

Syllabus of Botany

(Semester-wise course structure for Post-Graduation in Botany
in CSJM University, Kanpur in accordance with guidelines of
NEP-2020)



As approved by
Board of Studies for Botany,
CSJM University, Kanpur

[Handwritten signatures and initials]
Anand
Phodha
Jeehan Sunkh
MChakraborty
SPB

Minutes of BoS meeting of Botany for Post Graduate Syllabus and semester-wise course structure of P.G for CSJM University, Kanpur as per NEP-2020 guidelines.

An online BoS meeting of Botany was conducted on 12-5-2022 from 1:30 PM – 2:24 PM.

Following board members participated in the meeting -

Convenor

Dr. Shailendra Kumar Singh
Associate Professor, Dept. of Botany
D.A-V College, Kanpur

External Experts:

- 1) Dr. A. K. Shukla
Head and Dean, Dept. of Botany
IGNTU, Amarkantak, M.P
- 2) Dr. S. M. Prasad
Professor, Dept. of Botany
University of Allahabad, Prayagraj
- 3) Dr. Nandita Ghoshal
Professor, Centre of Advanced Studies,
Dept. of Botany, Institute of Science
BHU, Varanasi

Internal Experts:

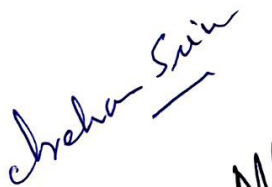
- 1) Dr. Archana Srivastava
Head, Dept. of Botany
D.G College Kanpur
- 2) Dr. Navin Kumar Ambasht
Head, Dept. of Botany
Christ Church College, Kanpur
- 3) Dr. Sunil Kumar Singh (Special Invitee)
Assistant Professor, Dept. of Botany
D.A-V College, Kanpur

The meeting was conducted very smoothly. Board members gave some suggestions, such as –

- Dr. Nandita Ghoshal was not satisfied with the topic of one of the papers, which was corrected. She also asked for a change in the structure of one of the papers, but, later on, agreed with the same.
- Dr. A. K. Shukla was very happy with the course structure and found it very appropriate semester-wise.
- Dr. S. M. Prasad suggested to curtail some content of the paper as the teaching period is less.
- Dr. Sunil Kumar Singh also mentioned that as there is a lack of staff in many colleges, so, it will be difficult to cover a large syllabus in a time-bound semester system. Hence, some portion was deleted from the syllabus.
- Dr. Archana Srivastava also wanted to change the topic of a paper, but, the majority was in favor of that topic and Dr. Navin Kumar Ambasht explained why that topic was correct.

At last, every participant of the meeting unanimously agreed with the syllabus and the course structure. Convenor Dr. Shailendra Kumar Singh thanked all the board members for their participation and suggestions.

Meeting was adjourned



This syllabus has been approved by the following members of the board of studies (BoS), CSJM University, Kanpur through an online meeting held on Thursday, 12 May 2022 from 1.30 to 2.24 pm.

Convenor

Dr. Shailendra Kumar Singh
Associate Professor, Dept. of Botany
D.A-V College, Kanpur

External Experts:

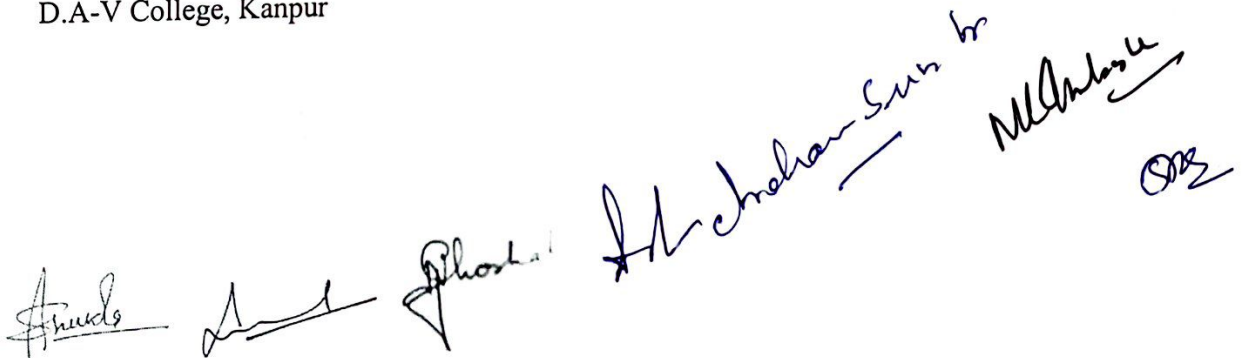
- 1) Dr. A. K. Shukla
Head and Dean, Dept. of Botany
IGNTU, Amarkantak, M.P
- 2) Dr. S. M. Prasad
Professor, Dept. of Botany
University of Allahabad, Prayagraj
- 3) Dr. Nandita Ghoshal
Professor, Centre of Advanced Studies,
Dept. of Botany, Institute of Science
BHU, Varanasi

Internal Experts:

- 1) Dr. Archana Srivastava
Head, Dept. of Botany
D.G College Kanpur
- 2) Dr. Navin Kumar Ambast
Head, Dept. of Botany
Christ Church College, Kanpur

Special Invitee

- 3) Dr. Sunil Kumar Singh
Assistant Professor, Dept. of Botany
D.A-V College, Kanpur

Handwritten signatures of board members. From left to right: a signature that appears to be 'Shukla', a signature that appears to be 'Prasad', a signature that appears to be 'Ghoshal', a signature that appears to be 'Sunil Kumar Singh', a signature that appears to be 'Ambast', and a signature that appears to be 'Srivastava'.



CHHATRAPATI SHAHU JI MAHARAJ UNIVERSITY, KANPUR

STRUCTURE OF SYLLABUS FOR THE

PROGRAM: M.Sc., SUBJECT: BOTANY

Syllabus Developed by		
Name of BoS Convenor / BoS Member	Designation	College/University
DR. SHAILENDRA KUMAR SINGH	Convenor	D.A.V. COLLEGE, CIVIL LINES, KANPUR
DR ARCHANA SRIVASTAVA	Member	D.G. P.G. COLLEGE, KANPUR

YEAR/ SEMESTER	COURSE CODE	TYPE	COURSE TITLE	CREDIT	CIA	ESE	MAX. MARKS					
I ST YEAR / I ST SEM	B040701T	CORE	DIVERSITY OF MICROBES AND FUNGI	4	25	75	100					
	B040702T	CORE	DIVERSITY OF ALGAE AND BRYOPHYTES	4	25	75	100					
	B040703T	CORE	DIVERSITY OF PTERIDOPHYTES AND GYMNOSPERMS	4	25	75	100					
	B040704T	CORE	PLANT ECOLOGY	4	25	75	100					
	B040705P	PRACTICAL	PRACTICAL	4	25	75	100					
I ST YEAR / II ND SEM	B040801T	CORE	TAXONOMY OF ANGIOSPERMS AND BIOSYSTEMATICS	4	25	75	100					
	B040802T	CORE	MORPHOLOGY, ANATOMY AND EMBRYOLOGY OF ANGIOSPERMS	4	25	75	100					
	B040803T	CORE	CYTOGENETICS & BASIC MOLECULAR BIOLOGY	4	25	75	100					
	B040804T	ELECTIVE	PALEOBOTANY	4	25	75	100					
	B040805T		PLANT BREEDING AND ELEMENTARY BIOSTATISTICS									
	B040806P	PRACTICAL	PRACTICAL	4	25	75	100					
	B040807R	PROJECT	RESEARCH PROJECT	8	25	75	100					
		MINOR ELECTIVE	FROM OTHER FACULTY (IN 1 ST YEAR)	4/5/6	25	75	100					
II ND YEAR / III RD SEM	B040901T	CORE	PLANT PHYSIOLOGY AND BIOCHEMISTRY	4	25	75	100					
	B040902T	CORE	PLANT BIOTECHNOLOGICAL AND MOLECULAR TECHNIQUES	4	25	75	100					
	B040903T	ANY 2	PLANT TISSUE CULTURE	4	25	75	100					
	B040904T	ELECTIVES	BASICS BIOANALYTICAL TECHNIQUES									
	B040905T	TO BE CHOSEN	BIODIVERSITY AND CONSERVATION									
	B040906T		MEDICINAL AND AROMATIC PLANTS	4	25	75	100					
	B040907P	PRACTICAL	PRACTICAL	4	25	75	100					
II ND YEAR / IV TH SEM	B041001T	ANY 4 ELECTIVES TO BE CHOSEN	ADVANCED GENETICS & MOLECULAR BIOLOGY	4	25	75	100					
	B041002T		ADVANCED PLANT PATHOLOGY									
	B041003T		ADVANCED PHYCOLOGY									
	B041004T		ENVIRONMENTAL SCIENCES									
	B041005T		ADVANCED PLANT PHYSIOLOGY AND BIOCHEMISTRY									
	B041006T		ENVIRONMENTAL & APPLIED MICROBIOLOGY									
	B041007T		CONSERVATION AND RESTORATION ECOLOGY									
	B041008T		BIOINFORMATICS AND INTELLECTUAL PROPERTY RIGHTS (IPR)									
	B041009T		BIOFERTILIZER TECHNOLOGY									
	B041010T		MICROBIAL GENETICS									
	B041011P		PRACTICAL					PRACTICAL	4	25	75	100
	B041012R		PROJECT					RESEARCH PROJECT	8	25	75	100

Archana Srivastava



CHHATRAPATI SHAHU JI MAHARAJ UNIVERSITY, KANPUR

STRUCTURE OF SYLLABUS FOR THE

PROGRAM: M.Sc., SUBJECT: BOTANY

NOTE:

1. *A MINOR ELECTIVE FROM OTHER FACULTY SHALL BE CHOSEN IN 1ST YEAR (EITHER 1st / IInd SEMESTER) AS PER AVAILABILITY.
2. In both years of PG program, there will be a Research Project or equivalently a research-oriented Dissertation as per guidelines issued earlier and will be of 4 credit (4 hr/week), in each semester. The student shall submit a report/dissertation for evaluation at the end of the year, which will be therefore of 8 credits and 100 marks
3. Research project can be done in form of Internship/Survey/Field work/Research project/ Industrial training, and a report/dissertation shall be submitted that shall be evaluated via seminar/presentation and viva voce.
4. The student straight away will be awarded 25 marks if he publishes a research paper on the topic of Research Project or Dissertation.

Arjun Sivarani

***Practical**

1. Practical work will be based on the paper (allotted or opted) in the given semester
2. Each practical work will be of 4 credits (or 100 marks)
3. Distribution of Marks will be as follows-
 - Experimental work based on the allotted or opted papers. Total four experiments (4x10) =40 Marks
 - Spotting.....=20 Marks
 - Viva-voce=25 Marks
 - Record /chart/collection.....=15 Marks

Totals =100 Marks

****Research project in postgraduation**

- ❖ A student has to do a detailed research project in 4th and 5th year of higher education (first and second year of post-graduation)
- ❖ This research project will be based on the main subject.
- ❖ This research project can be interdisciplinary/ multidisciplinary. It can also be based on industrial training/ internship/ survey work.
- ❖ This research project will be done under a supervisor from the institutional teaching faculty. A Co-supervisor from any industry/company/ technical institute/Research Institute can also be chosen.
- ❖ A postgraduate student has to do a research project of 4 credits (4 hours per week) per semester.
- ❖ The final project report/dissertation of both semesters will be submitted at the end of the year by the student.
- ❖ The final report will be evaluated by the supervisor and an external examiner appointed by the university for 100 marks. It will have 8 credits.
- ❖ Evaluation of the project work will be done considering the project report, presentation and viva-voce.
- ❖ Students can be credited 25 extra marks if they get research papers based on projects published in UGC-CARE listed journals during their postgraduation course. Nevertheless, the maximum marks will not exceed 100.
- ❖ Grades will be mentioned on the basis of marks obtained in the research project and they will be included in the CGPA calculations.

*****Minor elective paper from other faculty**

- ❖ In the first year, a PG student will have to opt for one minor elective paper from any other faculty of 4 credits.

[Handwritten signatures and initials]

B040701T

Diversity of Microbes and Fungi

Semester-I

Unit I

Virus: Nature, ultrastructure, symptomology, method of transmission of plant viruses, multiplication and importance of TMV and Bacteriophage.

2. **Bacteria-** General account, classification, ultrastructure, nutrition, reproduction, ecological aspect and economic importance of bacteria.

3. **Mycoplasma-** General characteristics

4. **Lichens:** Thallus structure, reproduction and economic importance.

Unit II

5. **Fungi-** Recent trends in classification, characteristics, reproduction, heterothallism, parasexual cycle and sex hormones, degeneration of sexuality and economic importance of fungi.

6. Classification and comparative studies of the following groups-

a. Myxomycotina: Plasmodiophorales

b. Mastigomycotina: Chytridiales, Saprolegniales and Peronosporales

c. Zygomycotina: Mucorales and Entomophthorales

d. Ascomycotina: Endomycetales, Protomycetales, Taphrinales, Erysiphales, Eurotiales, Pezizales and Hypocreales

e. Basidiomycotina: Uredinales, Ustilaginales and Agaricales

f. Deuteromycotina: Sphaeropsidales, Moniliales

Suggested readings:

1. Willey JM, Sherwood L, Woolverton CJ (2013) Prescott's Microbiology, 9th edition, McGraw-Hill, New York.
2. Pelczar M.J., Chan E.C.S. and Krieg N.R. (2003) Microbiology. 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi.
3. Gangulee, H.C. and Kar, A.K., College Botany Vol. II- 2011 (Algae+Fungi+Brophyta+Pteridophyta), New Central Book Agency, Kolkata
4. Singh, Pande, Jain, A Text Book of Botany, (2014) (Algae+Fungi+Brophyta+Pteridophyta), Rastogi Publication, Meerut
5. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (2007). Introductory Mycology. Fourth Edition Wiley India Pvt. Limited
6. Webster, J. and Weber, R. (2007). Introduction to Fungi. Third Edition. Cambridge University Press. Cambridge and New York
7. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi & Their Allies, Second Edition. MacMillan Publishers Pvt. Ltd., Delhi, India

Shukla

Shukla

Shukla

Shukla

Shukla

Shukla

Shukla

B040702T

Diversity of Algae and Bryophytes

Semester-I

I

Unit I – Algae

1. Algae in diverse habitats, symbiotic association and economic importance of algae.
2. Principles and system of algal classification; a comparative account of photosynthetic pigments, cell wall, reserve food, flagellation, chloroplast and type of reproduction in algae and their phylogenetic and taxonomic importance.
3. A general account of range of thallus organization and reproduction in Chlorophyta, Pheophyta and Rhodophyta.
4. A brief account of Chrysophyta, Bacillariophyta, Xanthophyta and Euglenophyta.
5. Cyanobacteria; cell and thallus organization, chromatic adaptation, movement, heterocyst and reproduction.

Unit II- Bryophytes

6. Criteria and recent trends in the classification of Bryophytes
7. Fossil history, origin, evolution and phylogenetic affinities in Bryophytes.
8. Regeneration, ecological significance and economic importance of Bryophytes.
9. A comparative study of morphology, anatomy, life history of the following groups-

Hepaticopsida – Calobryales, Sphaerocarpaceles, Marchantiales, Jungermanniales.

Anthocerotopsida – Anthocerotales

Bryopsida - Sphagnales, Andreaeales, Polytrichales

Suggested readings:

1. Graham Robin South and Alan Whittick, 1998, Introduction to Phycology, Blackwell Scientific Publication
2. Bold, H.C. and Wynne, M.J., 1985, Introduction to the Algae, 2nd Edition, Prentice-Hall Inc.
3. Dixon, R., Biology of Rhodophyta, Koelt Science Publisher, West Germany
4. Fritsch, F.E., Structure and Reproduction of Algae, Vol. I & II, Cambridge University Press, Cambridge
5. Gangulee, H.C. and Kar, A.K., 2011, College Botany Vol. II (Algae+Fungi+Brophyta+Pteridophyta), New Central Book Agency, Kolkata
6. Singh, Pande, Jain, 2010, A Text Book of Botany (Algae+Fungi+Brophyta+Pteridophyta), Pub. Rastogi Publication, Meerut
7. Parihar N. S. 1965, An Introduction to Embyophyta- Bryophyta. Central Book Depot. Allahabad.
8. Kashyap S. R. 1972, Liverworts of the Western Himalayas & the Punjab Plains. Part 1 & 2.
10. Janice. M. Glime, 2006, Bryophyte Ecology.
11. Goffinet B. & Shaw. A. J. 2008, Bryophyte Biology.

[Handwritten signatures and initials]

Unit I- Pteridophytes

1. General features, classification, affinities of Pteridophytes and their economic importance
2. Stellar system, heterospory and evolution of seed habit, apospory and apogamy in Pteridophytes.
3. A general account of fossil Pteridophytes.
4. A comparative morphology, anatomy, reproductive biology and evolutionary study of the following groups- Psilophytopsida, Psilopsida, Lycopsidea, Sphenopsida and Pteropsida.
5. Monographic study of *Psilotum*, *Isoetes*, *Ophioglossum*, *Osmunda*, *Lygodium*, *Adiantum*,

Unit II- Gymnosperms

6. General features, classification up to the order, distribution and economic importance of Gymnosperms.
7. Origin and evolution with special reference to Progymnosperm.
8. A comparative morphology, anatomy, reproductive biology and phylogenetic study of the following groups – Pteridospermales, Caytoniales, Bennettitales, Pentoxylales, Ginkgoales, Coniferales, Ephedrales and Gnetales.
9. Monographic study of *Cryptomeria*, *Araucaria*, *Podocarpus*, *Thuja*, *Taxus*, and *Gnetum*.

Suggested readings:

1. Rashid, A, 2011, An Introduction to Pteridophyta, 2nd edition, (Reprint), Pub. Vikas Publishing House Pvt. Ltd., Noida.
2. Gifford, Ernest, M., Foster, Adriance.S., 1989, Morphology and Evolution of vascular plant. W. H. Freeman, Third Edition.
3. Ogura, Yuzuru., 1972, Comparative Anatomy of Vegetative Organs of The Pteridophytes. Gebr. Borntraeger, 2nd edition.
4. Rashid, A.1999, An Introduction to Pteridophyta: Diversity, Development, Differentiation. Vikas Publishing House Pvt Ltd.
5. Parihar, Narayan Singh., 1977, The Biology and Morphology of The Pteridophyte. Central Book Depot.
6. Eames, A.J. (1936) Morphology of Vascular plant-lower group. Tata Mc Graw Hill, New Delhi.
7. Chamberlain, Charles Joseph, b.(1863), Gymnosperm; Structure and Evolution. Chicago, Ill., The University of Chicago Press
8. Chhaya Biswas and B.M.Johri. The Gymnosperm. Springer; 1997, edition (16 April 2014)
9. Bhatnagar, S.P. Moitra, Alok. (1996). Gymnosperms. New Age International.
10. Pant DD. (2002), An Introduction to Gymnosperms, Cycas, and Cycadales, Birbal Sahni Institute of Palaeobotany.

Handwritten signatures and notes:
Anurag
Alok
Bhatnagar
Chhaya Biswas
Jyoti Swam
MChhaya
S.P.

PLANT ECOLOGY

Semester-I

1. Ecosystem organisation: Structure and functions; primary production (methods of measurement, global pattern); energy dynamics (trophic organisation, energy flow pathways, ecological efficiencies); global biogeochemical cycles of carbon, nitrogen, phosphorus and sulphur.
2. Ecosystem stability: Concept of resistance and resilience; ecological perturbation (natural and anthropogenic) and their impacts on plants and ecosystem. Ecology of plant invasion; ecosystem restoration.
3. Vegetation organisation: origin of intrapopulation variations; population and environment; ecades, ecotypes, ecophenes; community coefficients, ordination, concept of ecological niche.
4. Ecological succession: Models and mechanisms of ecological succession (relay floristic, facilitation, tolerance and inhibition models); changes in ecosystem properties during succession.
5. Biological diversity: Concepts and levels and role of biological diversity in ecosystem, causes and consequences of degeneration of biodiversity and its repercussions on the future course of evolution.
6. Ecological management: Concept, sustainable development and sustainability indicators.
7. Global Climate Change: Green house gases (GHGs), consequences of climate change; ElNino and LaNina effect.
8. Environmental Pollution: kinds, sources, effects on plants and ecosystem; Biological magnification; eutrophication; photochemical smog and acid rain; ozone layer depletion, causes and consequences and control.

Suggested readings:

1. Odum EP, Barret GW (2005) Fundamentals of Ecology, Thomson Ed. Brooks/Cole, Cengage Learning India Pvt Ltd, New Delhi.
2. Odum EP (1983) Basic Ecology, Saunders College Pub, Philadelphia.
3. Korondy EJ (1996) Concepts of Ecology, Prentice-Hall, New Jersey.
4. Singh JS, Singh SP, Gupta SR (2014) Ecology, Environmental Science and Conservation, S Chand & Co, New Delhi.
5. Pungnaire FI, Valladares F (2007) 2nd Edition, Functional Plant Ecology CRC Press/Taylor & Francis Group, Boca Raton, Florida
6. Schulze ED, Beck E, Hohenstein K (2005) Plant Ecology Springer-Verlag Berlin Heidelberg, New York
7. Barbour, M. G.; Burk, J. H.; Pitts, W. D. (1987) 2nd Edition Terrestrial Plant Ecology. The Benzamin/Cummings Publishing Company, San Francisco
8. Ambasht R S and Ambasht N K (2018) A text book of Plant Ecology, CBS Publisher, New Delhi.
9. Ambasht R S and Ambasht Navin. K (2003) Modern Trends in Applied Terrestrial Ecology , Kluwer Academic Press , USA

Handwritten signatures and initials:
Shukla, [unclear], Phosha, J. K. Chohan, Swain K, M. K. Swain, [unclear], [unclear]

B040801T

Taxonomy of Angiosperms and Biosystematics

Semester-II

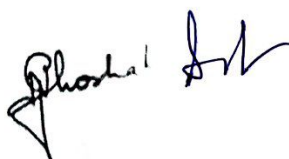
1. Angiosperms; evolutionary trends in characters. Principles and outline of classification proposed by Bentham and Hooker, Takhtajan
2. International Code of Botanical Nomenclature; Principle, Rules and Recommendations; Priority, Typification, Effective and Valid publication, Illegitimate names; Name changes; Basionyms and Synonyms.
3. Taxonomic features and economic importance of the following Families-
Dicots- Magnoliaceae, Cappariaceae, Caryophyllaceae, Fabaceae, Myrtaceae, Rubiaceae, Asteraceae, Asclepiadaceae, Apocynaceae, Solanaceae, Bignoniaceae, Acanthaceae, Verbenaceae, Lamiaceae, Euphorbiaceae, Moraceae.
Monocots- Orchidaceae, Arecaceae, Amaryllidaceae, Poaceae.
4. Biosystematics; concepts, biosystematics categories, methods in experimental taxonomy.
5. Numerical Taxonomy; aims and objectives, character and attribute, OTUs, coding, cluster analysis, merits and demerit.
6. Chemotaxonomy; role of phytochemicals [non-protein amino acids, alkaloids, betalins, cyanogenic glucosides] in taxonomy.
7. Palynotaxonomy
8. Embryology in relation to Taxonomy
9. Molecular approach to plant taxonomy; Angiosperm Phylogeny Groups [APG], DNA barcoding and its practical application in Angiosperm taxonomy.

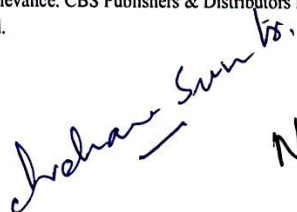
Suggested readings

1. Sambamurty, A.V. S. S. 2005. *Taxonomy of Angiosperms*. I. K. International Pvt. Ltd., New Delhi.
2. APG III 2009. An update of the Angiosperm Phylogeny Group Classification for the Orders and Families of Flowering Plants: APG III. *Bot. J. Linn. Soc.* 161: 105-121.
3. Bhattacharyya, B. and B. M. Johri. 1998. *Flowering Plants - Taxonomy and Phylogeny*. Narosa Publishing House, New Delhi.
4. Heywood, V. H. and Moore, D. M. 1984. *Current Concepts in Plant Taxonomy*. Oxford University Press.
5. Duthie, J. F. "Flora of upper gangetic plain and of the adjacent siwalik & sub-himalayan tracts," Calcutta, Vol. 3, No. 1, 1915
6. Jain, S.K. and Rao, R.R. 1977. *A Handbook of Field and Herbarium Methods*. Today and Tomorrow's Printers and Publishers, New Delhi-
7. Rao, R. R. 1994. *Biodiversity in India* (Plant Aspects), Bishan Singh Mahandrapal Singh, Dehradun.
8. Sharma, O. P. 1993. *Plant Taxonomy*. Tata McGraw Hill Publishing Co. Ltd., New Delhi.
9. Singh, V. & Jain, D.K. 2006. *Taxonomy of Angiosperms*. : Rastogi Publications, Meerut.
10. Singh, Gurcharan 2012. *Plant Systematics: An Integrated Approach- Science Publishers, Enfield, (1st edn.)*
11. Stace, C. A. 1989. *Plant Taxonomy and Biosystematics*. University Park Place, Baltimore (2nd edn.)
12. Takhtajan A. 2009. *Diversity and classification of flowering plants*, 2nd edn. Berlin: Springer.
13. Verma, B. K. 2010. *An introduction to Taxonomy of Angiosperms*. PHI Learning Pvt. Ltd. New Delhi.
14. Jones, SB Jr. and Luchsinger, AE. 1986. *Plant Systematics* (2nd edition). McGraw Hill Book Co., New York.
15. Pandey, A. K., J.V.V. Dogra & Wen, J. 2006. *Plant Taxonomy: Advances and Relevance*. CBS Publishers & Distributors Pvt. Ltd.
16. Subrahmanyam, N. S. *Taxonomy of Angiosperm*, Vikas publishing house Pvt Ltd.
17. Pullaih, T. 2007. *Taxonomy of angiosperm*. Regency publications, New Delhi.













Unit I

1. Morphological nature of the flower with special reference to stamen and carpel. Ontogeny of flower and inferior ovary.
2. Primary meristems; organization of shoot and root apices. Vascular cambium and cork cambium; structure and function. Anomalous secondary growth.
3. Leaf anatomy and abscission layer.
4. Nodal anatomy and root-stem transition.
5. Structure of Wood, Trichomes and Stomata and their taxonomic significance.

Unit II

6. Microsporogenesis and Megasporogenesis; development of male and female gametophyte. Structure and type of Embryo sac.
7. Fertilization, double fertilization and triple fusion. Polyspermy and hetero-fertilization.
8. Endosperm; development and type of endosperm, endosperm haustoria and morphological nature of endosperm.
9. Development and type of embryo.
10. Apomixis; Diplospory, Apospory and Adventive embryony.
11. Polyembryony and induced parthenocarpy.

Suggested readings:

1. Bhojwani, S.S. and Bhatnagar, S.P.(1985), Embryology of Angiosperms, Vikash Publishing House, New Delhi
2. Johri, B.M (1984) Embryology of Angiosperms. Springer-Verlog Berlin Heidelberg.
3. Maheshwari, P. (1950) An Introduction to the Embryology of Angiosperms. Tata McGraw Hill.
4. Pandey, B.P., Angiosperms-Taxonomy, Embryology and Anatomy, S. Chand and Co., New Delhi
5. Esau, Katherine, (1965), Plant Anatomy, John Wiley and Sons. Inc, New York.
6. Esau, Katherine, (1960), Anatomy of seed plants. Wiley, New York.
7. Evert, Ray. F. (1960), Esau's Plant Anatomy. John Wiley & Sons.
8. Fahn, A. (1982), Plant Anatomy Vol I and Vol II Pergamon Press. Oxford New York.

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

B040803T

Cytogenetics and Basic Molecular Biology

Semester II

1. **Cell cycle:** Cell division and regulation
2. **Chromosome Organization:** Nucleosome and higher-order organization of chromatin, euchromatin and heterochromatin
3. **Chromosome banding patterns:** Linear differentiation of chromosome segments, types of chromosome banding, uses of chromosome banding in cytogenetics
4. **Genome organization:** Genome size and C-value paradox, repetitive DNA, satellite DNA, split genes, overlapping genes, pseudogenes.
5. **Genetics:** Mendelism and gene interaction, extrachromosomal inheritance.
6. **Variation:** Chromosomal Aberration (structural and numerical changes); polyploidy and its role in crop improvement and evolution.
7. **Mutation:** Spontaneous and induced mutation; physical and chemical mutagens, molecular basis of mutations. Role of mutations in crop improvement, site directed mutagenesis.
8. **Modern concept of genes:** Fine structure of gene, genome organization in prokaryotes and eukaryotes
9. **Structure and conformation of nucleic acids;** Replication of DNA, DNA damage and repair. Transcription of gene; Structure of mRNA, rRNA and tRNA.
10. **Protein synthesis:** Genetic code and its properties, Mechanism of translation (initiation, elongation and termination); Post-translational modification.

Suggested readings:

1. Clark MS, Wall WJ (1996) Chromosomes: The Complex Code, Chapman & Hall, London.
2. Sharma AK, Sharma A (1985) Advances in Chromosome and Cell Genetics, Oxford & IBH Publishing Co, Kolkata.
3. Krebs JE, Lewin B, Goldstein ES (2011) Genes X, Sudbury, Massachusetts.
4. Gardner EJ, Simmons MJ, Snustad DP (2006) Principals of Genetics, 8th edition, John Wiley & Sons, Wiley India Edition, New Delhi.
5. Hartl DL, Jones EW (2007) Genetics—Analysis of Genes and Genomes, 7th edition, Jones and Barlett publishers, Burlington.
6. Karp G (2009) Cell and Molecular Biology: Concepts and Experiments, 6th edition, John Willey & Sons, New York.
7. Lodish H, Berk A, Kaiser CA, et al. (2013) Molecular Cell Biology, 7th edition, WH Freeman and Comp, New York.
8. Buchanan, B., Gruissem, W., & Jones, R.L., 2002, Biochemistry and Molecular Biology of Plants. American Society of PlantBiologists, USA.
9. Watson, JD, Baker, TA, Bell, SP, Gann, A, Levine, M and Richard, L. 2008. Molecular Biology of the Gene. Pearson Education Inc.

Arund

[Signature]

[Signature]

[Signature]

Chohan

Mishra

[Signature]

ELECTIVE PAPERS

B040804T

Paleobotany

Semester II

1. **Objectives of paleobotany-** General discussion on Prebiotic Environment, chemical evolution and origin of life, Pre-Cambrian life. Indian Pre-cambrian stratigraphy and life forms.
2. **Basic geological information** – structure of Earth, plate tectonics and Wegener's continental drift theory, super continental cycles, Types of rocks. Geological time scale, Principles of stratigraphy, Radioactive dating. **Fossilization-** Process of fossilization, Types of fossils, techniques to study fossils,
Fossil Taxonomy- Reconstruction and nomenclature of fossils, concepts of Parataxa and Eutaxa.
3. **Applied Palaeobotany-** Life as fuel maker, sources of natural fossil fuels, Peat, coal and its varieties, constitution of coal, Coal Palynology, coal maceral, Petroleum – its origin, Palynology in oil exploration. Fundamentals of Paleofloristics, Palaeogeography and Palaeoclimatology.

Suggested readings: -

1. Steward W.N., Palaeobotany and evolution of plant. Cambridge University Press, New York.405 p.(1)
2. Stewart,W.N.,and G.W.Rothwell.(1993) Palaeobotany and the evolution of plant. 2nd ed. Cambridge University Press, New York.521 p.(1)
3. Andrews ,H.N.,jr. (1974). Palaeobotany (1947-1972) Annals of the Missouri Botanical Garden 61:179-202.(8) Page 7 of 21

B040805T

Plant Breeding and Elementary Biostatistics

Semester II

1. **Plant Breeding:** Breeding Systems, methods of plant breeding, selection in self and cross pollinated crops, male sterility and self-incompatibility, Heterosis: concept and theories, inbreeding depression, hybrid vigour. Mutation breeding and distant hybridization in plant breeding. Uses of polyploidy in plant breeding.
2. Biotechnology and genetic engineering in relation to crop improvement.
3. Crop improvement in wheat, maize, paddy sugarcane, pulses, oil seeds, potato and cotton with reference to work done in India.
4. **Biostatistics:** General concepts and terminology, probability and its applications to life sciences, sampling methods, contingency of tables and chi-square test, comparison of means: T-test, analysis of variance (ANOVA), correlation and regression analysis, types of statistical software and their applications in analysis of statistical data.

Suggested readings:

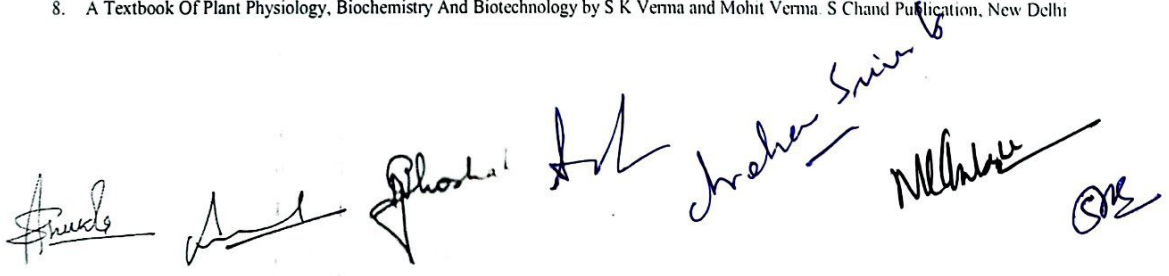
1. Forthofer RN, Sullee E, Hernandez M (2006) Biostatistics: A guide to design, analysis & discovery, Academic Press, USA.
2. George W, Snedecor W, Cochran G (1989) Statistical Methods, Publisher Iowa State University Press, Ames, Iowa, USA.

Handwritten signatures:
Shukla, Singh, Ghoshal, Jh, Jha, Mishra, SPS

1. Water relations: water movement; water relations of cell and tissues with reference to idealised cell; active and passive absorption, theories of ascent of sap.
2. Transport of water and solutes: comparison of xylem and phloem transport, phloem loading and unloading, passive and active transports
3. Transpiration mechanisms: pathways of water vapour loss; theories of stomatal movement; anti-transpirants
4. Photochemistry and Photosynthesis: Photosynthetic pigments, chlorophyll, carotenes and xanthophyll, light-harvesting complexes, photolysis of water, photophosphorylation; carbon assimilation and the Calvin cycle; photo-respiration; the C₃, C₄ and CAM pathway physiological and ecological consideration.
5. **Respiration:** Glycolysis; TCA cycle, electron transport and ATP synthesis, Respiratory quotient (RQ)
6. **Plant growth regulators:** Discovery, Bioassay, Physiological effects and mechanisms of action of plant growth hormones- Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroid, Jasmonic acid, salicylic acid.
7. **The flowering process:** Photoperiodism, endogenous clock and its regulation; floral induction mechanism, floral meristem and ABCDE Model; vernalization.
8. **Enzymes:** Classification, physicochemical nature, enzyme kinetics, mechanism of action and regulation, allosteric enzyme, isoenzyme, Michaelis-Menten equation and its significance
9. **Lipids:** Classification, structure and properties of important lipids, biological significance of glycolipids, oxidation of lipids.

Suggested readings

1. Buchanan BB, Gruissem W, Jones RL (2015) Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley Blackwell, New Jersey.
2. Hopkins WG, Huner NPA (2009) Introduction to Plant Physiology, 4th edition Wiley International edition, John Wiley & Sons, New York.
3. Taiz L, Zeiger E, Moller IM, Murph A (2015) Plant Physiology and Development, 6th edition, Sinurer Associates Inc Publishers, Sunderland, Massachusetts.
4. Frank B. Salisbury and Cleon W. Ross (1985) Plant Physiology Wadsworth Publishing Company, Belmont, California.
5. Robert M. Devlin (3rd edition) (1975) Plant Physiology Van Nostrand Reinhold Company, New York.
6. Nelson, D.L. and Cox, M.M., 2008, Lehninger Principles of Biochemistry, W. H. Freeman & Co, New York, USA
7. V.K. Jain, Plant Physiology, S Chand Publication, New Delhi.
8. A Textbook Of Plant Physiology, Biochemistry And Biotechnology by S K Verma and Mohit Verma. S Chand Publication, New Delhi



Handwritten signatures of faculty members, including names like Anand, Phodha, Anil, Jyoti Singh, and others.

B040902T

Plant Biotechnological and Molecular Techniques

Semester III

1. A brief introduction to Biotechnology; Recombinant DNA technology: Restriction endonucleases, DNA Modifying enzymes, DNA polymerases; Vectors, Markers and reporter genes, Cloning, Screening of recombinant clone.
2. Polymerase chain reaction: Principle, method, variants and practical applications.
3. Gene cloning and identification: Genomic and cDNA library.
4. Hybridization techniques: Southern, northern and western hybridization; FISH, McFISH; Molecular markers: RFLP, RAPD, AFLP, SSR and SNP.
5. Methods of gene transfer, Agrobacterium mediated genetic transformation of plants, Regeneration methodologies and Screening of plant transformants; Genetic engineering and its applications in Agriculture, Molecular farming; Biosafety concerns in Plant Biotechnology.

Suggested readings:

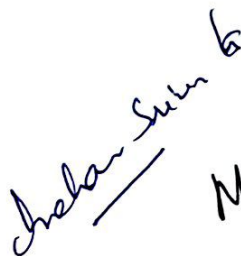
1. Brown TA (2006) Gene Cloning and DNA Analysis, Blackwell Publishers, Oxford.
2. Tropp BE (2012) Molecular Biology 4th edition, Jones and Barlett Learning, USA.
3. Green MR, Sambrook J (2000) Molecular Cloning: a laboratory manual 4th edition, Cold Spring Harbor Laboratory Press, New York.
4. Wilson K, Walker J (2013) Principle & techniques of biochemistry and molecular biology, 7th edition, Cambridge University Press, Cambridge.
5. Bhojwani SS, Razdan MK (1996) Plant tissue culture: theory and practice, 1st edition, Elsevier, New Delhi.
6. Sambrook J, Russell DW (2001) Molecular Cloning: a laboratory manual, 3rd edition, Cold Spring Harbor Laboratory Press, New York.
7. Sohail M (2004) Gene Silencing by RNA Interference: Technology and Application, 1st edition, CRC Press, Boca Raton.
8. Hannon GJ (2003) RNAi: A Guide to Gene Silencing, 1st edition, Cold Spring Harbor Laboratory Press, New York.
9. Introduction to plant biotechnology by H S Chawla.















B040903T

Plant Tissue Culture

Semester III

1. Principles of plant tissue culture: Historical perspectives, organization of laboratory, types of cultures, media composition and preparation, role of phytohormones and aseptic manipulation
2. Cellular totipotency and differentiation: Process and molecular mechanism of totipotency and differentiation, induction and maintenance
3. Cell culture and cell cloning: Isolation of cells, preparation of pure cell culture, cell cloning techniques and its application
4. Somatic embryogenesis: Induction, controlling factors, cytological and molecular changes
5. Organogenesis: Process, inducing factors, molecular basis of organogenesis
6. Haploids: Androgenic and gynogenic haploids
7. Parasexual hybridization: Isolation, culture and fusion of protoplasts, regeneration of hybrids and cybrids.
8. Micropropagation: General technique and stages of micropropagation, methods of micropropagation and its application.
9. Tissue culture-induced variations: Somaclonal, protoclonal and gametoclonal variations, molecular basis of somaclonal variation, genetic and epigenetic changes and their selection.
10. Germplasm conservation: Synthetic seed technology and industrial applications.

Suggested Readings:

1. Bhojwani SS, Razdan M K (1996) Plant Tissue Culture: Theory and Practice, revised edition, Elsevier Science, Amsterdam.
2. Newmann KH (2009) Plant Cell and Tissue Culture, A Tool in Biotechnology: Basics and Applications (Principles and Practice), Springer, Berlin.
3. Loyola- Vargas VM, Flota FV (2005) Plant Cell Culture Protocols, 2nd edition, Humana Press, Totowa.
4. Jain SM, Sopory SK, Velleux RE (1996) *In Vitro* Haploid Production in Higher Plants, Vol 1-5, Kluwer Publishers, Dordrecht, Netherlands.
5. Vasil IK, Thorpe TA (1994) Plant Cell and Tissue Culture, Kluwer Academic Publishers, Netherlands.
6. Razdan MK (2003) An Introduction to Plant Tissue Culture, Oxford & IBH Publishing Co, New Delhi

B040904T

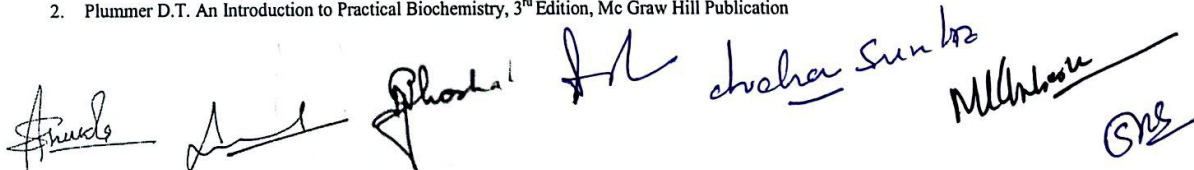
Basic Bioanalytical Techniques

Semester III

1. **Microscopy:** Light, Phase Contrast, Confocal, Fluorescence, Scanning and Transmission Electron Microscopy
2. **Chromatography:** Basic concept, Paper, TLC, HPLC, GC, Size-exclusion chromatography, Ion-exchange chromatography and Affinity chromatography.
3. **Labeling Techniques:** Radiolabeling and Fluorescent labeling of biomolecules and their detection, Safety guidelines
4. **Biophysical Techniques:** Spectrophotometry, Spectroscopy - Basic Concept, MALDI-TOF, Mass Spectroscopy, X-Ray Diffraction, FTIR, NMR and ESR Spectroscopy.
5. **Isolation and purification:** Genomic and plasmid DNA; RNA; proteins
6. **Electrophoresis:** Polyacrylamide gel electrophoresis (PAGE), agarose gel electrophoresis, native PAGE, SDS-PAGE, 2D electrophoresis.

Suggested Readings:

1. Wilson K, Walker J (2013) Principle & techniques of biochemistry and molecular biology, 7th edition, Cambridge University Press, Cambridge.
2. Plummer D.T. An Introduction to Practical Biochemistry, 3rd Edition, Mc Graw Hill Publication



B040905T

Biodiversity and Conservation

Semester III

1. An introduction to biodiversity
2. Levels of biodiversity: Species, Genetic, Community and at the ecosystem levels.
3. Threats to biodiversity: loss of biodiversity its causes and consequences, speciation and extinction of species; list of endangered, vulnerable, threatened species; IUCN categories, Red Data Book.
4. Myths and facts of biodiversity.
5. Magnitude and distribution: major hot spots of biodiversity; mega diversity centres
6. Strategies for conservation of biodiversity: Principles of biodiversity conservation, in situ and ex situ conservation strategies, restoration of species, biodiversity act.
7. Endemism in relation to biodiversity.
8. Wetland and conservation; important RAMSAR sites.

Suggested Readings:

1. Heywood VH, Watson RT (1996) Global Biodiversity Assessment, Cambridge University Press, London
2. Bryant PJ (2009) Biodiversity and Conservation, University of California, Irvine, USA.
3. Singh JS, Singh SP, Gupta SR (2014) Ecology, Environmental Science and Conservation, S Chand & Co, New Delhi.
4. Ambashit R.S and Ambashit . Navin. K (2003) (Eds) Modern Trends in Applied Terrestrial Ecology , Kluwer Academic Press USA

B040906T

Medicinal and Aromatic Plants

Semester III

1. Medicinal and aromatic plants; past and present status. National and state medicinal plant boards; objectives and function.
2. Diagnostic features, bioactive molecules and therapeutic value of some common medicinal plant of India viz., Giloy, Brahmi, Safed musli, Amla, Kalmegh, Satavari, Bel, Sarpagandha, Ashwagandha, Dhritkumari, Tulsi, Neem, Haldi, Ashok and Punarnava.
3. Nutraceuticals and medicinal foods.
4. Some important aromatic plants of India with their systematics and uses viz., Citronella, Rose, Geranium, Khus, Lavender, Lemon grass, Mentha, Basil, Palma rosa, Vetiver, and Eucalyptus.
5. Essential oils of aromatic plants, their method of extraction and use in cosmetics and perfumery.
6. Commercial cultivation of medicinal and aromatic plants.
7. Bioprospecting, biopiracy and protection of traditional medicinal knowledge.

Suggested readings

1. Cultivation of Selected Medicinal Plants, National Medicinal Plant Board, 36, Janpath, New Delhi.
2. Mandal SC, Mandal V, Das AK (2015) Essentials of Botanical Extraction: Principles and Applications, Academic Press, Elsevier, Amsterdam
3. Prajati ND, Purohit SS (2006) A Hand Book of Medicinal Plants, Agrobios, Jodhpur, India.
4. Samant SS and Palini LMS (1998) Medicinal Plants of Himalaya: Diversity, Distribution and Potential Values, Gyanadra Prakashan, Nainital.
5. Singh MP (2011) Indigenous Medicinal Plants, Social, Forestry and Tribals, Daya Publishing House, New Delhi
6. S K Bhattacharjee (2004), Handbook of a medicinal and aromatic plant.

B041001T

Advanced Genetics, Molecular Biology and Genomics Semester IV

1. Genome organization: from nucleotides to chromatin.
2. Epigenetics: Concept and scope of epigenetics, chromatin remodelling through histone modifications, remodelling of chromatin through DNA methylation.
3. Tools for analyzing gene expression: analysis of DNA-protein interactions: ESMA, ChIP, DNase I foot printing.
4. Molecular analysis of genes: Southern blotting, DNA sequencing (Sanger's Di-deoxy method, Pyrosequencing and nanopore sequencing).
5. Functional genomics: Quantitative Real Time PCR, Microarray, RNA interference (RNAi), Mutagenesis and Genome editing, Metagenomics.
6. Analysis of protein-protein interactions- pull-down assay, yeast two-hybrid assays, FRET.
7. Molecular techniques to study RNA as parameters of gene expression: non-PCR methods (northern analysis, nuclease protection and nuclear run-off assay) and PCR methods (5'RACE-Rapid Amplification of cDNA Ends).

Suggested readings:-

10. Sharma AK, Sharma A (1985) Advances in Chromosome and Cell Genetics, Oxford & IBH Publishing Co, Kolkata.
11. Krebs JE, Lewin B, Goldstein ES (2011) Genes X, Sudbury, Massachusetts.
12. Gardner EJ, Simmons MJ, Snustad DP (2006) Principals of Genetics, 8th edition, John Wiley & Sons, Wiley India Edition, New Delhi.
13. Hartl DL, Jones EW (2007) Genetics—Analysis of Genes and Genomes, 7th edition, Jones and Barlett publishers, Burlington.
14. Lodish H, Berk A, Kaiser CA, et al. (2013) Molecular Cell Biology, 7th edition, WH Freeman and Comp, New York.
15. Buchanan, B., Grissem, W., & Jones, R.L., 2002, Biochemistry and Molecular Biology of Plants. American Society of PlantBiologists, USA.
16. Watson, JD, Baker, TA, Bell, SP, Gann, A, Levine, M and Richard, L. 2008. Molecular Biology of the Gene. Pearson Education Inc.
17. Brown TA (2006) Gene Cloning and DNA Analysis, Blackwell Publishers, Oxford.
18. Tropp BE (2012) Molecular Biology 4th edition, Jones and Barlett Learning, USA.
19. Wilson K, Walker J (2013) Principle & techniques of biochemistry and molecular biology, 7th edition, Cambridge University Press, Cambridge.
20. Sohail M (2004) Gene Silencing by RNA Interference: Technology and Application, 1st edition, CRC Press, Boca Raton
21. Hannon GJ (2003) RNAi: A Guide to Gene Silencing, 1st edition, Cold Spring Harbor Laboratory Press, New York.

Sharma

Sharma

Sharma

Sharma

Jehar Sun b

Mishra

SR

B041002T

Advanced Plant Pathology

Semester IV

1. Historical and developmental aspects of plant pathology, diseases caused by fungi, bacteria, viruses and parasitic organisms.
2. Mode of infection and role of enzymes and toxins in plant disease.
3. Defense mechanisms of plants against infection: Pre-existing structural and chemical defense, induced structural and chemical defense, hypersensitive reaction, role of phytoalexins and other phenolic compounds
4. Management of plant diseases: Cultural, chemical, biological, biopesticides, breeding for resistant varieties, plant quarantine, integrated pest management
5. Molecular plant pathology: Molecular aspects of host pathogen interactions; PR proteins, systemic resistance mechanism; transgenic approach for crop protection, engineering chemicals that elicit defense response to plants
6. Preparation of Media, isolation, inoculation and Pathogenicity
7. Plant disease and their Control: Wheat- Rust, Loose smut, Bunt and Ear cockle; Barley -Covered smut; Paddy -Blast disease, false smut and bacterial leaf blight; Maiz- Smut; Bajra- Green ear disease and ergot; Pea- Powdery mildew and rust; Arhar- wilt; Linseed- rust; Sesamum- phyllody; Potato- late blight, leaf roll, brown rot and mosaic; Cabbage- root knot; Coriander- stem gall; Turmeric- Leaf spot (*Taphrina maculans*).

Suggested readings:

1. Agrios, G. N., 1988. Plant Pathology, Academic Press.
2. John A Lucas, 1998. Plant Pathology and Plant Pathogens, Wiley-Blackwell, CRC Press.
3. Dickinson, C. M., 2003. Molecular Plant Pathology, Bios Scientific Publisher
4. Robert, N., Trigiano, Windham, M. T. and Windham, A.S., 2003. Plant Pathology: Concepts and Laboratory Exercises, CRC Press.
5. Singh RS (2008) Plant Diseases, Oxford and IBH Publishing Co Pvt Ltd, New Delhi.
6. Singh RS (2008) Principles of Plant Pathology, Oxford and IBH Publishing Co Pvt Ltd, New Delhi.
7. Dhingra OD, James B, Sinclair (1995) Basic Plant Pathology Methods, CRC Publication, Boca Raton, USA.

Handwritten signatures and notes:
A handwritten signature on the left.
A handwritten signature in the middle.
A handwritten signature with the word "Phos" written above it.
A handwritten signature with the text "chokar Sun to" written above it.
A handwritten signature on the right.
A handwritten signature on the far right.

1. Distribution pattern of marine algal forms in Indian sea coast.
2. Isolation, purification and mass culture of Algae.
3. Biochemistry of algal pigments, reserve food material and cell wall composition.
4. Regulation of heterocyst and akinete differentiation in Cyanobacteria.
5. Algal blooms; their importance, triggering factors and dynamics of bloom formation.
6. Toxins of Cyanobacteria, Dinoflagellates and Diatoms; mode of action and ecological significance.
7. Algae and Cyanobacteria as a source of bioactive molecules [antimicrobial and anticancer].
8. Role of Algae in global climate regulation; carbon concentration and sequestration mechanism including calcification.
9. Role of algae in user land reclamation, in agriculture with reference to rice field and biological nitrogen fixation.
10. Algae and environmental pollution with reference to water pollution, sewage biology and role of algae in purification of sewage.
11. Algae as food and fodder, Single Cell Protein, Phyco- colloids and other compounds. Biotechnological application of algae.

Suggested Readings:

1. Bold HC, Wynne MJ (1985) Introduction to the Algae, 2nd edition, Prentice-Hall Inc, New Jersey.
2. Kumar HD (1999) Introductory Phycology, 2nd edition, Affiliated East-West Press Pvt. Ltd., New Delhi
3. Fritsch FE (1935) The Structure and Reproduction of the Algae, Vol I, Cambridge University Press, Cambridge.
4. Fritsch FE (1945) The Structure and Reproduction of the Algae, Vol II, Cambridge University Press, Cambridge.
5. Lee RE (2008) Phycology, 4th edition, Cambridge University Press, Cambridge.
6. Gangulee, H.C. and Kar, A.K., 2011, College Botany Vol. II (Algae+Fungi+Brophyta+Pteridophyta) , New Central Book Agency, Kolkata
7. Singh, Pande, Jain, 2010, A Text Book of Botany (Algae+Fungi+Brophyta+Pteridophyta) , Pub.Rastogi Publication, Meerut

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature

Handwritten signature: Chohan Sans

Handwritten signature

Handwritten signature

B041004T

Environmental Science

Semester IV

1. A brief outline of earth's environment and its evolution
2. Atmospheric composition and climate: Gaseous and particulate pollutants, emission trends and scenarios; climate change, green house gas emission, causes and consequences, control of global warming; acid rain, consequences on soil fertility, rivers and effects on forest decline.
3. Gaseous derivatives: Sulphur dioxide and Nitrogen dioxide; effect on plants, human health and ecosystem.
4. Stratospheric ozone depletion: Phenomenon, causes and consequences; effects of enhanced UV-B radiations on plants and human health.
5. Fresh water: classification of water bodies; physic-chemical and biological properties of freshwater; zonation of water bodies.
6. Effect of water pollution: effect on phytoplankton's productivity; biological magnification; effect on water quality due to discharge of city sewage.
7. Water management strategies: Rain water harvesting, uses of rain water; recharging ground water; recycling of waste water. NGOs in water pollution management.
8. Soil Pollution: Origin, treatment and disposal of pollutants of the soil with special reference to municipal garbage, pesticides, heavy metals, mining and processing wastes.
9. Thermal and Noise pollution: Its causes and consequences and impact on living systems.
10. Environmental impact assessment (EIA); basic concepts of sustainable development and environmental laws.

Suggested readings:

1. PD Shrama, Ecology and Environment Thirteenth Edition, Rastogi publication, New Delhi.
2. Singh JS, Singh SP, Gupta SR (2014) Ecology, Environmental Science and Conservation, S Chand & Co, New Delhi.
3. Agrawal SB, Agrawal M (1999) Environmental Pollution and Plant Responses, CRC Press, Boca Raton. USA.
4. Gurjar BR, Molina T, Ojha CSP (2010) Air Pollution Health and Environmental Impacts, CRC Press, Boca Raton. USA.
5. Vallero DA (2007) Fundamentals of Air Pollution, Elsevier Academic Press, Amsterdam.
6. Rao MN, Rao HVN (2009) Air Pollution, Mc Graw-Hill Pub Co Ltd, New Delhi
7. Ambasht R S and Ambasht P.K. (2014) Environment and Pollution (An Ecological Approach), CBS Publisher, New Delhi.
8. Ambasht R.S and Ambasht . Navin. K (2004) (Eds) Modern Trends in Applied.Aquatic Ecology , Kluwer Academic Press USA.

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

[Handwritten signature]

B041005T

Advanced Physiology and Biochemistry

Semester IV

1. **Sensory photobiology** - Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins.
2. **Cell Signalling:** Overview, types of receptors and G-protein, phospholipid signalling, signal transduction pathways, secondary messenger. Types and regulation of signalling pathways in plants.
3. **Stress Physiology:** Plant responses to biotic and abiotic stress, mechanism of biotic and abiotic stress tolerance towards water deficit, drought, salinity, freezing, heat stress and heavy metal stress, oxidative stress.
4. **Secondary metabolites:** Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.
5. **Nitrogen fixation, nitrogen and sulfur metabolism:** Biological nitrogen fixation, nodal formation and node factor, mechanism of nitrate uptake and reduction, ammonium assimilation, sulfate uptake transport and assimilation.
6. **Amino acids and proteins:** Classification, structure and physicochemical properties of amino acids; Proteins: Primary, secondary, tertiary and quaternary structure of proteins, physical and chemical properties of proteins and biological significance, Ramachandran plot.
7. **Carbohydrates:** Classification, Structure and Physico-chemical properties of carbohydrates, biological significance, importance of glycoprotein.
8. **Vitamins and coenzyme:** Types of vitamins and Coenzyme, structure and their function.

Suggested readings

1. Buchanan BB, Gruissem W, Jones RL (2015) Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley Blackwell, New Jersey.
2. Hopkins WG, Huner NPA (2009) Introduction to Plant Physiology, 4th edition Wiley International edition, John Wiley & Sons, New York.
3. Taiz L, Zeiger E, Moller IM, Murph A (2015) Plant Physiology and Development, 6th edition, Sinauer Associates Inc Publishers, Sunderland, Massachusetts.
4. Frank B. Salisbury and Cleon W. Ross (1985) Plant Physiology Wadsworth Publishing Company, Belmont, California.
5. Robert M. Devlin (3rd edition) (1975) Plant Physiology Van Nostrand Reinhold Company, New York.
6. Nelson, D. L. and Cox, M.M., 2008, Lehninger Principles of Biochemistry, W. H. Freeman & Co, New York, USA
7. V.K. Jain, Plant Physiology, S Chand Publication, New Delhi.
8. A Textbook Of Plant Physiology, Biochemistry And Biotechnology by S K Verma and Mohit Verma. S Chand Publication, New Delhi

B041006T

Environmental and Applied Microbiology

Semester IV

1. Microbes and environment: Pollution abatement, bioindicators, restoration of degraded ecosystems, biodegradation, bioremediation, biogenic gases, microbes in biological warfare.
2. Application of microbes in fermentation processes: Types, design and maintenance of bioreactors, application of fermentation technology in industry.
3. Role of microbes in relation to agriculture: Nitrogen economy, plant health, biological control.
4. Microbes in food and dairy industry: Mushrooms, fermented foods, microbial spoilage of food and dairy products, toxins.
5. Extremophiles and their biotechnological applications.
6. Microbial technology: Biosensors, biomolecules, enzymes.

Suggested Readings

1. Liu WT, Jansson JK (2010) Environmental Molecular Microbiology, Caister Academic Press, Norfolk.
2. Willey JM, Sherwood L, Woolverton CJ (2013) Prescott's Microbiology, 9th edition, McGraw-Hill, New York.
3. Hurst CJ, Crawford RL, Garland JL, Lipson DA, Mills AL, Stetzenbach LD (2007) Manual of Environmental Microbiology, 3rd edition, American Society for Microbiology Press, Washington, D.C.
4. Kannaiyan S (2009) A Text Book of Applied Microbiology, Vols 1 to 2, Associated Publishing Company, New Delhi.
5. Mitchel R (1993) Environmental Microbiology, Wiley-Liss Publisher, New York.
6. Dubey, RC and Maheshwary, DK. 1999. A Text Book of Microbiology. S, Chand & Company Ltd.

B041007T

Conservation and Restoration Ecology

Semester IV

1. Introduction to conservation ecology: Principles, postulates and ethics
2. Population dynamics and conservation: Genetic variation and its loss, variation in natural populations, mechanisms of population regulation, habitat specific demography, population viability analysis
3. Species and habitat conservation: Prioritizing species and habitat, protected area networks, theory of reserve design
4. Conservation strategies: Planning and management, plan process for species and site management; general principles of management; models of sustainable development
5. Ecology of disturbed ecosystems: Ecosystem dynamics and stability, disturbances, impact of disturbances on the structure and functioning of ecosystems
6. Aims and strategies of restoration: Concepts of restoration, ecosystem reconstruction, major tools used in restoration
7. Degradation and restoration of natural ecosystems

Suggested readings

1. Wali MK (1992) Ecosystem Rehabilitation, SPB Academic Publishing, Amsterdam.
2. Singh JS (1993) Restoration of degraded land: concepts & strategies, Rastogi Publications, Meerut.
3. Pimm SL (1991) The Balance of Nature? Ecological Issues in the Conservation of Species and Communities, The University of Chicago Press, Chicago
4. Smith RL (2001) **Ecology and Field Biology**, 6th edition, Benjamin Cummings, San Francisco.
5. Primack RB (2010) Essentials of Conservation Biology, 5th edition, Sinauer Associates Inc, Sunderland.
6. Meffe GK, Carroll CR (2006) Principles of Conservation Biology, 3rd edition, Sinauer Associates Inc, Sunderland.
7. Ambasht RS, Ambasht Navin K (2003). Modern trends in applied terrestrial ecology. (Eds) Kluwer Academic Press USA.

B041008T

Bioinformatics and Intellectual Property Rights (IPRs)

Semester IV

1. **Bioinformatics**: Introduction, Databases (Genomic and Protein databases), NCBI, EMBL, Genbank, PDB.
2. **Bioinformatics tools and software**: BLAST and FASTA, Primer designing, Gene prediction, Restriction site annotation, ORF Finder, Multiple sequence alignment, Phylogenetic tree.
3. **Intellectual Property Right**: Definition, World Intellectual Property Organizations (WIPO) and its role; Patent: Kinds of Patent Classification, Patent criteria, Procedure of obtaining Patent, Copyright and trademark, Organization of Patent Offices in India.

Suggested readings:

1. Baxevanis AD, Ouellette BFF (2005) Bioinformatics: A practical Guide to the analysis of Genes and Proteins, 3rd edition, John Wiley and Sons, New York.

Handwritten signatures:
Arun
[Signature]
Phosha
[Signature]
Chaker Saha
[Signature]
M. [Signature]
SPS

B041009T

Biofertilizer Technology

Semester IV

1. Biofertilizers: Definition, types and applications in agriculture
2. Characteristics of biofertilizers: *Rhizobium*, *Azotobacter*, *Azospirillum*, phosphate-solubilizing microorganisms (PSMs), cyanobacteria, *Azolla*, mycorrhizae
3. Biological nitrogen fixation: Nitrogenase, substrates for nitrogenase, mechanism of action of nitrogenase, strategies to exclude oxygen and need to control hydrogen evolution, regulation of nitrogen fixation
4. Plant growth promoting *Rhizobia* (PGPR)-legume symbiosis
5. Production technology: Strain selection, sterilization, growth and fermentation, mass production of various biofertilizers

Suggested readings

1. Gallon JR, Chaplin AE (1987) An Introduction to Nitrogen Fixation, Cassel Educational Limited, London.
2. Smith RJ, Lea PJ, Chaplin JR (1999) Nitrogen Fixation. In : Plant Biochemistry & Molecular Biology, 2nd edition, eds: Lea PJ, Leegood RC, John Wiley & Sons, New York, pp. 137-162.
3. Rai AN (1990) A Handbook of Symbiotic Cyanobacteria, CRC Press, Boca Raton, USA.
4. Postgate JR (1987) Nitrogen Fixation, 2nd edition, Arnold, London.
5. Kannaiyan S, Kumar K, Govindrajan K (2007) Biofertilizers Technology, Saujanya Books, New Delhi.

B041010T

Microbial Genetics

Semester IV

1. **Tools of microbial genetics:** Bacteriophages (T4, lambda), *Neurosopra crassa* Extrachromosomal DNA- profile, function and evolution.
2. **Transposition:** Structure of transposons, replicative and non-replicative transposition, Transposon mutagenesis.
3. **Genetic recombination;** Molecular models and mechanism, Gene conversion.
4. **Cell signaling:** Communication between cell and environment with special reference to nutrients (N and P) and temperature.
5. **Bacterial associations in plants:** perception and signaling.
6. **Gene expression and regulation:** Operons and regulons, Lactose and Tryptophan operon, Regulation of virulence genes in pathogenic bacteria, heat shock regulon, SOS regulation.
7. Use of microbes in genetic engineering.

Suggested Readings

1. Snyder L, Champnees W (2007) Molecular Genetics of Bacteria, ASM Press Washington, DC.
2. Jermy WD, Park SF (2013) Molecular Genetics of Bacteria, 4th edition, John Wiley and Sons Ltd, New York.
3. Joseph WL, Gerhart D, Hans GS (1999) Biology of the Prokaryotes, Blackwell Science Ltd, Oxford.
4. Krebs JE, Lewin B, Goldstein ES (2011) Genes X, Publishers Sudbury, Massachusetts.
5. James DW, Tania AB, Stephen PB, Alexander G, Michael L, Richard L (2008) Molecular Biology of the Gene, 6th edition, Cold Spring, New York.
6. Stanly R, Maloy JC, David F (1994) Microbial Genetics, Narosa Publisher, New Delhi
7. Bernard R, Glick, Jack JP (2003) Molecular Biotechnology: Principles and application of recombinant DNA, ASM Press, Washington, DC.
8. Brown TA (2007) Genomes, Garland Science, Taylor & Francis Group, New York & London.
9. Alberts B (2014) Molecular Biology of the Cell, 6th edition, Martin, Roberts Keith and Walter Peter- Garland Science (Taylor & Francis Group), New York & London.
10. Lodish H, Berk A, Zipursky SL, Paul M, Baltimore D, Darnell JE (2008) Molecular Cell Biology, WH Freeman Company, New York.
11. Tropp BE (2012) Molecular Biology 4th edition, Jones and Barlett Learning, USA.

[Handwritten signatures and initials]
