immunoglobulins- types, and significance in diagnosis of allergy, diagnosing allergic diseases, Testing and treatment standardization, pollen calendar and daily census of airborne pollen, Correlation between aerobiological, clinical and meteorological data.

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Semester IV

4T3 - Core Elective II:(Plant Physiology - II)

Objectives:

- **Understanding the role of secondary metabolites in plants.**
- **Understanding various industrial applicable concepts and nanobiotechnology**
- **Understanding neuro and electro physiology**
- **Understanding the signal transduction in plant cells.**

Outcomes:

After successful completion of the course the students will be able to

- **Understand the importance of secondary metabolites and their medicinal importance**
- **Understand the applicability of learnt concepts at industrial level.**
- **Understand the pathways and proteins involved for different signaling response at cellular level.**

Module-I

Secondary metabolites :-Introductionand classification, Secondary metabolitesand ecological functions in plants , secondary metabolites defend plants against herbivoresand pathogens

a. Alkaloids:- alkaloid biosynthesis, Biotechnological application of alkaloidsBiosynthesis, plant defense against pathogens

b. Terpenoids:- terpenoids and herbivory, steroids and sterols, polyterpens,prenyltrasferase and terpene synthase reactions, modifications of terpeniod skeletons toward transgenic production

c. Phenolic compounds:- medicinal properties of phenolic compounds, types- simple phenolics, coumarins, lignin, flavonoids, tannins

d. Glycosides:-saponins, cardiac glycosides, cyanogenics glycoside,glucosinolates

Module-II

Leaf protein: - Green crop fractionation (GCF), Leaf Protein Concentrate (LPC), Chloroplastic LPC, Cytoplasmic LPC, Deproteinised Leaf Juice (DPJ), Uses of DPJ.Importance of leaf protein

Industrial fermentation:-importance of fermentation, type of fermentation, alcoholic fermentation, enzyme production , antibiotic production

Biodiesel production:- introduction and historical account of biodiesel,methods of preparation biodiesel from vegetable oil, biochemical properties of biodiesel Importance of biodiesel.

Module-III

Plant Neuro/electro physiology:- introduction and historical account of plantelectrophysiology, Factor affecting electrical potential, electrodes and methods usedfor Measuring the Electrical potential energy of plants and fruits

S**ignal Perception and Transduction**:-Introduction, overview of signal transduction pathway, receptors, specific examples of plant receptors, signal transduction in Prokaryotes, signal transduction in eukaryotes, G-proteins and phospholipids signaling, cyclic nucleotides, secondary messengers (Calcium, calcium-calmodulin complexes, Protein kinases particular pathways of signal transduction Associated with plant growth regulators

Module-IV

Vitamins:- water and fat- soluble vitamins, biochemical function of thiamine, riboflavin, nicotinic acid, pantothenic acid, pyridoxin, biotin, folic acid, vitamin B12, ascorbic acid, vitamin A and vitamin D

Antioxidants:-what are antioxidants, types of antioxidants, role of antioxidants in medicine and in disease control, cure and prevention, antioxidant rich foods

Nanobiotechnology:-Application of nano-biotechnology in medicine and food, synthetic and natural bionanomaterials. Implications of nanoscience and nanotechnology on society.

Issues- biosensors and their applications, biological nanostructures.Applications of bionanoscience to materials research.

4T4 - Foundation Course II: Applied Botany
(Student shall opt for this paper from any other subject other than his/her main subject for post graduation)

Objectives:

- **Know the concept and types of entreneurship, types of start-ups**
- **Understanding the production of various plant products**
- **Understanding green herbal and cultural techniques**
- **Knowledge on different types of garden, floriculture, silviculture developments, post-harvent techniques.**

Outcomes:

After successful completion of the course the students will be able to

- **Learn the production of plant bio-products**
- **Applying knowledge with reference to green herbal techniques, culture technique and cultivation of garden, silviculture,post-harvesting techniques etc.**

Module I: Entrepreneurship in Botany

Concept, definition, structure and theories of entrepreneurship; Types of start-ups; Types of entrepreneurship, Entrepreneurship of NTFP (collection/Production, value addition, marketing strategies), Biodiesel/bio-ethanol plant production, *Trichoderma* production for control of soil borne fungi, honey production., Plant enzyme production

Module II: Green herbal techniques

Phytochemistry: Classification of secondary metabolites accumulated by the plants; extraction of phytochemicals

Plant based products: Techniques for extraction/preparation of various dyes, cosmetics, perfumes (essential oils), sweeteners (*Stewia* etc.), herbal medicine, nutraceuticals.

Fibre production: Coir, Jute, banana, cotton, silk cotton etc.

Cultivation of common medicinal herbs: *Aloe vera, Curcuma longa, Zingier officinalis, Withania somnifera, Chlorophytum borivilianum.*

Module III: Gardening, silviculture and Post harvesting techniques

Gardening: History, types of gardens, landscape gardening, major gardens of the world.

Floriculture: General introduction, nursery management, methods of propagation (Bonsai, cutting, grafting, budding) poly house and green house, commercial floriculture.

Silviculture: Introduction, Agro-forestry, avenue trees, ornamental shrubs and trees cultivation.

Kitchen gardening: Spinach, tomato, brinjal, coriander, drumstick, lady's finger, chilly, curry leaf, methi and other spices etc.

Post harvest techniques: Vegetables, fruits, ornamentals, neutraceuticals,

Module IV: Culture techniques

Sterilization techniques for various types of cultures

Technique of- Mushroom culture, *Spirulina* cultivation, compost, vermi-composting, bio-fertilizer production, hydroponics, plant tissue culture, techniques to increase shelf-life of ornamental plants.

Suggested readings

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